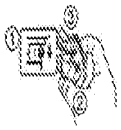
POWER SUPPLY

The camera features a two-way power supply that lets you use either batteries (AA-size alkaline, lithium or Ni-MH) or household AC current.

Loading Batteries

Be sure that camera power is turned off whenever loading or replacing batteries.

1. On the bottom of the camera, slide the battery compartment cover lock towards the front of the camera (①) to release the cover.

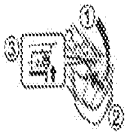


2. Grasping both sides of the battery compartment cover, swing it open (② ③).

3. Load batteries so their plus (+) and minus (–) ends are facing as shown in the illustration.



4. Close the battery compartment cover (② ③), and then slide the battery compartment cover lock towards the back of the camera to lock the cover in place (①).



Be sure to use alkaline, lithium or Ni-MH batteries. Never use manganese batteries (see precautions on the next page).

- Make sure the battery compartment cover is locked securely. Failure to do so can result in the cover opening, creating the danger of personal injury and corruption of image data.

Standard Battery Life

This camera can be powered using AA-size alkaline, lithium or Ni-MH batteries.

The battery life reference values given below indicate the amount of time at standard temperature (25°C) until power automatically turns off due to battery failure. They do not guarantee that batteries will perform the amount of service indicated. Battery life is reduced by low temperatures and continued use.

Type of Operation	AA-size Alkaline Batteries LR6	AA-size Lithium Batteries FR6	AA-size Ni-MH
Continuous Playback	110 minutes	290 minutes	190 minutes
Continuous Recording	400 shots	1020 shots	620 shots

- The above figures are approximations only.
- The above guidelines are based on the following battery types:
  Alkaline: MX1500 (AA) DURACELL ULTRA
  Lithium: Energizer
  Ni-MH (Nickel-metal hydride): CASIO NP-H3
- Battery life varies with brand.
- Figures are based on continuous recording under the following conditions.
  Flash turned off
  One zoom slider switching between T (Telephoto) and W (Wide-angle)

Battery life is greatly affected by how much you use flash, zoom and other functions, and how long you leave power turned on.

❋ About rechargeable batteries

- Use only the nickel-metal hydride batteries (NP-H3) that are available from your dealer as options for this camera. Proper camera operation is not guaranteed when other rechargeable batteries are used.
  Nickel-metal hydride Batteries (4-battery set)/Quick Charger Set BC-1HB4
  Nickel-metal hydride Batteries (4-battery set) NP-H3P4
- Be sure to keep all four batteries together as a set at all times, for both charging and powering the camera. Mixing batteries from different sets can shorten overall battery life and cause malfunction of the camera.
- Rechargeable batteries cannot be charged while they are loaded in the camera.

❋ Tips for Prolonging Battery Life

- Use the ⚡ button to turn off the flash when you are not using it.
- You can also use the power save settings (page 40) to protect against wasting battery power when you forget to turn off the camera.

❋ How low temperature affects battery life

- The life of alkaline batteries is shortened by use under very cold temperatures. The life of alkaline batteries used at 0°C is about one fifth of what it is at normal temperatures (about 25°C). When shooting under very cold temperatures, we recommend use of lithium or nickel-metal hydride batteries, which are not so dramatically affected by cold. If you must use alkaline batteries, be sure to have plenty of spares on hand.

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POWER SUPPLY

Battery Handling Precautions

Incorrect use or handling of batteries can cause them to leak or burst and seriously damage your camera. Be sure to note the following important precautions to avoid problems with batteries.

CAUTION

- Use only LR6 (AM-3) type alkaline or FR6 type lithium or Ni-MH (nickel-metal hydride) dry cell batteries with this camera. Never mix old batteries with new ones. Doing so can result in bursting or leaking of batteries, creating the danger of fire or personal injury.
- Always make sure that the positive (+) and negative (–) ends of the batteries are facing correctly, as noted by the markings on the camera itself. Improper loading of batteries can result in bursting or leaking of batteries, creating the danger of personal injury or soiling of objects nearby.

- Remove batteries from the camera if you do not plan to use it for more than two weeks.
- Never recharge batteries, never allow direct connection between two ends of a battery, and never try to take batteries apart.
- Do not expose batteries to direct heat or dispose of them by burning. Doing so can create the danger of explosion.
- Never mix batteries of different types.
- Dead batteries are susceptible to leakage, which can cause serious damage to your camera. Remove batteries from the camera as soon as you notice they are dead.
- The batteries that power the camera normally become warm as they discharge.

Battery Capacity Indicator

The battery capacity indicator (shown only when the image information display is turned on) changes in the following sequence as battery power decreases: "[■■■]" → "[■■□]" → "[■□□]" → "[□□□]". If you continue to use the camera while the battery level is "[□□□]" or "[□□□]", camera power will automatically turn off.

Auto Power Off (Battery Powered Operation Only)

Power automatically turns off whenever you do not perform any camera operation for a specific period. See page 48 for details about how you can specify the Auto Power Off time.

- To restore power, simply use the POWER Switch to turn power back on again.

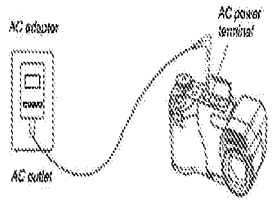
IMPORTANT!

The Auto Power Off function does not operate under the following conditions.

- During Slide Show (page 84)
- While the camera is being operated from a computer or printer connected via a cable or the USB port (page 96).
- Whenever the AC adaptor is connected to the camera.

Using the AC Adaptor

Use the optional AC adaptor (AD-C620) to power the camera from standard AC power.



AC Adaptor precautions

CAUTION

- Never use an electrical outlet whose voltage is outside the rating marked on the AC adaptor. Doing so can create the danger of fire or electrical shock. Use only the optional AC adaptor specified for this camera.
- Should the cord of the AC adaptor become damaged (exposed internal wiring), request a replacement from an authorized CASIO service provider. A damaged AC adaptor cord creates the danger of fire or electrical shock.

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CAUTION

- Always be sure to use the AD-C620 AC adaptor only. Using any other AC adaptor can cause damage to the camera not covered by this warranty.
- When unplugging the AC adaptor from the wall socket, be sure to grasp the adaptor (not the cord).
- Avoid any undue bending, pulling, and twisting of the AC adaptor's cord, and never try to lengthen the cord by splicing it with other wire.

- Be sure to turn power off before connecting or disconnecting the adaptor.
- Always turn camera power off before disconnecting the AC adaptor, even if the camera has batteries installed. If you don't, the camera will turn off automatically when you disconnect the AC adaptor. You also run the risk of damaging the camera whenever you disconnect the AC adaptor without first turning power off.
- The AC adaptor may become warm to the touch after extended periods of use. This is normal and is not cause for alarm.
- After using the camera, turn it off and unplug the adaptor from the AC outlet.
- The camera automatically switches over to AC adaptor powered operation whenever the AC adaptor is plugged into the camera.
- Always use the AC adaptor to power the camera whenever it is connected to a computer.

Power Save Settings

The settings described below let you specify sleep and auto power off trigger times that help to conserve valuable battery power.

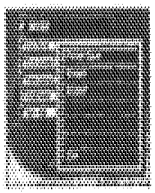
SLEEP ..... The monitor screen enters a sleep state if no operation is performed for a specified amount of time in the Record Mode. Pressing any button restores full power. You can specify 30 seconds, 1 minute, or 2 minutes before the sleep state is triggered, or you can turn off this setting entirely.

AUTO POWER OFF ..... Auto Power Off turns off camera power if no operation is performed for a specified amount of time. You can specify 2 minutes, 5 minutes, or 10 minutes before AUTO POWER OFF is triggered, or you can turn off this setting entirely.

- AUTO POWER OFF takes priority when both SLEEP and AUTO POWER OFF are both set for a 2-minute trigger time. This means camera power turns off if no operation is performed after two minutes.

Setting SLEEP and AUTO POWER OFF Trigger Times

1. Slide the Function Switch to REC.
2. Press MENU.



3. Select "Options" → "Power Save" → "Power Save".
   - "Options" appears on the advanced menu only.
4. Use [+] and [–] to select "Sleep" or "Auto Power Off".
5. Select the trigger time you want to set.
6. When the settings are the way you want them, press the shutter button.
7. Select "Exit".

Initializing Power Save Trigger Times

Use the following procedure to return SLEEP and AUTO POWER OFF trigger time settings to their initial factory defaults (SLEEP: 1 minute, AUTO POWER OFF: 2 minutes).

IMPORTANT!

Note that performing the following procedure to initialize the power save trigger time settings also initializes mode memory (page 79).

1. Slide the Function Switch to REC.
2. Press MENU.
3. Select "Options" → "Power Save" → "Power Save".
   - "Options" appears on the advanced menu only.
4. Use [+] or [–] to select "Sleep" or "Auto Power Off".
5. Select "Restore".
6. Select "Exit".

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SETTING THE CURRENT DATE AND TIME

Use the following procedures to set the current date and time, and to select the date format.

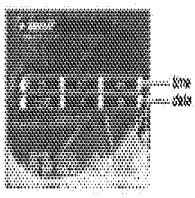
When you record an image, the time and date the image was shot is registered in accordance with data from the camera's built-in clock. You can even use the TIME STAMP function to "stamp" the date and time inside the image.

**** IMPORTANT! ****

- The time and date settings are cleared if the camera is left for about 24 hours without battery and AC power being supplied. If this happens, restore power and make new time and date settings before using the camera again.
- A flashing time display indicates that the time and date (clock) settings have been cleared. Use the procedure on this page to make the correct time and date settings.
- If you do not set the camera's built-in clock to the current date and time, all images are recorded with the default date and time, which probably is not your correct current date and time. Be sure to correctly set the clock before you use the camera.

Setting the Date and Time

1. Press MENU.
2. Select "Set Up" → "Date" → "Adjust".



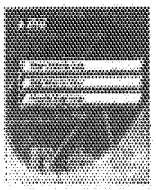
3. Set the current date and time.
   - Use [+] and [–] to select the green setting on the monitor screen, and then press the shutter to advance to the next setting. Repeat this for all of the settings on the monitor screen.
4. After making all the settings on the monitor screen, press DISP to register them.

Selecting the Date Format

Example: Sep 12, 1999

You can select any one of the following formats for the above date: 99/09/12, 12/09/99, 9/12/99.

1. Press MENU.
2. Select "Set Up" → "Date" → "Style".



3. Use [+] and [–] to select the date format you want, and then press the shutter button.

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EXHIBIT A

RECORDING

Using the Shutter Button

The following steps describe how to operate the shutter button so that Auto Focus has a chance to focus the image.

1. Press the shutter button about half way.

- The Auto Focus feature automatically focuses the image.



2. Press the shutter button as far as it will go to record the image.



Basic Recording Operation

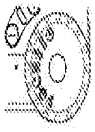
The following describes the basic operation for recording images.

1. Slide the Function Switch to REC.



- The REC position selects the Record Mode, while PLAY selects the Playback Mode.

2. Rotate the dial so its ▣ (normal recording) setting is aligned with the dot on the top of the camera.



3. Slide the POWER Switch in the direction indicated by the arrow.



- The POWER Switch returns to its original position when you release it.
- Turning on power enters the Record Mode.
- If power turns off, use the POWER Switch to turn it back on again.

4. After composing the image on the monitor screen, press the shutter button about half way and hold it there.

- The camera's Auto Focus feature automatically focuses the image.
- The operation lamp lights green and the Auto Focus Frame in the monitor screen turns green when the Auto Focus operation is complete.
- Take care to avoid blocking the lens, distance sensor or light sensor with your fingers.



- Carefully press the shutter button, taking care not to move the camera as you do.

5. After confirming that the Auto Focus operation is complete (the operation lamp lights green), press the shutter button all the way down to record the image.

- Pressing the shutter button releases the shutter, even if Auto Focus was unsuccessful and the image is out of focus.
- After you record an image, the camera takes a few seconds to store it in memory. If you try to change to the Playback Mode while a save operation is in progress, the message "Press DISP to cancel save" appears on the monitor screen. Pressing DISP at this time cancels the save operation.
- Use of a tripod and the wired remote controller is recommended for slow shutter speeds and telephoto shots to avoid blurring of the image due to camera movement.

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EXHIBIT A

!!! IMPORTANT! !!!

Auto Focus tends not to work well with the following types of subjects.

- Solid color walls or objects with little contrast
- Strongly backlit objects
- Polished metal or other brightly reflective objects
- Venetian blinds or other horizontally repeating patterns
- Multiple images that are varying distances from the camera
- Subjects in poorly lit areas
- Auto Focus also may not work properly when the camera is unsteady or shaking.

These cases may make it impossible for Auto Focus to focus properly, which is indicated by the operation indicator and the Auto Focus Frame inside the monitor screen remaining red. When this happens switch to the Manual Mode for focusing (page 59). The following are the fixed focusing distances when Auto Focus is unable to focus.

Wide-tit Location: 1.5 (4.9') meters minimum
With Flash: Approximately 2 meters (6.6')

!!! CAUTION !!!

- Never open the battery compartment cover, disconnect the AC adaptor from the camera, or unplug the adaptor from the wall socket while the operation indicator is flashing green. Doing so will not only make storage of the current image impossible, it can also corrupt other image data already stored in camera memory.
- Fluorescent lighting actually flickers at a frequency that cannot be detected by the human eye. When using the camera indoors under such lighting, you may experience some brightness or color problems with recorded images.

Using Focus Lock

Normally, Auto Focus automatically focuses on the object that is inside the Auto Focus Frame. Focus lock is a technique that lets you lock the focus on a subject and then move the camera so the Auto Focus Frame is pointed at another subject when you record. This keeps the original subject in focus, even though a different object is within the Auto Focus Frame.

- Locking the focus also locks the exposure setting.

1. Align the Auto Focus Frame with the subject you want to lock on and press the shutter button half way down.

- The Auto Focus frame turns green when the image is in focus.
- If you are using the wired remote controller, press its FOCUS LOCK ON/OFF button to turn focus lock on and off.



2. While keeping the shutter button depressed half way, move the camera and compose the image as you want.



3. Press the shutter button all the way down to record the image.

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Using the Flash

You can use the built-in flash unit to provide illumination during recording.

1. **Slide the Function Switch to REC.**
2. **Press ↯.**
   - Each press of ↯ cycles through the flash mode in the following sequence: Auto → On → Off → Red-eye Reduction.



Indicator	Flash Mode	Description
None	Auto Flash	Flash is automatically enabled and disabled in accordance with exposure conditions.
↯	Flash On	Flash is always fired, regardless of exposure conditions.
⊘	Flash Off	Flash is never fired, regardless of exposure conditions.
◉	Red-eye Reduction	Fires a pre-flash followed by recording with flash, which reduces the chance of red-eye.

- The monitor screen goes blank and the operation lamp flashes amber while the flash unit is charging.

Camera Shake Indicator

The [camera shake indicator] appears on the monitor screen when the ZOOM slider is set to T (telephoto) or when a slow shutter speed is being used.

- If the camera shake indicator appears, use a tripod and the wired remote controller to avoid camera movement.

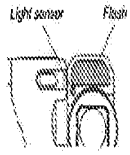
Flash Indicator

When you press the shutter button half way, the flash icon appears on the monitor screen to indicate that the flash will fire when shutter button is pressed the rest of the way down.

▶▶▶ IMPORTANT! ◀◀◀

- Never use the flash in areas where combustible or explosive gas is present. Doing so creates the danger of fire and explosion.
- Never fire the flash in the direction of a person operating a motor vehicle. Doing so can interfere with the driver's vision and create the danger of accident.

- Never fire the flash while it is too close to the subject's eyes. Intense light from the flash can cause eye damage if it is fired too close to the eyes, especially with young children. When using the flash, the camera should be at least one meter from the eyes of the subject.
- Make sure that you do not touch or block the flash or light sensor with your fingers. Doing so can soil these components and interfere with correct flash operation.



- Flash should be used for distances in the ranges shown below. Flash does not work well outside these ranges.

Normal : Approximately 0.5 meters to 2.5 meters (1.6' to 8.2')
Macro : Approximately 0.1 meters to 0.5 meters (0.3' to 1.6')

- Depending on operating conditions (type of battery being used, temperature, etc.), it may take up to 10 seconds for the flash unit to charge.
- The flash is disabled in the Movie Mode. This is indicated by the ⊘ indicator.
- The flash unit will not charge when battery power is low. The ⊘ indicator appears to warn you that the flash will not fire correctly, which may affect exposure of the image. Replace batteries as soon as possible when this happens.
- Red-eye reduction may not work well when the camera is not pointed directly at the subject or when the subject is far from the camera.
- In the Red-eye Reduction Mode, the flash is fired automatically in accordance with exposure. Because of this, the flash will not fire in a well-lit area.
- White balance is fixed while the flash is being used, so the coloring of the recorded image may be affected by sunlight, fluorescent lighting, or other sources of illumination in the immediate area.

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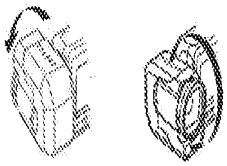
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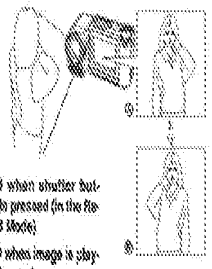
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Rotating the Lens Compartment

The lens of the camera is built into a rotating lens body. This means you can change the angle of the lens without moving the rest of the camera.



• Any images recorded while the lens body is rotated so the lens is pointed towards the back of the camera are stored as mirror images of the image that appears in the LCD before the shutter button is pressed.



Ⓐ ..... LCD when shutter button is pressed (in the Record Mode)

Ⓑ ..... LCD when image is played back from camera memory

!! IMPORTANT! !!

- Do not apply excessive force when rotating the lens body. Doing so can cause serious damage to the lens.
- Do not carry the camera or move it around while holding onto only the lens body.
- Return the lens body to its normal position (with the lens point up) before storing the camera.
- Never lay the camera down or store it with the lens pointing downwards. Doing so can cause bending of the ring around the outside of the lens.
- Always leave the lens cap in place on the lens except when actually using the camera for recording.

Quality & Size

The camera has three quality modes: FINE, NORMAL, ECONOMY.

- To determine the number of images that can be stored on a memory card of a different capacity, multiply the capacities in the table below, by the appropriate value.
- The actual number of images that can be stored in memory cannot be specified precisely because the amount of memory required for storage of each image differs according to image contents.

Setting (Indicator)	FINE		NORMAL		ECONOMY	
Quality	Fine		Normal		Economy	
Camera-to-image ratio	1280 x 960 pixels	640 x 480 pixels	1280 x 960 pixels	640 x 480 pixels	1280 x 960 pixels	640 x 480 pixels
Number of images (approximate)	12	39	16	48	24	68
Number of images with memory card (1mb)	90	265	122	357	536	518
File size (per image)	1000 KB	1500 KB	1000 KB	1500 KB	1000 KB	1500 KB

• Numbers in parentheses are compressed image file sizes.
• The figures in the left are approximations only. The actual number of images depends on image subject matter.
Use the procedure under "Using the Record Menus" on page 75 for details on changing the quality modes.
• Note that the maximum number of images that can be stored in a single folder is 250. Because of this, even if you are using a card that allows storage of more than 250 images, the camera's monitor screen will show capacity for up to 250 images only. You will be able to store additional images by changing to another folder.
• The number of images that can be recorded may differ when you use card browser (page 108).

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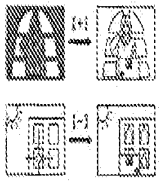
Exposure Compensation

This camera features an program AE function that automatically changes shutter speed and aperture in accordance with available light. In addition, you can also manually adjust the exposure to compensate for backlighting, indirect indoor lighting, dark backgrounds, and other special conditions.

1. Slide the Function Switch to REC.

2. Use [+] and [–] to perform exposure compensation.

- Pressing [+] or [–] displays an EV indicator that shows the current exposure compensation setting.
- Pressing [+] makes the image on the monitor screen brighter. Use it to adjust for dim indoor lighting and backlighting.
- Pressing [–] makes the image on the monitor screen darker. Use it to adjust for bright sunlight.
- The EV indicator turns red whenever the compensation value is at its limit.



3. After adjusting the exposure, press the shutter button to record the image.

NOTES on

- Exposure compensation is generally expressed in terms of an exposure compensation (EV) value. The exposure compensation value is always set to zero whenever you turn on the camera.
- Each press of [+] or [–] changes the exposure compensation value by 0.3EV. A change in either direction is indicated on the monitor screen by arrows pointing left (negative correction) or right (positive correction).
- The normal maximum range for exposure compensation is –2EV to +2EV. Under certain conditions, however, the camera may impose lower maximum values when exposure compensation would result in an image that is too dark or too light.

- The exposure compensation value automatically reverts to zero whenever the shutter button is pressed. You can manually reset the exposure compensation value by using [+] and [–] to change the value back to zero. 0.0 is indicated when the EV indicator disappears from the monitor. EV value is fixed during panorama recording.

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EXHIBIT A

OTHER RECORDING FUNCTIONS

This section describes more advanced recording operations that are also provided by this camera.

Using Quick Shutter

Quick Shutter lets you record up to five images at intervals of approximately one second. Quick Shutter can be used in record normal, Night Scene Mode, Landscape Mode, or Portrait Mode images.

&&& IMPORTANT! &&&

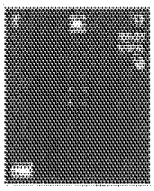
- The operation lamp flashes while data is being written to the memory card. Never remove the memory card from the camera while this lamp is flashing.
- Quick shutter is disabled under any of the following conditions: while the flash is charging, while a slow shutter speed it being used, and when conditions cause Auto Focus to take a long time to finish.
- Even if Quick Shutter is enabled, the camera automatically uses the Single shutter mode whenever the battery level is "Low".
- If you use the dial to try to change to another recording mode while the camera is saving buffer data to the memory card, the mode will not change to another recording mode until the data transfer and the save operation is complete.

1. **Slide the Function Switch to REC.**
2. **Select "Functions 1" → "Shutter Mode" → "Quick".**
   - "Functions 1" appears on the advanced menu only.
   - Turning on "Quick" causes "QQQQQ" to appear under the quality indicator.
3. **Press the shutter button.**
   - The ○ marks sequentially change to ● marks as images are recorded.
   - Images you record using Quick Shutter are initially stored in a buffer, and then sequentially transferred to the memory card. Images continue to be recorded as long as you hold down the shutter button or until the buffer becomes full (five images). The buffer may be able to hold only four images when you are using the Night Scene Mode or a slow shutter speed.

Continuous Recording

With continuous recording, you can hold down the shutter button and record up to five images at an interval of about 0.25 seconds. Continuous recording can be used for normal recording, as well as in the Night Scene, Landscape, and Portrait modes.

1. **Slide the Function Switch to REC.**
2. **Press MENU.**
3. **Select "Functions 1" → "Shutter Mode" → "Continuous", and then press the shutter button.**
   - "Functions 1" appears on the advanced menu only.
   - The "⊡" indicator is on the monitor screen while the Continuous Mode is selected.



4. **Compose the image and then record it.**
   - Focus is locked when you record the first image, and this setting is applied to all subsequent images.
   - The flash does not fire in the Continuous Mode.
   - The interval of Continuous Mode shots may be longer than 0.25 seconds at slower shutter speeds.
   - You may be able to record only four images in the Continuous Mode when using the Night Scene Mode, a fixed shutter speed, or a slow shutter speed.
   - Do not start a Continuous Record operation when the low battery indicator is on the monitor screen.
   - Storage of images recorded in the Continuous Mode to a memory card can take about 10 seconds (for five images).
   - Never remove camera batteries, unplug the AC adaptor from the camera, or remove the memory card while images are being saved.

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Using the Zoom Feature

The zoom features let you move in closer on subjects that are located far from the camera. You can choose either optical zoom or digital zoom, or even use them in combination to increase the size of the original image by 16 or 32 times its original size.

Using Optical Zoom

Optical zoom enlarges the image by changing the focal distance of the lens.
You can increase the size of the image by eight times using optical zoom.

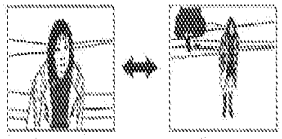
1. Slide the Function Switch to REC.

2. Move the ZOOM slider towards T (telephoto) to zoom in on the subject, or W (wide-angle) to zoom out.



ZOOM slider

- The camera performs an Auto Focus operation if you move the ZOOM slider towards T (telephoto).



T (telephoto) W (wide-angle)

3. Compose the image and then record it.

- Brightness (aperture) is also affected by using optical zoom.
- Use of a tripod and the wired remote controller is recommended for slow shutter speeds and telephoto shots to avoid blurring of the image due to camera movement.

Using Digital Zoom

Digital zoom produces a VGA size image (640 x 480 pixels) that can be double or four times the size of the original image.
Using digital zoom and optical zoom in combination can zoom an image to 32X.

<< IMPORTANT! >>

- The focus range for Auto Focus depends on the optical zoom setting as shown below.

Optical Zoom	Focus Range
X1	0.4m to ∞ (1.3' to ∞)
to	to
X8	1m to ∞ (3.3' to ∞)

- The camera may not be able to focus on an image if the subject is closer than the distances noted above. Use the macro mode for very close subjects.
- Note that 4X digital zoom produces a relatively rougher image than OFF or 2X when used in combination with Auto Focus.

See "Using the Record Menu" on page 75 for details on making digital zoom settings.

Using Focus

Manual Focus lets you manually adjust the focus of an image.

1. Slide the Function Switch to REC.

2. Press MF/▽/🔥 a number of times until the MF indicator appears on the monitor screen.

- Each press of MF/▽/🔥 cycles the focus mode in the following sequence: Auto Focus → Manual Focus (MF) → Infinity (∞) → Macro (🔥).

3. While "MF" is flashing on the monitor screen, use [+] and [–] to focus the image.

- If you do not perform any focus operation for about two seconds, the "MF" indicator stops flashing.
- After "MF" stops flashing, you can use [+] and [–] to adjust exposure compensation (EV).
- If "MF" stops flashing before you have a chance to focus, press MF/▽/🔥 to make "MF" flash again.
- Pressing MF/▽/🔥 while "MF" is flashing changes the focus mode to infinity.

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4. Compose the image and then record it.
   - The operation lamp and the Auto Focus frame do not appear while manual focus is in use.

Using Infinity Recording

Use the infinity mode when recording images of scenery or objects that are far away. This mode performs Auto Focus in the vicinity of ∞ (infinity).

1. Slide the Function Switch to REC.
2. Press MF/∞/🌷 a number of times until the ∞ indicator appears on the display.
   - Each press of MF/∞/🌷 cycles the focus mode in the following sequence: Auto Focus → Manual Focus (MF) → Infinity (∞) → Macro (🌷).
3. Compose the image and then record it.

Using the Macro Mode

With the macro mode, you can record close up images of subjects located only 1 cm to 50 cm (0.4" to 19.7") from the lens' frame.
- In the macro mode, optical zoom is limited to the range of x1 to x3.6.

1. Slide the Function Switch to REC.
2. Press MF/∞/🌷 a number of times until the 🌷 indicator appears on the monitor screen.
   - Each press of MF/∞/🌷 cycles the focus mode in the following sequence: Auto Focus → Manual Focus (MF) → Infinity (∞) → Macro (🌷)
3. Compose the image and then record it.

Movie Recording

You can record movies that are approximately 10 seconds long. Movies are recorded in 320 x 240 pixel AVI format. For details, see "Using the Record Menus" on page 75.
There are two types of movie recording: PAST and NORMAL. PAST lets you capture images of events that occurred before you pressed the shutter button while NORMAL records what happens after you press the shutter button.
See "Using the Record Menus" on page 76 for details on how to select the movie type.
- AVI files can be displayed and saved on a computer that is set up to support use of CompactFlash cards. For such a computer, install QuickTime 3.

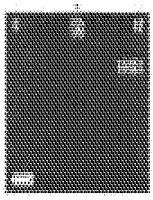
NORMAL

1. Slide the Function Switch to REC.

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2. Align the dial with [icon] to select Movie Recording Mode.

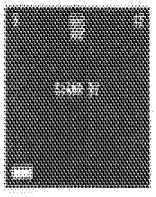


3. Compose the image and then record it.

- Auto Focus automatically adjusts in accordance with the movement of the subject.
- See "Playing Back a Movie" on page 80 for details on playing back a movie.
- Movie recording stops automatically 10 seconds after you start the record operation.
- To stop recording before the 10-second period is up, press the shutter button.

PAST

1. Slide the Function Switch to REC.
2. Select "Movie Mode" → "Past".
   - On the advanced menu, select "Functions 2" → "Movie Mode" → "Past".
3. Align the dial with [icon] to select Movie Recording Mode.
4. Compose the image on the monitor screen and then press the shutter button about half way.
   - Auto Focus automatically adjusts in accordance with the movement of the subject.
   - The message "STAND BY" appears on the monitor screen to indicate that the camera's buffer memory is accumulating image data. This message remains displayed for about 10 seconds.
   - After "STAND BY" disappears from the monitor screen, the contents of the buffer memory continues to be updated as long as you keep the shutter button depressed about half way.



5. Keep the camera pointed at the action you want to record, and press the shutter button all the way down when you want to end recording.
   - Pressing the shutter button after "STAND BY" disappears from the monitor screen records everything that went on in front of the lens during the 10-second period before you pressed the shutter button.
   - Pressing the shutter button while "STAND BY" is still on the monitor screen records everything that went on in front of the lens during the period from when you pressed the shutter button half way down and when you pressed it all the way down. In this case, the recording will be less than 10 seconds long.

*** IMPORTANT! ***

Flash is disabled during movie recording.

*** NOTE ***

Movie Storage Capacity

Storage Capacity	Approximately 30KB/ second
Recording Time	10 seconds per movie

* When using 8MB CF card.

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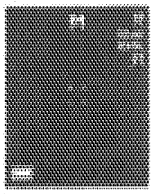
EXHIBIT A

Panorama Recording

With panorama recording you record a series of images and then link them to create a single panoramic effect.



1. Slide the Function Switch to REC.
2. Align the dial with [XII] to select Panorama Recording Mode.



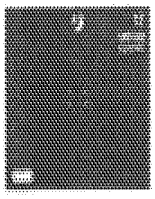
3. Compose the image and then record it.
   - The right edge of the previous image you recorded remains on the monitor screen, so you can align it correctly with the next image.
   - From the second image onwards, aim the camera further to the right and overlap the next image with the previous one on the monitor screen.
   - Up to nine images can be grouped into a panorama. Press MENU when you want to stop a panorama recording operation.
   - When the lens is pointing in the same direction as the monitor screen, the right edges of the previous image you recorded remains on the monitor screen.
   - Aperture setting and white balance settings are locked when you record the first image of a panorama, and these settings are applied to all subsequent images in that panorama.
   - If you want to link more than 9 images into a panorama, upload the images to a computer and use your computer application to link them.
   - See "Panorama Playback" on page 61 for details on playing back panoramas.

Night Scene Mode

The Night Scene Mode is for recording images in dark areas. When recording images of people on a twilight or night time background, you can use the flash in combination with the Night Scene Mode for slow synchro recording.



1. Slide the Function Switch to REC.
2. Align the dial with "☽".



3. Compose the image and then record it.

※※ IMPORTANT! ※※

- The maximum shutter speed in the Night Scene Mode is one second. Set the shutter speed manually (page 70) when you want to use a slower speed.
- The shutter speed is quite slow in the Night Scene Mode, so you should be sure to use a tripod to hold the camera steady.
- Slow shutter speed also causes slow monitor screen refresh. Because of this, the image recorded may be slightly different from the image that was on the monitor screen when you pressed the shutter button.
- Auto Focus is difficult in the dark. If you experience problems, use manual focusing (page 59). There may be some blurring of the image if the subject is fast moving.
- In the Night Scene Mode, Quick Shutter records up to 4 consecutive shots.
- The contrast of Night Scene Mode images is not affected by changes made using the Record Menu's Contrast (Record Settings) settings.

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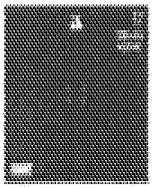
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Landscape Mode Recording

The Landscape Mode provides clear images from close ups to telephoto. The Landscape Mode records images where everything is in clear focus, from the foreground to the background. You can use the Landscape Mode with the ZOOM slider towards W (wide-angle) to record wide-angle images with clear focus from foreground to background.

1. Slide the Function Switch to REC.
2. Align the dial with .

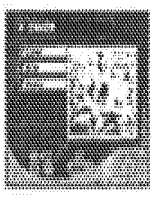


3. Compose the image and then record it.

Monochrome and Sepia Recording

Use the following procedure to record an image in monochrome (black and white) or sepia. Note that you cannot convert an image to color after recording it in monochrome or sepia.

1. Slide the Function Switch to REC.
2. Press MENU.
3. Use [+] and [–] to select "Color" and then press the shutter button.
   - On the advanced menu, select "Functions 2" → "Color."

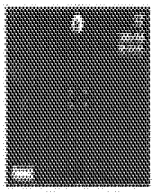


4. Use [+] and [–] to select "B/W" or "Sepia" and then press the shutter button.
5. Compose the image and then record it.

Portrait Recording

In the Portrait Mode, focus is adjusted so the background is slightly blurred, which highlights the subject in the foreground.

1. Slide the Function Switch to REC.
2. Align the dial with .



3. Compose the image and then press the shutter button about half way down.
4. After confirming that the subject is in focus, press the shutter button all the way down.

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Using the Self-timer

You can use the self-timer for either of the two following recording operations.

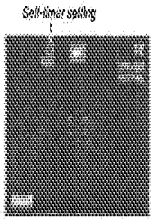
10-second recording .... Records about 10 seconds after the shutter button is pressed. Use this method when you want to be included in the image that is recorded.

2-second recording ..... Records about 2 seconds after the shutter button is pressed. Use this method to avoid camera movement caused when the shutter button is pressed.

1. Slide the Function Switch to REC.

2. Press ⏲.

- Each press of ⏲ cycles the self-timer in the sequence: 10SEC → 2SEC → Off.
- The self-timer is disabled while the Shutter Speed is set to "Bulb".



3. Compose the image and then record it.

NOTE

During self-timer recording, you may find it helpful to rotate the swivel lens mechanism so the monitor screen faces the same direction as the lens. This way you can always see how much time is left until the start time is reached and recording begins.

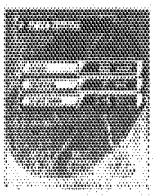
Using the Timer

You can use the timer to perform any one of the following operations.

- Interval Recording
  Use this method to record a series of images at fixed time intervals.
- Timer Recording
  Use this method to record a single image after passage of a fixed amount of time.
- Interval Timer Recording
  Use this method to record a series of images at fixed time intervals, starting after passage of a fixed amount of time.

1. Slide the Function Switch to REC.

2. Align the dial with ⏱ to select timer recording.



3. Specify the number of images (Shots), the interval between shots (Interval), and the record start time (Start time).

- Shots ..... 250 maximum
- Interval ..... 1 to 99 minutes
- Start time ... Current time to current time plus 24
- The interval cannot be specified when 1 is specified for Shots.

4. Compose the image and then record it.

- When the start time you set is reached, the operation lamp lights and image recording starts.
- The monitor screen of the camera turns off between shots of a timer operation. If you turn on camera power during this time, the message "TIMER CANCEL" appears and the timer operation is cancelled.

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»» IMPORTANT! ««

- The "Bulb" Shutter Speed setting cannot be used with a timer operation. If the Shutter Speed setting is "Bulb" it automatically changes to "Auto" when you select the timer with the dial.
- The camera requires a certain amount of time to store an image in memory after it is recorded. Because of this, setting a shutter speed of "24 sec" or higher and an interval of "01 min" may result in an interval that is longer than one minute.

Shutter Speed Priority Image Recording

You can fix the shutter speed at a specific level.

Auto: Automatic shutter speed setting in accordance with subject

Manual range: Bulb, 64 to 1/2000 second

- You can fix both the shutter speed and aperture (page 71).
- For shutter speed priority recording, set the "Aperture" setting to "Auto".

1. Slide the function switch to REC.

2. Press MENU.

3. Select "Functions 1" → "Shutter Speed" → "Manual".

- "Functions 1" appears on the advanced menu only.

4. Use [+] and [–] to select the shutter speed setting you want to use and then press the shutter button.

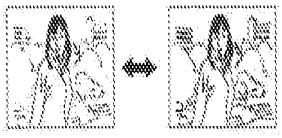
5. Select "Exit".

6. Compose the image and then record it.

- When the Shutter Speed is set to "Bulb", exposure continues as long as you depress the shutter button. Because of this, use of the wired remote control unit is recommended whenever using the "Bulb" setting.
- The self-timer is disabled while the Shutter Speed is set to "Bulb".
- The slowest shutter speed when "Bulb" is selected is 64 seconds.
- Note that using a slower shutter speed increases the chance of static being present in your image, and the amount of static visible in an image is inversely proportional to the shutter speed.
- At shutter speeds of one second or slower, the camera automatically performs internal data processing intended to limit image static, so the image record operation takes longer at slow shutter speeds. At shutter speeds of one second or greater, doubling the shutter speed setting tells you about how long it takes for an image to be recorded. For example, image recording with a shutter speed of one second takes about two seconds.

Aperture Priority Image Recording

You can fix the aperture at a specific level. A larger aperture (indicated by a smaller aperture value) narrows the focus range, while a smaller aperture widens the focus range.



Manual settings: F3.2, F4.8, F8

Auto: Automatic aperture setting in accordance with subject

- You can fix both the aperture and shutter speed (page 70).
- For shutter speed priority recording, set the "Shutter Speed" setting to "Auto".
- Adjust the aperture setting to compensate for the relative brightness or darkness of the subject you are recording.

1. Slide the function switch to REC.

2. Press MENU.

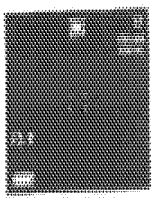
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3. Select "Functions 1" → "Aperture".
   - "Functions 1" appears on the advanced menu only.
4. Use [+] and [–] to select the aperture setting you want to use and then press the shutter button.
5. Select "Exit".



6. Compose the image and then record it.

Fine-Tuning Manual White Balance

Certain lighting conditions can cause auto white balance to take a very long time or can result in a limitation of the adjustable range (color temperature). If you suspect your current lighting conditions are causing problems, try performing manual white balance. This sets white balance to a level that can be used under any lighting conditions.

The following procedure describes how to perform manual white balance using a white piece of paper. For optimum results, you should use a special reflective plate that should be commercially available from a local camera equipment shop.

1. Slide the Function Switch to REC.
2. Press MENU.
3. Select "Functions 1" → "White Balance" → "Manual".
   - "Functions 1" appears on the advanced menu only.
4. Keeping the camera pointed at the white sheet of paper, press DISP to make the manual white balance settings.
   - Pressing the shutter button at this time returns the camera to the white balance setting that was obtained the last time you performed this manual white balance procedure.
5. The manual white balance procedure stops automatically when it is done.
   - If the manual white balance procedure does not end automatically, press the shutter button to interrupt it.
6. After the camera finishes making the white balance setting, it returns to the screen in step 3 above. Select "Exit" to exit the manual white balance procedure.

NOTE

White balance is automatically set to "Day Light" whenever you enter the Night Scene mode. You can leave this as it is or change it using the above procedure.

Changing Power On Default Settings

A power on setting is one that is set by the camera automatically whenever you turn it on. Normally, the camera uses its own built-in power on default settings.

The following table shows the items whose settings you can save in mode memory. Note that the procedure described here only lets you select ON (save current setting in mode memory) or OFF (use the camera's preset default setting).

Mode Memory Item	On	Off
Mode 1 (Mode Memory 1)		
Focus	AF, MF, ∞, [ ]	AF
Flash	Auto, ⚡, (S), ◎	Auto
Digital Zoom	Off, Auto, ×2, ×4	Auto
Mode 2 (Mode Memory 2)		
Metering	Multi, Center, Spot	Multi
White Balance	Auto, Day Light, Shade, Tungsten, Fluorescent, Manual	Auto
Flash Intensity	Strong, Normal, Weak	Normal
Aperture	Auto, F3.2, F4.6, F8	Auto
Shutter Speed	Auto, Manual (Bulb, 64 to 1/2000 second)	Auto

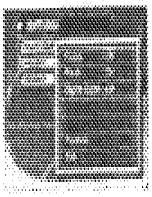
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Turning power on default settings on and off

1. Slide the Function Switch to REC.
2. Press MENU.
3. Select "Options".
4. Select "Mode 1" or "Mode 2".
5. Select "Mode 1" or "Mode 2".



6. Select the item whose setting you want to change.
7. Select "On" or "Off".
   - Repeat steps 5 and 7 for other items if you want.
8. Select "Exit".

Initializing Mode Memory

Use the following procedure to initialize the mode memory.

IMPORTANT!

Note that performing the following procedure to initialize mode memory also initializes power save trigger time settings (page 43).

1. Perform steps 1 through 3 under "Turning power on default settings on and off".
   - "Options" appears on the advanced menu only.
2. Select "Power Save", "Mode 1" or "Mode 2".
3. Select "Power Save", "Mode 1" or "Mode 2".
4. Select "Restore".
   - The following table shows the mode memory status of each item following the above procedure.
5. Select "Exit".

Item	Initialized Setting
Power Save	
Sleep	1 min
Auto Power Off	2 min
Mode 1 (Mode Memory 1)	
Focus	Off (AF)
Flash	On (Auto)
Digital Zoom	Off (Auto)
Mode 2 (Mode Memory 2)	
Metering	On (Multi)
White Balance	Off (Auto)
Flash Intensity	Off (Normal)
Aperture	Off (Auto)
Shutter Speed	Off (Auto)

- An item that is "On" stores its current setting in mode memory when camera power is turned off, and restores the setting when power is turned back on again.
- An item that is "Off" uses the camera's preset power on default setting.

About the Record Menus

The record menus make it easy to control image quality, white balance, and other settings to suit specific conditions and preferences. Each record menu has two formats: a basic menu and an advanced menu. Press DISP to toggle between the basic menu and advanced menu.

NOTES

- Focus Mode, Flash Mode, Digital Zoom, Metering, White Balance, Flash Intensity, Shutter Speed, and Aperture settings are retained when camera power is turned off by only if you specify them as such with the Mode 1 and Mode 2 items of the Record Menus. All other settings are retained when you turn off camera power.
- Exposure compensation (page 54) and auto flash (page 50) settings are valid only when the shutter speed and aperture settings are both "Auto".

Record Menus

See "Menu Screens" on page 32 for information about how to use menus.

Basic menu items are indicated by [redacted].

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Picture

Quality
Use this setting to control the quality of the image.
Fine / Normal / Economy

Size
You can specify either of two image sizes in pixels.
1280 x 960 / 640 x 480

Sharpness
This setting specifies the sharpness of image outlines.
Hard : Sharp outlines
Normal
Soft : Soft outlines

Saturation
This setting controls the intensity of colors.
High : Colors appear deeper.
Normal
Low : Colors appear lighter.

Contrast
This setting controls the difference between the light areas and dark areas of the image. Contrast is not applied in the Night Scene Mode.
High : Larger difference between light and dark.
Normal
Low : Less difference between light and dark.

Functions 1

Aperture
Use this setting when you want to fix the aperture at one of the values shown below.
Auto / F2.2 / F4.8 / F8

Shutter Speed
Use this setting to fix the shutter speed at one of the values shown below.
Auto / Manual (Bulb, 64 to 1/1000 second)

Shutter Mode
This setting specifies how the shutter operates.
Single : Records single images at an interval of about three seconds.
Quick : Allows recording of sequential images at an interval of about one second.
Continuous : Allows recording of sequential images at an interval of about 0.25 second while the shutter button is held down.
* With any of the above settings, the interval may be longer at dark shutter speeds.

Metering
This setting sets the metering method.
Multi : Takes readings across the entire image, and provides balanced exposure settings.
Center : Takes reading at the center of the image.
Spot : Takes reading at a very limited spot at the center of the image. Peripheral lighting does not affect the reading, so exposure is based on the subject alone.

White Balance
Use this setting to select the white balance setting that makes the colors of the subject appear most natural.
Auto / Day Light / Shade / Tungsten /Fluorescent/ Manual
Day Light : Outdoors
Shade : Blue tinted sunlight
Tungsten : Red tinted incandescent light
Fluorescent : Green tinted fluorescent light
Manual : Sets up the camera for recording of a white sheet of paper under currently available light (page 78).

Flash Intensity
Select the setting for the flash intensity you want to use.
Strong / Normal / Weak

Functions 2

Movie Mode
Select the movie mode you want to use.
Normal / Fast

Digital Zoom
This item does digital zoom at the setting you want.
Off / Auto / X2 / X4

Color
Use this setting to select the color mode you want.
Color / B/W / Sepia

Grid
This item turns an on-screen grid on or off. The grid can be used to help align image components vertically and horizontally.
Off / On

Time Stamp
Use this item to turn time stamping on and off, and to control the format of the stamp.
Off / YMD (Year-Month-Day) / D HM (Day-Hour-Minutes) / YMD HM (Year-Month-Day-Hour-Minutes)
Note that the time stamp cannot be deleted from an image.

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EXHIBIT A

OTHER RECORDING FUNCTIONS

Options	
Power Save	This item can be used to make power save settings to preserve battery power. Sleep (Off / 30sec / 1min / 2min) / Auto Power Off (Off / 2min / 5min / 10min)
Mode 1	Use this item to specify which of the following settings are retained when camera power is turned off. Focus / Flash / Digital Zoom
Mode 2	Use this item to specify which of the following settings are retained when camera power is turned off. Metering / White Balance / Flash Intensity / Aperture / Shutter Speed

Set Up	
Card Browser	Use this item to select the card browser file type. Off / Type1 / Type2 / Type3 / Type4
Format	Select this item to format a memory card.
Date	Use this item to specify the format of the date that appears in the monitor screen, and to adjust the date setting. Style (Year/Month/Day / Day/Month/Year / Month/Day/Year) / Adjust
Video Out	This item can be used to specify the format of the video output signal. NTSC: Video format in the United States and Japan PAL: Video format in Europe and other areas
Language	This setting lets you select either English or Japanese as the display language.
Beep	Use this item to turn the key input confirmation tone on and off.

PLAYBACK

The following describes the different techniques that you can use to playback recorded images.

Built-in Monitor Screen

The built-in monitor screen of the camera lets you play back recorded images without connecting an external monitor.

1. Slide the Function Switch to PLAY.



2. Use [+] and [–] to scroll through the images stored in camera memory.

- Press [+] to scroll forward and [–] to scroll back. Holding down either button scrolls at high speed.



NOTES

- Sliding the Function Switch to PLAY immediately after recording an image displays the image you just recorded first.
- Pressing the shutter button while a movie or panorama image is on the monitor screen starts playback of the movie or panorama.
- The image that initially appears on the monitor screen in the PLAY mode is a preview image. The full image appears after a few seconds. Images copied from another digital camera or a computer may take longer time to appear.

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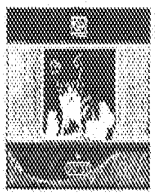
EXHIBIT A

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Playing Back a Movie

Use the following operation to play back a movie that was recorded using the operation under "Movie Recording" on page 81.

1. **Slide the Function Switch to PLAY.**
2. **Use [+] and [–] to select the movie you want to play back.**

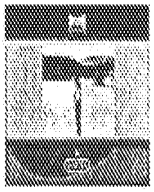


3. **Press the shutter button to start playing back the movie.**
   - You can use [+] (forward) and [–] (reverse) while playing back a movie to change the playback direction.
   - To enlarge the movie image so it fills the entire monitor screen, press DISP. Pressing the DISP again returns the image to its original small size.
   - Pressing the shutter button during movie play pauses playback. Press the shutter button again to resume playback.
   - While movie playback is paused, you can use [+] (forward) and [–] (reverse) to move frame-by-frame through the movie.
4. **After the movie is complete, press MENU.**

Panorama Playback

Use the following operation to playback panoramas recorded using the operation under "Panorama Recording" on page 84.

1. **Slide the Function Switch to PLAY.**
2. **Use [+] and [–] to select the panorama you want to play back.**



3. **Press the shutter button to start panorama playback.**
   - You can change the direction of a panorama that is playing back by pressing [+] or [–].
   - Pressing DISP changes to a small-image display. Press DISP again to return to the full-screen size.
   - Pressing the shutter button during panorama play pauses playback. Press the shutter button again to resume playback.
   - While panorama playback is paused, you can use [+] (forward) and [–] (reverse) to move frame-by-frame through the panorama.
4. **Press MENU to stop panorama playback.**

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EXHIBIT A

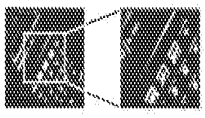
2318

Using Zoom

The following operation lets you magnify an image to twice its normal size. Note that you can zoom only a single still image.

IMPORTANT!

Movie and panorama images cannot be zoomed.



1. Slide the Function Switch to PLAY.
2. Use [+] and [–] to select the image you want to zoom.
3. Press MENU.
4. Select "Zoom".
   - On the advanced menu, select "View" → "Zoom".
5. Specify the area.
   - The portion of the selected area appears on the display at twice its normal size.
   - Use [+] and [–] to move the area selection frame left and right. Use 🔍 and MF/zoom/🔍 to move it up and down.
   - Press the DISP button to toggle on-screen guidance on and off.
6. To return the image to its normal size, press any button besides [+], [–], 🔍, MF/zoom/🔍 and DISP.

Viewing Nine Images

The following operation lets you simultaneously view nine images on the same screen. This capability is especially useful when playing back to the screen of a connected TV, and can be used to display a catalog of products, etc.



1. Slide the Function Switch to PLAY.
2. Press MENU.
3. Select "9 Multi".
   - On the advanced menu, select "View" → "9 Multi".
   - The first image of the set is the image that was on the screen when you performed step 2 of this operation. The other images are those that sequentially follow the first one.
4. Use [+] and [–] to scroll through images stored in memory.
   - To view a particular image in normal size, press DISP. This causes the [X] mark to appear in the upper left corner of the monitor screen. To produce an enlarged view of an image, use [+] and [–] to move the [X] mark to the image you want and then press the shutter button.



5. After you are finished, press any button besides [+], [–], or DISP return to the normal single-image display.

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EXHIBIT A

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Slide Show

Slide Show automatically scrolls through the images stored in memory. You can also specify how much time should be allowed between each image.



IMPORTANT!

Auto Power Off (page 41) is disabled whenever Slide Show is being used. This means you should not leave Slide Show running when using batteries to power the camera. Doing so can rundown batteries. Be sure to stop Slide Show and turn off the camera after you are finished.

1. Slide the Function Switch to PLAY.
2. Press MENU.
3. Select "Slide Show".
   - On the advanced menu, select "View" → "Slide Show".
4. To stop Slide Show, press any button besides MENU.
   - Pressing MENU while a Slide Show is in progress displays a screen that lets you change the interval within the range of 3 to 30 seconds.
   - Note that all buttons are disabled while an image change is in progress. Wait until an image is stopped on the monitor screen before performing a button operation, or hold down the button until the image stops.
   - Images copied from another digital camera or a computer may take longer time to appear.

Screen Saver

The screen saver function automatically activates Slide Show (which automatically scrolls through images) whenever you do not perform any operation for about five minutes in the Playback Mode. This protects the camera's monitor screen and the screen of a connected TV against "burn in" of a static image that is left displayed too long.

IMPORTANT!

- The screen saver is enabled only when the camera is being powered by its optional AC adaptor. If you do not perform any operation for five minutes under battery power, camera power automatically turns off (Auto Power Off).
- The screen saver displays protected images only. The screen saver is disabled if there are no protected images in memory.
- Photo Loader will not send images between the camera and a personal computer while the screen saver is turned on. Make sure you turn off the screen saver before trying to perform any image transfer operation. Note that the screen saver is turned on when you purchase the camera.

1. Slide the Function Switch to PLAY.
2. Press MENU.
3. Select "Tools" → "Screen Saver" → "On".
   - "Tools" appears on the advanced menu only.
   - To turn off the screen saver, perform the above procedure and select "Off".
   - The screen saver activates if you do not perform any operation for about five minutes in the Playback Mode.
   - Press any key to exit the screen saver.
   - When changing between images, the screen saver uses the interval that is specified for Slide Show (page 84).

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EXHIBIT A

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Using the Playback Menu

The playback menus provide you with control over the display format and DPOF settings, image delete and save operations, and other settings. Each playback menu has two formats: a basic menu and an advanced menu. Press DISP to toggle between the basic menu and advanced menu.

Playback Menus

See "Menu Screens" on page 32 for information about how to use menus.

Basic menu items are indicated by ●

Basic	Enlarge	Enlarges the image on the monitor screen.
	E-Mail ●	Displays new images on the monitor screen.
	Slide Show ●	Automatically scrolls through the images one by one.

Protect		Use this item to protect images against deletion. Select : Protects a single specific image. Folder : Protects all images in a specific folder. All : Protects all images.
Advanced	DPOF ●	Use this item to specify images for printing on a DPOF printer. Select : Prints a single specific image. Folder : Prints a specific number of copies of all images in a specific folder. All : Prints a specific number of copies of all images
	Screen Saver	This item turns the screen saver on and off.
	Select ●	Deletes a single specific image.
	Folder ●	Deletes all unprotected images in a specific folder.
	All ●	Deletes all unprotected images.

Advanced	Card Browser ●	Use this item to select the card browser file type. DIR-Type1 / Type2 / Type3
	Format ●	Select this item to format a memory card.
	Date ●	Use this item to specify the format of the date that appears on the monitor screen, and to set/ set the date setting. Off/Day/Hour/Min/Day / Day/Month/Year / Month/Day/Year / Adjust
	Video Out ●	This item can be used to specify the format of the video output signal. NTSC : Video format in the United States and Japan PAL : Video format in Europe and other areas
	Language ●	This setting lets you select either English or Japanese as the display language.
	Beep ●	Use this item to turn the key input confirmation tone on and off.

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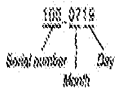
EXHIBIT A

FOLDER TYPES

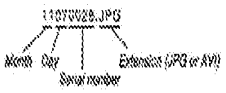
Folder Types and Folder Creation

The camera automatically creates folders (directories) on the memory card and assigns them names based on dates (month and day). Any image you record is automatically stored into the folder that corresponds to the date it is recorded.

- Up to 100 folders can be created on a single card. The following shows a typical folder name.



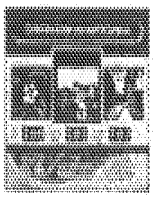
- Up to 250 image files can be stored in each folder. The following shows a typical file name.



- When you try to save the 251st image to a folder, the camera automatically creates a new folder and store the image there.
- The above maximum number of files and folders are absolute maximums. The actual number of folders and files may be less due to memory card capacity and the size of each image.
- Panorama images are divided into multiple images and stored on the memory card.
- See "USING CompactFlash CARDS WITH YOUR COMPUTER" on page 103 for information about how files and folders are organized.
- If there are more than 250 image files in a folder (due to copying from another digital camera or a computer), only the first 250 (in name sequence) can be played back.

Selecting a Folder for Playback

1. Slide the Function Switch to PLAY.
2. Press [redacted].
3. Use [+] and [-] to select the folder you want to select for playback.



4. Press the shutter button to playback the first image in the folder.

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EXHIBIT A

IMAGE PROTECTION

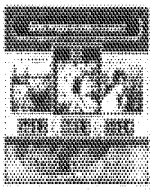
Use the following operations when you want to protect images against accidental deletion. A protected image cannot be deleted until it is unprotected. You can protect and unprotect a single specific image, all the images in a particular folder, or all images currently on the memory card.

IMPORTANT!

Formatting a memory card (page 36) deletes all images on the card, even if some or all of the images are protected.

Protecting and Unprotecting a Single Image

1. Slide the Function Switch to PLAY.
2. Press MENU.
3. Select "Tools" → "Protect" → "Select".
   - "Tools" appears on the advanced menu only.
4. Select the image you want to protect.



   - Selected images are indicated by 🔑.
   - Repeat step 4 to select other images if you want.
5. After all the images you want to protect are selected, press DISP to protect them.

Selecting the Displayed Folder

1. Slide the Function Switch to PLAY.
2. Press MENU.
3. Use [◄] and [►] to select the folder you want to protect.
4. Press the shutter button.
5. Press MENU.
6. Select "Tools" → "Protect" → "Folder".
   - "Tools" appears on the advanced menu only.
7. Select "Protect" or "Unprotect".
   - The 🔑 indicator that is shown in the upper left corner of the images when image information is turned on indicates they are protected.
   - The 🔑 indicator does not appear when images are not protected.

Protecting and Unprotecting All Images in a Memory Card

1. Perform steps 1 through 2 under "Protecting and Unprotecting a Single Image".
2. Select "Tools" → "Protect" → "All".
   - "Tools" appears on the advanced menu only.
3. Select "Protect" or "Unprotect".
   - The 🔑 indicator that is shown in the upper left corner of the images when image information is turned on indicates they are protected.
   - The 🔑 indicator does not appear when images are not protected.

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EXHIBIT A

DELETING IMAGES

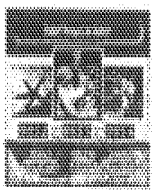
Use the following operations when you want to delete images. You can delete a single specific image, all the images in a particular folder or all images currently on the memory card.

IMPORTANT!

- Image deletion cannot be undone. Before deleting an image, make sure you no longer need it or you have a back-up copy saved on you computer, on diskette, or on some other medium.
- Be especially careful with "Deleting All Unprotected Images" operation, which deletes all unprotected images in memory.
- A protected image cannot be deleted. See "IMAGE PROTECTION" on page 80 for details on protecting and unprotecting images.

Deleting a Specific Image

1. Slide the Function Switch to PLAY.
2. Press MENU.
3. Select "Delete" → "Select".
4. Select the image you want to delete.

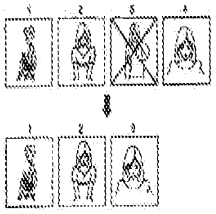


- Protected images are not displayed.
- Selected images are indicated by 🗑.
- Note that the first time you display an image its 🗑 icon is turned on.
- Repeat step 4 to select other images if you want.

5. After all the images you want to delete are selected, press DISP to delete them.
6. Select "Yes" to delete the contents of the folder, or "No" to abort the delete operation without deleting anything.
   - Deleting a panorama deletes all of the images that make it up as well.

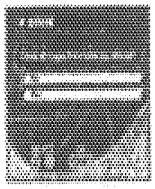
NOTE

The camera does not maintain open spaces in its memory. Deleting an images causes all images following the deleted image to be shifted up.



Deleting All the Images in a Folder

1. Slide the Function Switch to PLAY.
2. Press 🗑.
3. Use [+] and [–] to select the folder you want to delete.
4. Press the shutter button.
5. Press MENU.
6. Select "Delete" → "Folder".



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EXHIBIT A

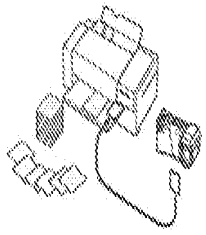
7. Select "Yes" to delete the contents of the folder, or "No" to abort the delete operation without deleting anything.
   - When the above procedure is performed while there are protected images in memory, the first of the protected images appears on the monitor screen after the unprotected images are deleted.

Deleting All Unprotected Images

1. Slide the Function Switch to PLAY.
2. Press MENU.
3. Select "Delete" → "All".
4. Select "Yes" to delete all unprotected images, or "No" to abort the delete operation without deleting anything.
   - When the above procedure is performed while there are protected images in memory, the protected image appears on the monitor screen after the unprotected images are deleted.

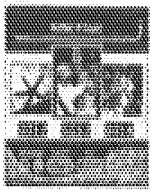
DPOF

The letters "DPOF" stand for "Digital Print Order Format", which is a format for recording on a memory card or other medium which digital camera images should be printed and how many copies of the image should be printed. DPOF makes it possible for a DPOF compatible printer or professional print service to print images from a memory card without having to specify individual file names.



Printing Specified Images

1. Slide the function switch to PLAY.
2. Press MENU.
3. Select "DPOF" → "Select".
   - On the advanced menu, select "Tools" → "DPOF".
4. Use [+] and [−] to select the image you want to print.
5. Press the shutter button.



- Selected images are indicated by 🖶.

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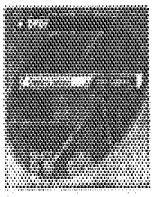
EXHIBIT A

6. Use [+] and [–] to specify the number of copies you want to print, and then press the shutter button.
   - If you want to specify more images for printing, repeat steps 4 through 6.
   - If you change your mind about printing an image, press [–] to clear its ☑ mark.
7. After you are finished, press DISP button to exit the image specification procedure.

Printing All Images in a Folder

1. Slide the function switch to PLAY.
2. Press MENU.
3. Use [+] and [–] to select the folder you want to print.
4. Press the shutter button.
5. Press MENU.
6. Select "DPOF" → "Folder" → "Set print order".
   - On the advanced menu, select "Tools" → "DPOF" → "Folder" → "Set print order".
   - To cancel current print settings, select "Cancel print order".
7. Press the shutter button.
   - If you selected "Cancel print order" in step 4, pressing the shutter button returns to the playback screen.

8. Use [+] and [–] to specify the number of copies of each image you want to print.



9. After you are finished, press the shutter button to exit the image specification procedure.

Printing All Images

1. Slide the function switch to PLAY.
2. Press MENU.
3. Select "DPOF" → "All" → "Set print order".
   - On the advanced menu, select "Tools" → "DPOF" → "All" → "Set print order".
   - To cancel current print settings, select "Cancel print order".
4. Press the shutter button.
   - If you selected "Cancel print order" in step 3, pressing the shutter button returns to the playback screen.
5. Use [+] and [–] to specify the number of copies of each image you want to print.
6. After you are finished, press the shutter button to exit the image specification procedure.

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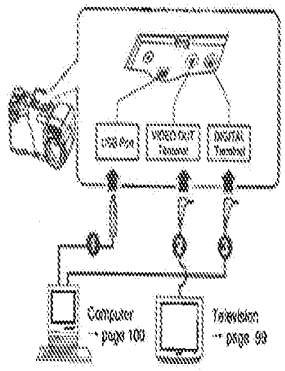
CASIO000167

EXHIBIT A

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CONNECTIONS

This camera is equipped with a VIDEO OUT terminal for connection to a television or video deck, and a DIGITAL terminal and USB port for connection to a computer or other equipment.



• When connecting a plug to the DIGITAL terminal, make sure the cord is facing in the direction of the VIDEO OUT terminal as shown in the illustration. Otherwise, you will not be able to fully insert the plug into the terminal.



❸ Special USB cable
When connecting to a computer, use the special USB cable and USB driver software that comes with the camera.
❹ Special video cable that comes with camera
❺ Cables
The type of cable you should use depends on the type of equipment to which you are connecting.

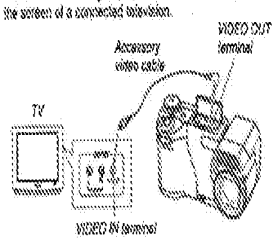
IMPORTANT!

- Be sure to turn off both the camera and other equipment before making any connections.
- Check the documentation that comes with your other equipment for information you may need to know when making connections.
- Leaving the same image displayed on a television or computer display screen for very long periods can cause the image to be "burned in" on the screen. When this happens, a faint after-image remains on the screen, even after you disconnect the camera. To avoid this, you should not leave the same image displayed on such a screen for very long periods.
- This camera does not support cable transfer of data with other CASIO digital cameras.

CONNECTING TO OTHER EQUIPMENT

Connecting to a TV Screen

Images being displayed on the camera's monitor screen, whether for recording or playback can also be displayed on the screen of a connected television.



1. Connect one end of the video cable to the camera and the other end to the television.
2. Set up the television for video input.
   - See the documentation that comes with the television for information about how to do this.
3. The connection procedure is the same for both recording and playback.

IMPORTANT!

- A television must have a video input terminal like the one shown in the illustration to connect to this camera.
- Battery capacity (page 40) and other displays that normally appear on the camera's monitor screen are also displayed on the television screen.
- The monitor screen goes blank as soon as you connect the video cable to the camera.

Selecting the Video Output Signal Mode

You can select either of two common video output modes: NTSC or PAL.
The video system you should use depends on the country where you plan to use the output signal. In the United States or Japan, for example, you should use NTSC, but in Europe you need to use PAL.
Check with your local video or TV retailer if you are unsure about which video mode you should use in your country.

1. Press MENU.
2. Select "Set Up" → "Video Out".
3. Select the video mode you want to use.

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EXHIBIT A

Connecting to a Computer

The following options are available to make it easy for you to connect to a computer for image transfer and management.

- USB cable
- USB driver software (on CD-ROM)
- Data Transfer Cable
- Photo Loader application (on CD-ROM)

USB Port Connections

The camera's USB port and accessories make it easy to connect to a computer equipped with a USB port. First install the USB driver software on your computer, and then use the special USB cable to make the connection. Once connected, you can view images on your computer's display and store images on its hard disk.

- See the separate installation manual for information about how to install the driver software on your computer.

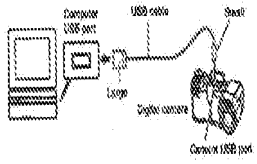
System Requirements

Windows	Macintosh
• IBM PC/AT or compatible computer pre-installed with Windows 98 • 486 or higher CPU (Pentium recommended) • CD-ROM drive (for installation) • Keyboard and mouse or equivalent input device • Available USB port	• Mac OS 8.5 or higher, Mac OS 8.1 with USB system extensions (Mac update 1.0 is required) • Power PC G3 • CD-ROM drive (for installation) • Keyboard and mouse or equivalent input device • Available USB port

- Proper operation is not guaranteed under the following conditions.
  - A computer that has been updated from Windows 95 to Windows 98
- This USB driver does not run under Windows 3.1, Windows 95 or Windows NT.

* This USB driver may not run correctly under certain hardware configurations.

USB Port Connection



IMPORTANT!

- Plug the USB connectors into the ports as far as they will go. Incorrect connection can result in improper operation.
- Turn off the camera before connecting the USB cable to it.
- The camera is not supplied power by the USB cable. Be sure to use the optional AC adaptor to power the camera whenever using a USB cable connection.
- Never disconnect the USB cable while a data communication operation is in progress. Doing so can corrupt memory data.

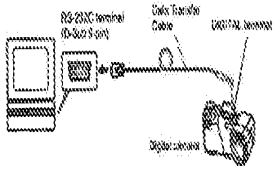
Data Transfer Cable Connection

You can use the Data Transfer Cable to connect to your personal computer through the camera's DIGITAL terminal. Then you save images on your computer's hard disk using the Photo Loader application.

- See the separate installation manual for information about how to install Photo Loader on your computer.

Windows 95, 98, NT Workstation 4.0

The Data Transfer Cable can be connected to an IBM PC/AT or compatible that is equipped with a D-Sub9 RS-232C terminal.



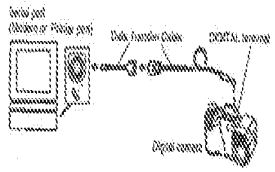
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EXHIBIT A

CONNECTING TO OTHER EQUIPMENT

Macintosh

You can connect the camera to the serial port (modem or printer port) of your Macintosh using the Data Transfer Cable.



IMPORTANT!

- See the documentation that comes with Photo Loader for information about system requirements.
- Be sure to turn off the camera, computer, and all peripherals (monitor, disk drive, etc.) connected to the computer before connecting the digital camera with the Data Transfer Cable.
- Never connect or disconnect the cable while Photo Loader is running. Doing so can cause problems with program execution, can corrupt data, and can damage the camera and your computer.
- Data transfer while camera batteries are low can result in sudden shutdown of the camera. Because of this, use of the optional AC adaptor is recommended whenever performing data communication with the camera.
- This camera does not support data communication with any of the optionally available CASIO PC link software applications: LK-1, LK-1A, LK-16V, LK-16W, LK-2, LK-2A, LK-2V, LK-21.

USING CompactFlash CARDS WITH YOUR COMPUTER

You can use any of the three methods described below to access the contents of a memory card with your computer. You can use the Photo Loader software to save images on the memory card to your computer.

CompactFlash Memory Card Slot

If your computer has a CompactFlash Memory Card Slot, insert the camera's memory card into the slot.

PC Card Slot

In this case you need an optionally available CASIO CA-10 PC Card Adaptor. See the instructions that come with the PC Card Adaptor and the documentation that comes with your computer for details on using this type of configuration.



Other Desktop Computer Configurations

Some desktop computers require a separately available PC card reader/writer and the optionally available CASIO CA-10 PC Card Adaptor to read memory card contents. See the instructions that come with the PC card reader/writer and the PC Card Adaptor for details on using this type of configuration.



About DCF

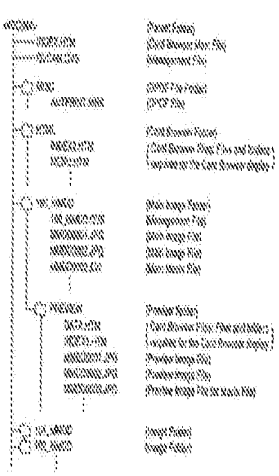
Images recorded with this camera and other data is stored on the memory card using DCF (Design rule for Camera File system) protocol. DCF protocol is designed to make it easier to exchange image and other data between digital cameras and other devices.

DCF Protocol

DCF devices (digital cameras, printers, etc.) can exchange images with each other. DCF protocol defines the format for image files (jpg) and the directory structure for the memory card, so images can be viewed using another manufacturer's DCF camera or printed on a DCF printer.

In addition to support for the DCF protocol, your CASIO digital camera also stores data in image folder names and image file names, which helps to make data management easier.

CompactFlash Card Directory Tree



Folder and File Contents

- Parent Folder
  Contents: All files used by the digital camera
- Card Browser Main File
  Contents: Template for card browser, which is used for viewing image previews with a web browser
- Management File
  Contents: Information about folder management, image sequence, etc.
- DPOF File Folder
  Contents: DPOF files
- DPOF File
  Contents: Printer data
- Card Browser Folder
  Contents: Files used by the card browser
- Card Browser File
  Contents: Data used by the card browser
- Main Image Folder
  Contents: Image file recorded by the camera
- Main Image File
  Contents: Still image file recorded by the camera
- Main Movie File
  Contents: Movie file recorded by the camera
- Preview Folder
  Contents: Preview images
- Preview Image File
  Contents: Preview images of still image and movie files used for temporary playback and card browser previews

Image Files Supported by the Camera

- Image files recorded with the CASIO QV-8000SX Digital Camera
- JPEG files stored using Photo Loader
  (1600 x 800 pixels or 640 x 480 pixels JPEG file)
- DCF protocol image files
- JPEG files stored using QV-LINK (1280 x 960 pixel and 640 x 480 pixel JPEG files)

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EXHIBIT A

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Personal Computer

- This camera uses management files to manage the sequence and attributes of image files. Because of this, adding files, deleting files, changing management file contents, or changing the sequence and attributes with your computer can cause panorama images to become ungrouped. It can also result in slower image scrolling on the camera.
- When transferring CompactFlash card contents to a hard disk, floppy diskette, MO disk, or other external storage, keep everything in the DCIM folder together. Changing the name of the DCIM folder to a date is a good way to keep track of your images. However, be sure to change the name of this folder back to DCIM if you ever copy it back to the memory card for playback on the camera. This camera does not recognize any folder name besides DCIM.
- The above is also true about the names of folders inside the DCIM folder. These folders must be returned to the names assigned to them by the camera whenever you copy the DCIM folder back to the memory card for playback on the camera.
- Never delete or modify the QVS file in any way.
- We also strongly recommend that after transferring data from a CompactFlash card to other external storage that you re-format the card and delete its contents before using it to record more images.

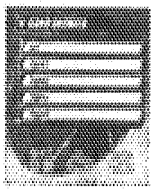
Card Browser

Card Browser makes it possible to use a browser application to view images recorded with the QV-800SX.

- The HTML file generated by this camera is best viewed using Microsoft Internet Explorer 4.01 or later, or Netscape Communicator 4.5 or later. It cannot be viewed using Photo Loader.
- QuickTime 3 is required to play back AVI movie files.

1. Press MENU.

2. Select "Set Up" → "Card Browser".



3. Specify the format.

There are four Card Browser formats.

Type1 ..... This is a powerful format that provides detailed information about each image and also includes a Slide Show feature.

Type2 ..... This format is a viewer with a Slide Show feature.

Type3 ..... This format shows information about each image. You should be able to use it with any browser, regardless of version.

Type4 ..... This format provides basic image viewing. Since it is the simplest option, you should be able to use it with just about any browser, regardless of version.

Card Browser Format	Type1	Type2	Type3	Type4
Date Screen	O	O	X	X
Index Screen	O	O	O	O
Actual Size (in pixels)	X	O	X	O
VGA Size	O	X	O	X
SXGA Size	O	X	O	X
Image Scrolling	O	X	O	X
Slide Show	O	X	O	X
Full Screen	O	X	O	X
Movie (AVI) Play	Endless	One Time	Endless	One Time

IMPORTANT!

- Note that the Type1 and Type3 formats use Java Script, so their use requires Microsoft Internet Explorer 4.01 or later, or Netscape Communicator 4.5 or later.
- In the case of Type1 and Type3, Slide Show displays 640 x 480 pixels and 1280 x 960 pixels image in the same size, so image details may appear relatively coarse.

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EXHIBIT A

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- The index screen uses the contents of the Preview Folder (page 104). Images copied from another digital camera or a computer may not have preview images, and so they do not appear in the index screen. If this happens, scroll through the images on the monitor screen until the copied images appear. At this time, the camera automatically generates a preview image, which will now appear on the Card Browser index screen.

- Turning on Card Browser causes an HTML file to be generated whenever you turn off camera power.
- Selecting "Off" in step 5 of the above procedure turns off Card Browser.
- Creation of an HTML file causes an INDEX.HTM file and other files to be added to the DCIM folder.

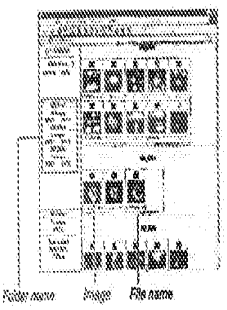
IMPORTANT!

- Though the camera's monitor screen goes blank when you turn off power, the operation lamp continues to flash for some time as the camera internally generates a Card Browser file (when Card Browser is turned on). Performing any of the operations while the operation lamp is flashing not only stops generation of the Card Browser file, it can also result in corruption of the image data on the CompactFlash Card.
  Note that a Card Browser file may be corrupted if batteries are low or if the CompactFlash Card becomes full during file generation.
- If the CompactFlash card in the camera has a large number of files on it, it may take quite a bit of time for the camera to generate the required HTML files and actually turn off after you slide the POWER switch towards OFF.
  Because of this, we recommend that you normally leave Card Browser turned off, except when you actually want to generate HTML files.
- This camera generates a Card Browser file whenever you turn off power. When the card in the camera contains a large number of files, it may take some time for the file generation operation to be performed. You can turn off the Card Browser feature if you do not want a file generated each time you turn off camera power.
- If you perform a timer operation while Card Browser is turned on, files are not generated until the number of shots specified for the timer's SHOTS setting are recorded. If you want to generate files for images recorded by a timer operation that is not yet complete, turn the camera off, wait for the files to be generated, and then turn the camera back on again. Note, however, that this also cancels the ongoing timer operation.

How to use the HTML file

Viewing HTML File Contents

Load the CompactFlash card into a card slot of your computer (page 103). Now drop the INDEX.HTM file (in the DCIM folder) onto your Web browser to display a list of all images contained on the CompactFlash card.
For information about importing data from a memory card, see "Setting Up to Access CompactFlash Card Contents from Your Computer" (page 103) and "Connecting to a Computer" (page 108).



Clicking on a folder name displays the following data about the images contained in the folder.

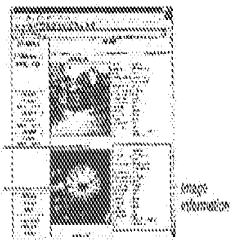


Image Information

File size (KB)
Resolution (pixels)
Quality
Recording mode
AE
Light metering
Shutter speed
Aperture stop
Exposure comp.
Focusing mode
Flash mode
Sharpness
Saturation
Contrast
White balance
Digital zoom
ISO
Model

Click Index to return to the image list.

Function Descriptions

Index Screen	When the computer accesses the memory card, it opens the INDEX.HTM file in the DCIM folder and displays an index of folders, with the newest one first. Clicking the INDEX button under a folder name in the left frame displays an index of all the images in the folder. Clicking the INDEX button under ALL Folder displays an index of all the files in all folders.
Data Screen	Clicking the DATA button under a folder name in the left frame displays the images in the folder and their recording information.
Actual Size (to pixels)	Accessing the memory card on your computer and clicking the INDEX.HTM in the DCIM folder displays 320 x 240-pixel size images in the newest folder. Clicking directly on the image changes SXGA size or VGA size, whichever was the recorded size of the image. This function is available with the Type2 and Type4 formats only.
VGA Size	Clicking directly on an image in the index or data screen displays its VGA size (CHILD PAGE) image.
SXGA Size	Clicking directly on a VGA size image displays its SXGA (IMAGE DISPLAY) image. The SXGA image is always displayed, regardless of the recorded size of the image.

Image Scrolling	Clicking the arrows above a VGA size image scrolls forward and back through the images. Clicking directly on an SXGA size image advances to the next image. You can select page scrolling for a particular folder or all folders. AVI files are not displayed.
Slide Show	Images in a specific folder or all folders opened to the maximum window size to match the monitor being used. AUTO or MANUAL can be selected as the image change type. AVI files are not displayed.
Full Screen	Selecting AUTO for the slide show causes images in a specific folder or all folders opened to the maximum window size to match the monitor being used. Images are changed at an interval of about five seconds.
Movie (AVI) Play	AVI movie files can be played back on the screen. Playback image size is the same as the record image size. Endless playback is performed with the Type1 or Type3 format, while Type2 and Type4 plays the movie once and then stops.

Saving an HTML File

- You can use the Photo Loader application to easily save the images in the HTML file to a computer. See the documentation that comes with Photo Loader for details.
- Before using the CompactFlash card again (after storing its images on other media), delete all its current files or reformat the card.

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EXHIBIT A

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TROUBLESHOOTING

	Symptom	Probable Cause	Action
Power Supply	No power	1. Batteries not loaded correctly. 2. Dead batteries 3. Wrong AC adaptor	1. Correctly load batteries (page 26). 2. Replace all four batteries with a set of new ones (page 26). 3. Use only recommended AC adaptor.
	Sudden power failure	1. Auto Power Off 2. Low battery power 3. Use of manganese batteries.	1. Turn power back on. 2. Replace all four batteries with a set of new ones (page 26). 3. Replace manganese batteries with alkaline, lithium or Ni-MH batteries.
	"⊐" indicator on LCD	Batteries are about to go dead.	Replace all four batteries with a set of new ones (page 26).
Recording	No recording when shutter button is pressed	1. Function Switch set to PLAY. 2. Flash unit is charging. 3. The message "MEMORY FULL" is on the monitor screen. 4. Insufficient memory card capacity or no memory card loaded in camera.	1. Set Function Switch to REC. 2. Wait until flash unit charging is finished. 3. Delete images you no longer need from camera memory. 4. Load a memory card.
	Auto Focus cannot focus the image.	1. Lens is dirty. 2. The object you want to focus is not in the focus frame. 3. Conditions make it impossible to obtain proper focus. 4. Camera is unsteady or shaking	1. Clean off the lens. 2. Aim the camera so the object you want to focus is in inside the focus frame. 3. Switch to the Manual Mode and focus manually. 4. Use a tripod to steady the camera.

TROUBLESHOOTING

	Symptom	Probable Cause	Action
Recording	The recorded image is out of focus.	The focus setting is not correct.	Make sure the subject you want to focus is within the Auto Focus Frame when you record the image.
	Power failure during self-timer operation	Low battery power	Replace all four batteries with a set of new ones (page 26).
	Monitor screen image is out of focus.	1. Failure to focus the image while the camera is in the Manual Mode. 2. Camera is in the Macro Mode. 3. Camera is in the Auto Focus Mode while the subject is too close.	1. Focus the image before recording it. 2. Use the Auto Focus Mode for scenery and group shots. 3. Use the Macro Mode when the subject is too close for Auto Focus.
	Poor color and brightness when indoors	Indoor fluorescent lighting	Shoot under incandescent or other non-fluorescent lighting (page 46).
	Cannot perform movie recording.	1. Movie Record Mode is not selected. 2. Insufficient camera memory capacity.	1. Select the Movie Record Mode (page 61). 2. Delete images you no longer need from camera memory.
	Recorded image is not saved.	1. Loss of power before image is stored in memory 2. Memory card cover was opened before the image was fully saved.	1. Replace all four batteries with a set of new ones (page 26). 2. Never open the memory card cover until the image is fully saved.
Playback	Colors of recorded image are different from those on the display when image was composed.	1. Reflection from sunlight or light from another source 2. Image quality setting	1. Reorient the camera so that light is not shining directly into lens. 2. Use the Recording Menu to change to a higher image quality for recording.

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EXHIBIT A

	Symptom	Probable Cause	Action
Playback	No +/– button operation during nine-page display	Button operation during page change	Wait until an image is on the monitor screen before performing a button operation.
	Cannot find an image.	1. Memory card images recording using a camera that does not support DCF. 2. Management files required to display images cannot be created.	1. The file management systems of cameras that do not support DCF are different from the one used by this camera. This camera cannot read cards recorded with such cameras. 2. Make more room available on the memory card by deleting some of its images or other data.
	Camera is connected to a TV, but LCD monitor contents do not appear on TV screen.	1. Incorrect camera-TV connection 2. Wrong TV set up 3. Wrong video mode is selected.	1. Connect correctly using the video cable (page 89). 2. Set up the TV correctly. 3. Change the video mode.
	Images cannot be displayed when downloaded back the camera from a computer.	The images were on a memory card when they were opened on the computer for editing and then restored back to the memory card.	Use the Photo Loader application to download edited images back to the camera.
Deletion	Delete operation does not operate.	All images are protected.	Unprotect the images you want to delete (page 80).

	Symptom	Probable Cause	Action
Other	Cannot select items in the Playback Menu.	Some functions are not available for playback of certain types of images.	Select a different function or change to the Record Mode.
	No buttons or switches operate.	• Malfunction due to static electrical charge or strong impact. • Camera is connected to a computer.	Remove batteries and disconnect the AC adaptor if you are using one. Replace power and turn the camera on. If this does not work, contact your dealer or an authorized CASIO service provider.
	Slide Show ends even though it is not selected.	Activation of the screen saver.	Turn off screen saver (page 85).
	Nothing appears on the monitor screen.	1. The camera is in the Sleep state. 2. Communication over the USB cable is in progress.	1. Exit the Sleep state. 2. After the communication operation over the USB cable is complete unplug the USB cable from the camera.

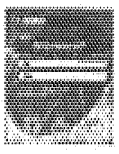
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EXHIBIT A

MESSAGES

Can't play PANORAMA	This message appears when there is not enough memory to perform panorama recording. Delete some images from the memory card to make room for the new image.
CF ERROR You must format the CompactFlash card before using it with this camera. FORMAT=>MENU	Perform this formatting procedure whenever a memory card starts to behave abnormally. Important! This procedure deletes all data stored in the memory card. Make sure all your important images are backed up onto a computer hard disk or other storage medium before performing this procedure. To reformat a memory card 1. Connect the AC adaptor to the camera and switch to AC power to load a new set of batteries into the camera. • Power failure while a format operation is being performed causes the reformat operation.

2. Press MENU.



3. Use [<] and [>] to select "Yes", and then press the shutter button.
• Select MENU if you want to abort the reformat procedure without deleting anything.
• Completion of the format operation is indicated by the message "NO IMAGE" appearing on the monitor screen. This message also indicates that the memory card was formatted successfully.

MEMORY FULL Change quality or delete unneeded images.	Not enough memory for recording in the current quality mode. Change to another quality mode, or delete some images from the memory (page 85, 92).
MEMORY FULL Delete unneeded images.	• Not enough memory for further recording. Delete some images from memory (page 92). • DCIM folder or other file (page 164) cannot be created due to insufficient memory when downloading data from a computer to the memory card. Use your computer to delete unneeded images to free up memory card space by the images you are downloading. You should also press the MENU button and format the memory card in the camera, but doing so deletes all images then currently stored on the memory card.
NO FORMAT	No images are stored in memory card.
NO IMAGE	There is no memory card installed in the camera.

RECORD ERROR	This message appears when the image you are trying to record cannot be compressed for some reason. Try changing the angle of the camera to the subject.
REPLACE BATTERY!	Battery power is low. Camera power turns off automatically shortly after this message appears.
There are no images	The memory card is not formatted. Format the memory card before trying to use it (page 38).
This camera cannot display the image you selected!	The JPEG image file you are trying to display is either corrupted or is a format that is not compatible with this camera.
Timer operation cancelled.	Timer recording was cancelled. To perform timer recording, make all necessary timer settings again.

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EXHIBIT A

SPECIFICATIONS

Description ..... Digital camera

Model QV-8000SX

Recorded Image
File Format ..... Still images (including pictures): JPEG (Exif. Ver. 2.1), DCF standard (design rule for camera file system), DPOF compatible, Motion JPI

Recording Medium ..... CompactFlash card

Recorded Image Size ..... 1280 x 960 pixels, 640 x 480 pixels

Standard Memory Capacity, Number of Image Files, Computer Output Image Size

Single			
1280 x 960	FINE	3MB	3MB size (900KB) / image
	NORMAL	1.5MB	1.5MB size (550KB) / image
	ECONOMY	800KB	800KB size (280KB) / image
640 x 480	FINE	800KB	800KB size (150KB) / image
	NORMAL	400KB	400KB size (120KB) / image
	ECONOMY	410KB	410KB size (50KB) / image

Movie: File Format: AVI
Approximate total: 150 seconds/25 seconds (320x240 pixels)/second * The maximum length of a single movie is 10 seconds.

* When using 64MB flash SD card

Image Deletion ..... Single image, all images in a folder, all images in memory (with image protection)

Imaging Element ..... 1/2.7-inch CCD (Total Pixels: 1.31 million, Effective Pixels: 1.25 million)

Lens ..... F3.2 to 5.5/f = 8 to 48mm (equivalent to 40 to 320mm lens for 35mm film)

Zoom ..... Optical zoom, 6X; Digital zoom: 20X (in combination with optical zoom)
Image size is 640 x 480 pixels when digital zoom is used.

Focusing ..... Contrast-detect Auto Focus (with focus lock), Manual Focus Mode, Macro Mode, Infinity Mode

Focus Range
Normal:
Wide-angle (maximum) ..... Approximately 0.4m to ∞ (1.3' to ∞)
Telephoto (maximum) ..... Approximately 1m to ∞ (3.3' to ∞)
Macro:
Auto focus ..... Approximately 1cm to 50cm (0.4" to 19.7") (Zoom: 1 to x1.5)
Manual focus ..... Approximately 10cm to ∞ (3.9" to ∞)

Exposure Control
Light Metering: ..... Multi-pattern, center point, spot by CCD
Exposure: ..... Program AE, Shutter priority AE, Aperture priority AE, Manual exposure
Exposure Compensation: ..... ±2EV to ±2EV (1/6EV units)

Shutter ..... CCD electronic shutter, mechanical shutter, Auto (Bulb, 64 to 1/2000 second)

Aperture ..... F3.2, F4.8, F8, auto switching or manual switching

White Balance ..... Automatic, fixed (4 modes), manual switching

Self-Timer ..... 10 seconds, 2 seconds

Built-in Flash
Flash Modes: ..... AUTO, ON, OFF, Red-eye reduction
Flash Range: ..... Normal: Approximately 0.5 to 2.5 meters (1.6' to 8.2')
Macro: Approximately 0.1 to 0.5 meters (0.3' to 1.6')

Recording Functions ..... One-shot, self-timer, movie, panorama, timer, continuous, macro, landscape, night scene, portrait

Monitor ..... 2.5" TFT, low-glare color HAST LCD (122K dots, 53 x 220)

Viewfinder ..... LCD Monitor

Clock ..... Built-in quartz digital timepiece for time and date recording and image with no-age date; auto calendar up to 2049

Input/Output Terminals ..... DIGITAL IN/OUT, USB port (special color port), AC adaptor connector, VIDEO OUT (NTSC, PAL)

Power Supply ..... Four AA-size alkaline or lithium batteries
Four AA-size nickel-hydrogen rechargeable batteries (NP-H3)
AC adaptor (AD-C620)

Battery Life
The values noted below indicate the number of hours before battery failure under normal operating temperature (25°C). These values are for reference only, and do not guarantee that any particular set of batteries actually will provide the service life indicated. Low temperatures shorten battery life.

Type of Operation	64-type Alkaline Batteries LR6	AA-size Lithium Batteries FR6
Continuous Playback	Approximately 140 minutes	Approximately 200 minutes
Continuous Recording	Approximately 400 shots	Approximately 1000 shots

* The above guidelines are based on the following battery types:
Alkaline: 1604 (GP) SUPERCELL (Ni-Tec)
Lithium: Energizer
* Battery life varies with brand.
* Figures are based on continuous recording under the following conditions.
Flash: turned off
One zoom ratio switching between 1 (Telephoto) and W (Wide angle), the position of one of the cursor's Rec, Play, and Menu buttons, turning on and off the POWER switch, as well as other operating conditions may affect the above values.

Power Consumption ..... Approximately 0.8W

Dimensions ..... 142.5(W) x 77.5(H) x 71(D) mm (5.6" (W) x 3.1" (H) x 2.8" (D))
(Excluding projections, lens cap.)

Weight ..... Approximately 330g (11.6 oz)
(excluding batteries)

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EXHIBIT A

SPECIFICATIONS

Standard Accessories ..... 2-way shoulder/wrist strap; soft case; lens cap; USB cable; video cable; wired remote controller; wired remote connector; battery (CR2025 x 1); User's Guide

- This camera does not have a replaceable battery to power its clock. Clock settings are cleared whenever power to the camera is cut off (by batteries going dead while the camera is not connected to an AC power outlet with the AC adaptor) for about 24 hours. After power is restored, either by loading fresh batteries or connecting to an AC power outlet, you will have to set the correct time and date again.
- The liquid crystal panel built into this camera is the product of precision engineering, with an effective pixel rate of 99.99%. This also means, however that 0.01% of the pixels can be expected to fail to light or to remain lit at all times.

For the latest information about CASIO Digital Cameras and accessories, visit our website at:

http://www.casio.com

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EXHIBIT A

CASIO

CASIO COMPUTER CO.,LTD.
6-2, Hon-machi 1-chome
Shibuya-ku, Tokyo 151-8543, Japan

Printed on recycled paper.

K714FCM2PMJ
MA0909-0025023 Printed in Japan

EXHIBIT 1009

DECLARATION OF SUSAN VANDERSCHANS

I, Susan VanderSchans, declare and state as follows:

1. I am the Director Marketing Communications at Casio America, Inc. ("Casio") and have held that position for 19 years. I have personal knowledge of the facts set forth in this declaration and, if called to testify as a witness, could and would do so under oath.

2. Attached hereto as Exhibit A, bearing bates numbers CASIO000217-CASIO000220, is a true, complete, and correct copy of a press release dated July 21, 1999, for the QV-8000SX digital camera.

I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct.

Executed on February 11, 2020, in Dover, New Jersey.

SUSAN VANDERSCHANS

7074496 v1

CASIO News

FOR IMMEDIATE RELEASE

www.casio.com

Contact: Pat Carrasco
Casio, Inc.
973-361-5400, x 1439
Gary Johnson
973-331-1070

CASIO INTRODUCES QV-8000SX DIGITAL CAMERA WITH 1.31-MEGAPIXEL CCD WITH OPTICAL 8X ZOOM LENS

Camera features USB cable connectability for Easy transfer of images to a computer

DOVER, NJ, July 21, 1999—Casio, Inc., in conjunction with Casio Computer Co., Ltd., Tokyo, Japan, today introduced the QV-8000SX, a 1.31-megapixel CCD digital camera with optical 8X zoom lens that is capable of zoom up to 32X when the optical and digital zoom combination is used. The camera, which features USB cable connectability for easy transfer of images to a computer, was introduced at MacWorld that opened at the Jacob Javits Convention Center in New York City today.

The new Casio QV-8000SX comes equipped with the QV Series unique swivel lens, plus 8X optical zoom, which is equivalent to 40 to 320mm zoom on a 35mm film based camera. Its macro features allows intimate close ups – up to 1cm from the subject. Other features include a Night Scene Mode with an original image processing algorithm that eliminates noise from the image; selection between shutter speed priority and aperture priority recording; a B Mode (Bulb Mode) for keeping the shutter open up to 64 seconds; a Continuous Recording Mode for recording up to five images at an interval of about 0.25 seconds, and much more. These features make the QV-8000SX the perfect tool for just about any type of digital image recording imaginable.

- **Bundled with automatic image transfer software**
  The QV-8000SX comes bundled with Photo Loader, a program that automatically transfers images to a Windows or Macintosh computer for easy viewing. Once Photo Loader is installed, it automatically transfers images to your computer whenever you connect the camera to your computer with the special USB cable that comes with the camera, or when you load the camera's CompactFlash™ card into your computer. Images are stored in folders created for each date, and can be viewed as a list or individually, using your computer's Web browser application.

EXHIBIT A

- **Designed for quick and easy operation**
  A Quick Shutter Mode has the camera ready for the next images about one second after you press the shutter release. During playback, images are scrolled at on interval of about 0.5 second, making it possible to quickly find the one you want.
- **Powerful record modes to suit a variety of subjects**
  - Landscape Mode for beautiful shots of scenery both near and far away
  - Portrait Mode that softens backgrounds so the foreground subject stands out.
  - Self-timer, Timer, and Interval Modes
- **Digital record and playback features**
  - Movie recording and playback with recording of action prior to pressing of the shutter release
  - Panorama recording and playback combines multiple images into a single panorama
- **Multi-function Remote Wired Remote Control**
  The wired remote control unit included with the QV-8000SX helps to eliminate the chance of camera shake when the shutter is released. It also provides quick and easy image scrolling during playback.
- **Three metering modes**
  Multi-pattern, center weighted, spot
- **Mode Memory**
  Stores power saving and other settings in memory when camera power is turned off.
- **Four flash modes**
  Auto, on, red-eye reduction, off
- **2.5-inch high-definition Hyper Amorphous Silicon TFT LCD monitor screen**
- **Video output**

Output images to a TV or video tape deck.

- **DCF (Design Rule for Camera File System) compliant**
- **DPOF (Digital Print Order Format) compliant**

CASIO COMPUTER CO., LTD. is one of the leading consumer electronics companies in the world, with sales of over Yen 451,141 million (over $4.1 billion) in fiscal year ending March 1999. Since its establishment in 1957, CASIO has been active in the development of electronic calculators, timepieces, musical instruments, LCD TVs, pagers and other communications devices. CASIO pioneered the personal digital camera market with the March 1995 release of the QV-10. Since then, the CASIO lineup of digital cameras has continued to evolve and grow with the addition of powerful new features and functions that made them the popular choice of digital camera users, especially for personal computer applications. CASIO's corporate activities are guided by the motto: "Creativity and Contribution."

CASIO, INC., Dover, NJ, is the U.S. subsidiary of Casio Computer Co., Ltd., Tokyo, Japan. Casio, Inc., with sales over $450 million, markets calculators, watches, business organizers, musical keyboards, audio and video products, electronic cash registers, digital imaging products and other consumer electronic products.

Specifications

Image File Record Format:

Still Images: JPEG (Exif. Ver. 2.1), DCF standard, DPOF compliant

Movies: AVI (Open DML Motion JPEG standard)

Recording Medium: CompactFlash™ memory card

Recorded Image Size and Quality:

	Image Size (Pixels)	Quality		
Still Images	1280 x 960	Fine	Normal	Economy
	640 x 480	Fine	Normal	Economy
AVI Movies	320 x 240	Max. Movie Length: 10 seconds		

Approximate Memory Capacity:

Still Images	Image Size (Pixels)	8MB CompactFlash Card
Fine mode	1280 x 960	13images
AVI Movies	320 x 240	25seconds

Image Deletion: Single image; all images in a folder; all images in memory (with image protection)

Imaging Element: 1/2.7-inch square pixel color CCD (Total Pixels: 1.31 million; Effective Pixels: 1.25 million)

Lens: F3.2 to 3.5 f = 6 to 48mm (equivalent to 40 to 320mm on a 35mm film camera); 11 elements in 9 groups; takes 43mm diameter filter

Zoom: 8X optical zoom; 2X/4X digital zoom; maximum 32X when optical and digital zoom are used in combination

Focusing: Contrast-detect TTL autofocus, manual focus; with Macro Mode; Infinity Mode and focus lock

Approximate Focus Range:

Normal Wide: 0.4m to ∞

Normal Telephoto: 1m to ∞

Macro: 1cm to 50cm (with optical zoom, 1X to 1.6X)

With Manual Focus: 1cm to ∞

Exposure:

Exposure Control: Light metering by CCD; multi-pattern, spot, center weighted

Exposure: Program AE; aperture priority AE; shutter priority AE

Exposure Correction: -2EV to +2EV (1/4EV units)

Shutter: CCD shutter, mechanical shutter

Shutter Speed: Bulb, 64 to 1/2000 second

Aperture: F3.2, F4.8, F8 automatic and manual switching

White Balance: Automatic/fixed (4 modes), manual switching

Self-timer: 10 seconds, 2 seconds

Flash Modes: AUTO, ON, OFF, Red eye reduction

Approximate Flash Range: 0.5 to 2.5 meters (Normal); 0.1 to 0.5m (Macro)

Monitor/Viewfinder: 2.5" low-glare color Hyper Amorphous TFT color LCD (122,100 pixels; 555 x 220)

Clock: Built-in quartz digital clock; date and time recorded with image; auto calendar up to 2049

Input/Output Terminals: USB (special mini connector); DIGITAL IN/OUT, VIDEO OUT (NTSC and PAL), AC adapter connector

Power Supply: Four AA-size batteries (alkaline or lithium)
Four AA-size rechargeable batteries (nickel metal hydride)
Optional AC adapter

Approximate Battery Life

Type of Operation	Alkaline Batteries (LR6)	Lithium Batteries (FR6)	Nickel Metal Hydride Rechargeable Batteries
Continuous Recording	400 images	1020 images	620 images
Continuous Playback	110 minutes	280 minutes	160 minutes

Dimensions: 5.62" (W) x 3.05" (H) x 2.8"(D) (excluding projections, lens facing upwards)

Weight: Approximately 11 oz. (excluding batteries)

Main Standard Accessories:
USB cable; serial cable (for use with IBM PC/AT compatible computer); Macintosh serial adapter cable; CD-ROM (with Photo Loader software); 8MB CompactFlash™ memory card; wired remote control unit; video cable; soft case; 2-way shoulder/hand strap; lens cap

CompactFlash and the CompactFlash logo are trademarks of San Disk Corporation. IBM PC/AT is a registered trademark of International Business Machines Corporation. The USD driver uses software developed by Phoenix Technologies Ltd. Compatibility Software Copyright 1997 Phoenix Technologies Ltd., All Rights Reserved. Other company, product and service names used herein may also be trademarks or service marks of others.

Photos available upon request

***

EXHIBIT 1011

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	T. NAKANO et al.
		Confirmation No.: TBD
Serial No.	:	To be assigned
Filed	:	April 23, 2018
For	:	ELECTRIC CAMERA
Group	:	To be assigned
Examiner	:	To be assigned
Docket No.	:	ASA-9606-09
Customer No.:		24956

PRELIMINARY AMENDMENT

Mail Stop Amendments
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

April 23, 2018

Sir:

Prior to examination, please amend the above-identified application as follows.

Amendments to the Specification begin on page 2;

Remarks are included following the amendments.

IN THE SPECIFICATION:

Please amend the first paragraph on page 1 of the specification following the heading "CROSS REFERENCE TO RELATED APPLICATION" as follows:

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application No. 15/386,656, filed December 21, 2016, which is a continuation of U.S. patent application No. 14/661,227 filed March 18, 2015, now U.S. Patent No. 9,544,517, which is a continuation of U.S. patent application No. 14/264,243, filed April 29, 2014, now U.S. Patent No. 9,100,604, which is a continuation of U.S. application serial no. 13/681,495, filed November 20, 2012, now U.S. Patent No. 8,736,729, which is a continuation of U.S. application serial no. 12/845,266, filed July 28, 2010, now U.S. Patent No. 8,339,493, issued December 25, 2012, which is a continuation of U.S. application serial no. 10/660,710, filed September 12, 2003, now U.S. Patent No. 8,059,177, issued November 15, 2011, and is related to U.S. application serial no. 10/660,711, filed September 12, 2003, now U.S. Patent No. 7,403,226, issued July 22, 2008, both of which are divisional applications of U.S. application Serial No. 09/520,836, filed March 8, 2000, now U.S. Patent No. 6,765,616, issued July 20, 2004, the subject matter of all the above is incorporated by reference herein.

REMARKS

Entry of the above amendments prior to examination is respectfully requested. No new matter is added by the amendments.

Please charge any shortage in fees due in connection with the filing of this paper, or credit any overpayment of fees, to the deposit account of MATTINGLY & MALUR, PC, Deposit Account No. 50-1417.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly, Reg. No. 30,293
(703) 684-1120

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	T. NAKANO et al.
		Confirmation No.: TBD
Serial No.	:	To be assigned
Filed	:	April 23, 2018
For	:	ELECTRIC CAMERA
Group	:	To be assigned
Examiner	:	To be assigned
Docket No.	:	ASA-9606-09
Customer No.:		24956

INFORMATION DISCLOSURE STATEMENT (IDS)
UNDER § 1.97 AND § 1.98

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

April 23, 2018

Sir:

In the matter of the above-identified application, Applicant is submitting herewith a copy, where required, of the documents listed in the attached form PTO/SB/08a. It is requested that the information be considered by the Examiner during prosecution of the application, and that the references be made of record therein.

Applicants note that:

One or more references cited on the attached PTO/SB/08a was cited by or submitted to the U.S. Patent and Trademark Office in parent application No. 15/386,656, filed December 21, 2016, which is relied upon for an earlier filing date under 35 U.S.C. §120. No copies of the references are attached pursuant to 37 CFR §1.98(d).

The Commissioner is authorized to charge any shortage in the fees due, or credit any overpayment, to Deposit Account No. 50-1417.

If the PTO determines that part(s) of the required content is inadvertently omitted, then it is requested that the Applicant(s) be given additional time and specific identification of such omission(s) to enable full compliance.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Registration No. 30,293
703-684-1120

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2018-04-23
First Named Inventor	T. NAKANO
Art Unit	
Examiner Name	
Attorney Docket Number	ASA-9606-09

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6765616	B1	2004-07-20	NAKANO et al.	
	2	7403226	B2	2008-07-22	NAKANO et al.	
	3	6781634	B1	2004-08-24	SHIOZAKI et al.	
	4	5402173		1995-03-28	NOGUCHI et al.	
	5	5438365		1995-08-01	YAMASHITA et al.	
	6	5638132		1997-06-10	HOKARI et al.	
	7	7352391	B1	2008-04-01	HATAKEYAMA	
	8	6661451	B1	2003-12-09	KIJIMA et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2018-04-23
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-09

	9	7154539	B1	2006-12-26	NISHIMURA et al.	
	10	5828406		1998-10-27	PARULSKI et al.	
	11	4054915		1977-10-18	SUGIHARA	
	12	5170249		1992-12-08	OHTSUBO et al.	
	13	5187569		1993-02-16	TANI	
	14	6195125	B1	2001-02-27	UDAGAWA et al.	
	15	6906746	B2	2005-06-14	HIJISHIRI et al.	
	16	6519000	B1	2003-02-11	UDAGAWA	
	17	5847758		1998-12-08	IIZUKA	
	18	6970191	B1	2005-11-29	SASE et al.	
	19	6734424		1998-03-31	SASAKI	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2018-04-23
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-09

	20	6798448	B1	2004-09-28	MOTONO et al.	
	21	5287192		1994-02-15	IIZUKA	
	22	8059177	B2	2011-11-15	NAKANO et al.	
	23	9100604	B2	2015-08-04	NAKANO; Takahiro	
	24	5986698	A	1999-11-16	NOBUOKA; Kousuke	
	25	4691253	A	1987-09-01	Silver; Bruce R.	
	26	4541010	A	1985-09-10	Alston; Lawrence E.	
	27	9544517	B2	2017-01-10	Nakano; Takahiro	
	28	4958915	A	1990-09-25	OKADA et al.	
	29	5060074	A	1991-10-22	KINUGASA et al.	
	30	5440343	A	1995-08-08	PARULSKI et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2018-04-23
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-09

	31	5493335	A	1996-02-20	PARULSKI et al.	
	32	5497191	A	1996-03-05	YOO et al.	
	33	5497192	A	1996-03-05	ISHIZUKA	
	34	5054052	A	1991-10-01	NONAMI	
	35	5793923	A	1998-08-11	SAWANOBORI	
	36	5828406	A	1998-10-27	PARULSKI et al.	
	37	6512541	A	2003-01-28	DUNTON et al.	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2018-04-23
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-09

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	9-270959	JP		1997-10-14	SONY CORP.		
	2	11-187306	JP		1999-07-09	SHARP CORP.		
	3	04-323973	JP		1992-11-13	HITACHI, LTD.		
	4	11-004456	JP		1999-01-06	FUJI PHOTO FILM CO., LTD.		
	5	11-355665	JP		1999-12-24	FUJI PHOTO FILM CO., LTD.		

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2018-04-23
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-09

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2018-04-23
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2018-04-23
Name/Print	John R. Mattingly	Registration Number	30293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Atty. Docket No. ASA-9606-09

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: To be assigned	Confirmation No.	: To be assigned
Applicant	: Maxell, Ltd.	TC/GAU	: To be assigned
Filed	: April 23, 2018	Examiner	: To be assigned
Title	: ELECTRIC CAMERA		

Customer No.: 24956

NOTICE OF RELATED PATENTS INVOLVED IN *INTER PARTES* REVIEW

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

April 23, 2018

Sir:

Applicant notifies the Office that two related patents, U.S. Patent Nos. 8,339,493 and 8,736,729, which matured from applications 12/845,266 and 13/681,495, respectively, and from which the above-identified application claims priority under 35 U.S.C. 120, are involved in the following *Inter Partes* Review proceedings:

ZTE CORPORATION and ZTE (USA) Inc. v. Hitachi Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,736,729, *Inter Partes* Review No. IPR2018-00238; and

ZTE CORPORATION and ZTE (USA) Inc. v. Hitachi Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,339,493, Inter Partes Review No. IPR2018-00236.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly, Reg. No. 30,293
(703) 684-1120

Atty. Docket No. ASA-9606-09

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: To be assigned	Confirmation No.	: To be assigned
Applicant	: Maxell, Ltd.	TC/GAU	: To be assigned
Filed	: April 23, 2018	Examiner	: To be assigned
Title	: ELECTRIC CAMERA		

Customer No.: 24956

NOTICE OF RELATED PATENTS INVOLVED IN LITIGATION

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

April 23, 2018

Sir:

Applicant notifies the Office that three related patents, U.S. Patent Nos. 7,403,226, 8,339,493, 8,736,729 and 9,544,517 which matured from applications 10/660,711, 12/845,266, 13/681,495 and 14/661,227, respectively, and from which the above-identified application claims priority under 35 U.S.C. 120, are involved in the following litigation:

Hitachi Maxell, Ltd. v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-179 RWS (E.D. Tex.), filed November 18, 2016.

Hitachi Maxell, Ltd. v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-178 RWS (E.D. Tex.), filed November 18, 2016.

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Respectfully submitted,

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Application Number	
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	
Examiner Name	
Attorney Docket Number	ASA-9606-09

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4958915	A	1990-09-25	OKADA et al.	
	2	5060074	A	1991-10-22	KINUGASA et al.	
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	9	5828406	A	1998-10-27	PARULSKI et al.	
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	1	ZTE (USA) Inc.'s Provisional Preliminary Invalidity Contentions which were filed in the following litigation: HITACHI MAXELL, LTD. v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-00179 RWS (E.D. Tex.), filed November 18, 2016	
	2	ZTE (USA) Inc.'s Invalidity Contentions which were filed in the following litigation: HITACHI MAXELL, LTD. v. HUAWEI DEVICE USA INC. and HUAWEI DEVICE CO., LTD., Civil Action No. 5:16-cv-00178 RWS (E.D. Tex.) and v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-00179 RWS (E.D. Tex.), filed November 18, 2016	

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	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-09

	3	Asustek Computer Inc. and Asus Computer International's Invalidity Contentions which were filed in the following litigation: MAXELL, LTD. v. ASUSTEK COMPUTER INC. AND ASUS COMPUTER INTERNATIONAL, Civil Action No. 2:17-cv-7528-R-MRW (C.D. CA), filed October 13, 2017	

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Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2018-04-23
Name/Print	John R. Mattingly	Registration Number	30,293

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ELECTRIC CAMERA

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application serial no. 13/681,495, filed November 20, 2012, which is a continuation of U.S. application serial no. 12/845,266, filed July 28, 2010, now U.S. Patent No. 8,339,493, issued December 25, 2012, which is a continuation of U.S. application serial no. 10/660,710, filed September 12, 2003, now U.S. Patent No. 8,059,177, issued November 15, 2011, and is related to U.S. application serial no. 10/660,711, filed September 12, 2003, now U.S. Patent No. 7,403,226, issued July 22, 2008, both of which are divisional applications of U.S. application Serial No. 09/520,836, filed March 8, 2000, now U.S. Patent No. 6,765,616, issued July 20, 2004, the subject matter of all the above is incorporated by reference herein.

BACKGROUND OF THE INVENTION

The present invention relates to a photography related to video cameras, camcorders, digital still cameras and others using a solid-state image sensing device, and more particularly to an electric camera using a solid-state image sensing device with a large number of pixels.

Electric cameras using solid-state image sensors such as CCDs (charge-coupled devices) include a so-called video camera or camcorder for taking moving images and a so-called digital still camera for taking still images. In recent years, video cameras with a still image taking function and digital still cameras with a moving image taking function have become available.

In a video camera to photograph moving images, it is generally assumed that the video is viewed on a display such as television monitor and thus the camera is designed to produce output signals conforming to a television system such as NTSC and

PAL. Therefore, the effective number of vertically arranged pixels or picture elements on the image sensing device used in such a camera is determined to enable television signals to be generated. The NTSC system, for example, performs interlaced scanning on two fields, each of which has an effective scanning line number of about 240 lines (the number of scanning lines actually

displayed on the monitor which is equal to the number of scanning lines in the vertical blanking period subtracted from the total number of scanning lines in each field). To realize this, the image sensing device has about 480 pixel rows as the standard effective number of vertically arranged pixels. That is, the signals of two vertically adjoining pixels in each field are mixed together inside or outside the image sensing device to generate about 240 scanning lines, and the combinations of pixels to be cyclically mixed together are changed from one field to another to achieve the interlaced scanning.

Some image sensing devices to take moving images according to the NTSC system have an area of pixels for image stabilization added to the area of effective pixel area, thus bringing the effective number of vertically arranged pixels to about 480 or more. In this case, an area beyond 480th pixels is read out at high speed during the vertical blanking period and therefore the signals thus read out are not used as effective signals. Therefore, the video signals can only be generated from those signals coming from the area of about 480 vertically arranged pixels. When such a camera is used to photograph a still image, it is relatively easy to generate a static image signal conforming to, for example, JPEG (Joint Photographic Expert Group) from the signals coming from the same pixel area that is used to take a moving image. A problem remains, however, that the number of vertically arranged pixels obtained is limited to around 480, making it

impossible to produce more detailed static image signals.

In a camera having an image sensing device with the area of pixels for image stabilization mentioned above, a method of alleviating this problem may involve using the entire area of effective pixels including the area of image stabilization pixels in photographing a still image. Even when photographing a still image, however, the photographed image needs to be monitored for check and, for that purpose, it is necessary to generate signals conforming to the television system from signals read out from all effective pixels.

An example of such a conventional camera has been proposed in JP-A-11-187306. In the camera disclosed in this publication, signals from all the effective pixels are read out taking two or more times the field period of the television system, stored in a memory means such as a field memory, and then subjected to interpolation processing for transformation into signals conforming to the field cycle and horizontal scan cycle of television.

This conventional camera, however, requires a large processing circuit, such as field memory, for signal conversion. Another drawback is that the image sensing device readout cycle is a plurality of times the field cycle, degrading the dynamic resolution. Even with the use of this circuit, the number of pixels obtained as the static image signals is limited to the number of effective pixels used for moving videos plus the area of image stabilization pixels.

In a digital still camera designed for taking still images, there has been a trend in recent years toward an increasing number of pixels used on the moving video image sensing device in order to obtain higher resolution static image signals. When taking a moving image or monitoring the video, it is necessary to generate signals that conform to the television system. The number of pixels on such an image sensing device, however, does not necessarily match the number of scanning lines of the television system and therefore some form of conversion means is required.

The conversion means may involve, as in the video camera with the area of image stabilization pixels, reading out signals from the image sensing device taking a longer time than the field cycle and interpolating them to generate television signals. This method has, in addition to the problem described above, a drawback that the readout cycle increases as the number of pixels increases, further degrading the dynamic resolution.

To mitigate this problem, JP-A-9-270959 discloses an apparatus which mixes together or culls the pixel signals inside the image sensing device to reduce the number of signals to be read and therefore the read cycle. Although this apparatus alleviates the problem of the degraded dynamic resolution, it requires a large processing circuit such as field memory to perform time-axis transformation to generate signals conforming to the television system and the image sensing device itself needs to have a

special structure for performing desired mixing and culling.

SUMMARY OF THE INVENTION

The present invention relates to a photography of video cameras, camcorders, digital still cameras and others using a solid-state image sensing device, and more particularly to an electric camera using a solid-state image sensing device with a large number of pixels.

The conventional electric cameras, as described above, have drawbacks that when taking a still picture by using a video camera, the number of pixels is not sufficient and that when taking a moving image with a still camera, the associated circuit inevitably increases and the dynamic image quality deteriorates. Taking both moving and static images of satisfactory quality with a single camera is difficult to achieve. In addition to solving the above problems, to obtain good dynamic picture quality by using an image sensing device having a large number of pixels intended for still images requires extracting a pixel area that is used to realize an image stabilizing function. The conventional art and cameras do not offer a means to accomplish this function.

An object of the present invention is to provide an electric camera that solves these problems and which uses an image sensing device with a sufficient number of pixels for still images and enables taking of highly detailed still images and a moving video taking with

reduced image quality degradation without increasing circuitry such as field memory. It is also an object of the present invention to provide an electric camera that can also realize the image stabilizing function.

According to one aspect of this invention, the electric camera to realize the above objectives has: an image sensing device with a light receiving surface having N vertically arranged pixels and an arbitrary number of pixels arranged horizontally, N being equal to or more than three times the number of effective scanning lines M of a display screen of a television system; a driver to drive the image sensing device to vertically mix or cull signal charges accumulated in individual pixels of every K pixels to produce a number of lines of output signals which corresponds to the number of effective scanning lines M, K being at least one of integers equal to or less than an integral part of a quotient of N divided by M (a number of lines of output signals corresponds to 1/K the number of vertically arranged pixels N of the image sensing device); and a signal processing unit to generate image signals by using the output signals of the image sensing device.

As explained above, since this invention eliminates the limit on the number of vertically arranged pixels, an electric camera can be provided which enables taking of highly detailed still images and a satisfactory moving video taking by using an image sensing device with a large enough pixel number even for still images.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram showing the configu

ration of a first embodiment of an electric camera according to the present invention.

Figure 2 is a schematic diagram showing the structure of an image sensing device in the first embodiment of the electric camera of the invention.

Figure 3 is a drive pulse timing diagram in the first embodiment of the electric camera of the invention.

Figure 4 is a schematic diagram showing a mixing operation in the first embodiment of the electric camera of the invention.

Figure 5 is a schematic diagram showing a readout area in the first embodiment of the electric camera of the invention.

Figure 6 is a schematic diagram showing a mixing operation in the first embodiment of the electric camera of the invention.

Figure 7 is a block diagram showing the configuration of a second embodiment of an electric camera according to the present invention.

Figure 8 is a schematic diagram showing a mixing operation in the second embodiment of the electric camera of the invention.

Figure 9 is a schematic diagram showing a readout area in the second embodiment of the electric camera of the invention.

Figure 10 is a schematic diagram showing the structure of an image sensing device in a third embodiment of the electric camera according to the present invention.

Figure 11 is a drive pulse timing diagram in the third embodiment of the electric camera of the invention.

Figure 12 is a schematic diagram showing an interpolation operation in the third embodiment of the electric camera of the invention.

Figures 13A and 13B are schematic diagrams showing the arrangement of color filters in the image sensing device in a fourth embodiment of the electric camera according to the present invention.

DESCRIPTION OF THE EMBODIMENTS

Now embodiments of the present invention will be described by referring to the accompanying drawings. Figure 1 is a block diagram showing the configuration of one embodiment of an electric camera according to the invention.

In Figure 1, reference number 1 represents a lens, 2 an aperture, 3 an image sensing device, 4 a drive circuit, 5 a gain adjust circuit, 6 an analog-digital (A/D) conversion circuit, 7 a signal processing circuit, 8 a vertical interpolation circuit to perform interpolation in a vertical direction, 9 a horizontal interpolation circuit to perform interpolation in a horizontal direction, 10 a recording unit including recording media such as magnetic tape, semiconductor memory and optical disk to record a video signal, 11 a control circuit to control these constitutional elements according to the operating state, 12 an encoder circuit to modulate the video signal into a

standard television signal, 13 a digital-analog (D/A) conversion circuit, 14 a mode selector switch to change over the operation mode between the moving video taking and the still image taking, 15 a record button to start or stop the recording, 16a and 16b gyro sensors to detect vertical image-unstability and lateral image-unstability, respectively, and 17 an image-unstability decision circuit to determine the image-instability from signals output from the gyro sensors.

In the above configuration, light coming from the lens 1 through the aperture 2 is focused on a light receiving surface of the image sensing device 3 where it is converted into an electric signal. In this embodiment the image sensing device 3 is of a CCD type. Figure 2 shows the structure of this image sensing device 3. In Figure 2, denoted 30 are pixels each formed of a photodiode, which are arranged horizontally and vertically in a grid pattern. On these grid-arrayed pixels three types of color filters that pass yellow (Ye), green (G) and cyan (Cy), respectively, are arranged in such a way that the combination of these three colors is repeated horizontally every three pixels and that the filters of the same colors are lined vertically in so-called vertical stripes. Although an arbitrary number of pixels may be used, this embodiment has an array of 1200 pixels vertically and 1600 pixels horizontally. A vertical transfer unit 32 is a CCD which is driven by three phase pulses V1, V2, V3. This CCD has a three-gate structure in which each pixel corresponds to

three phase pulses and thus can vertically transfer a signal charge of each pixel independently. Transfer gates 31 for transferring the charge of each pixel to the vertical transfer unit 32 are commonly connected to a gate of the vertical transfer unit 32 that corresponds to the V2 pulse. An operation to transfer the charge from each pixel to the vertical transfer unit 32 in response to a peak value of the pulse applied to the commonly connected gate and an operation to transfer the charge vertically are performed separately. A horizontal transfer unit 33 horizontally transfers the charges supplied from the vertical transfer units 32 and outputs them successively through an output amplifier 34 from the output terminal.

Referring back to Figure 1, the operation performed when the moving video mode is selected by the mode selector switch 14 will be explained. The number of vertically arranged pixels on the image sensing device in this embodiment is 1200, so if the number of effective scanning lines in the field of the NTSC system is assumed to be 240 lines, then vertically mixing five pixels (= 1200 pixel rows/240 scanning lines) can match the number of lines of output signals from the image sensing device to the number of effective scanning lines.

However, in this embodiment, to realize the image stabilizing function described later, four vertically arranged pixels are mixed together during motion image taking mode. When four vertically arranged pixels are to be cyclically mixed together, the signals from the area of

960 pixels (= 240 scanning lines × 4 pixels) out of the 1200 vertically arranged pixels are used as effective signals and the remaining 240 pixels (= 1200 (all pixels) - 960 (effective pixels)) are not used for image forming. Figure 3 shows the timing of a vertical drive pulse for the image sensing device in this operation mode, with V1, V2 and V3 representing three phase drive pulses applied to each gate of the CCD or vertical transfer unit 32.

In Figure 3, in a period T1 included in the vertical blanking period, the drive pulse V2 is held high to transfer the signal charge accumulated in each pixel to under the V2 gate of the vertical CCD. Next, in a period T2, while the V2 pulse is still at middle level, the V3 pulse is raised from low level to middle level; next, while the V3 pulse is at middle level, the V2 pulse is changed from middle level to low level, after which the V1 pulse is changed from low level to middle level; next, while the V1 pulse is at middle level, the V3 pulse is changed from middle level to low level, after which the V2 pulse is changed to middle level and finally the V1 pulse is changed from middle level to low level. With this sequence of pulse operations, the signal charges under the V2 gate for one pixel row are transferred and held again under the V2 gate.

By repeating this series of operations, the signal charges for a desired number of pixel rows can be transferred. In Figure 3, during a period T3 included in the vertical blanking period before the vertical effective

scanning period (the vertical scanning period minus the vertical blanking period which corresponds to the actually displayed image) and during a period T4 included in the vertical blanking period after the vertical effective scanning period, the above transfer operation for one pixel row is repeated a total of 240 times to transfer the signal charges of the 240 pixel rows not used for image generation to the horizontal transfer unit 33 during the vertical blanking period. For example, if this transfer operation is performed 120 times during the period T3 and 120 times during the period T4, the signal charges from upper 120 pixel rows and lower 120 pixel rows on the light receiving surface are transferred to the horizontal transfer unit 33 during the period T3 and period T4 within the vertical blanking period. During each of the subsequent periods T5 and T6 in the vertical blanking period, the horizontal transfer unit 33 is driven for a predetermined period to output the charges transferred to the horizontal transfer unit 33 from the output terminal. These charges are not used as valid signals as they are output during the vertical blanking period.

Next, in the vertical effective scanning period of Figure 3, the above one-pixel-row transfer operation is performed four times during each horizontal blanking period to transfer the signal charges of four pixel rows to the horizontal transfer unit 33 where they are mixed together. Then, during a horizontal effective scanning period (the horizontal scanning period minus the horizontal blanking

period which corresponds to the actually displayed image), the horizontal transfer unit 33 is driven to read out the signal charges from the horizontal transfer unit to produce an output signal conforming to the television system. If the above operation is performed on the A field and if, on the B field, the number of pixel rows transferred during the period T3 is set to 122 rows and that during the period T4 is set to 118 rows, then the combination of four pixel rows to be cyclically mixed together shifts by two rows between the two fields, thus allowing the interlaced scanning to be performed as shown in Figure 4. (Figure 4 shows the light receiving surface of the image sensing device and its relation to the displayed screen is vertically inverted.)

Let us return to Figure 1. The output signal from the image sensing device 3 is adjusted in gain by the gain adjust circuit 5 and then converted by the A/D conversion circuit 6 into a digital signal. The digital signal is then processed by the signal processing circuit 7 that performs color signal processing and luminance signal processing, such as generation of color signals, gamma correction, white balance processing and outline enhancement. The image sensing device in this embodiment has an array of vertical stripes of yellow (Ye), green (G) and cyan (Cy) color filters, so the color signals for Ye, G and Cy are obtained as a series of color points from one line of output signals at all times no matter how many pixels are vertically combined. From these color signals three

primary color signals R, G, B can be obtained from the following calculations.

$$R = Ye - G$$

$$B = Cy - G$$

$$G = G$$

The R, G and B signals undergoes the white balance processing and gamma correction processing in the signal processing circuit 7 and are then converted into color difference signals such as R-Y, B-Y or U and V. The luminance signals and the color difference signals are then entered through the vertical interpolation circuit 8 into the horizontal interpolation circuit 9. In this operation state the signals just pass through the vertical interpolation circuit 8 without being processed. The horizontal interpolation circuit 9 performs interpolation on the signals in the horizontal direction.

Figure 5 shows the light receiving surface of the image sensing device. As described above, in the operating state of this embodiment, the signals read out during the vertical effective scanning period correspond to an area having 960 of the 1200 vertically arranged pixels and a horizontal width of 1600 pixels, as shown shaded at A in Figure 5. If the entire light receiving surface of the image sensing device has a 4-to-3 (width to height) aspect ratio, the shaded area A is more laterally elongate than this aspect ratio. Hence, if the signals of all horizontal pixels of the light receiving surface are displayed, for example, on an NTSC standard television monitor with the

4-to-3 aspect ratio, the image displayed is compressed horizontally and looks vertically elongate, compared with the original image. It is therefore necessary to output during the horizontal effective scanning period only those signals coming from a pixel area with the horizontal width conforming to the aspect ratio of the television system, as shown by a shaded area B. When the television system has an 4-to-3 aspect ratio, the number of pixels in the horizontal width of the shaded area B is 1280 (= 960 (vertical effective pixels) × 4/3).

Returning back to Figure 1, the horizontal interpolation circuit 9 performs interpolation processing on the signals from the horizontal 1280 pixels to expand the signals so that they can be output over the entire horizontal effective scanning period. It also performs switching among different clocks as required. With the above operation, an area having 960 pixels in height and 1280 pixels in width is demarcated from the light receiving surface as signals conforming to the television system. Then, the luminance signal and the color difference signal are encoded by the encoder circuit 12 into television signals, which are then converted by the D/A conversion circuit 13 into analog signals for output. When the recording is specified by the record button 15, the signals are recorded by the recording unit 10. At this time, the signals may be compressed in the MPEG (Moving Picture Expert Group) format.

Next, the image stabilizing operation will be

explained. Image-unstability information obtained by the gyro sensors 16a, 16b that detect vertical and horizontal image-unstabilities is entered into the image-unstability decision circuit 17, which checks the received information for the amount and direction of the image-unstability and converts them into the number of pixels in vertical and horizontal directions on the light receiving surface of the image sensing device. Based on the converted pixel numbers, the position of an extracted area (effective pixel area) on the light receiving surface is shifted in a direction that cancels the image-unstability. This can correct the image-unstability. The positional shifting of the extracted area is performed as follows. The shifting in the vertical direction can be made by changing the number of pixel rows transferred during the periods T3 and T4 in Figure 3 and the shifting in the horizontal direction made by changing the interpolation start position in the horizontal interpolation circuit 9.

The operation during the moving video mode has been described above. Next, the operation performed when the static image mode is selected by the mode selector switch 14 will be explained.

In the static image mode, too, until the recording is requested by the record button 15, the camera outputs signals compatible with the television system to monitor the angle of view. Unlike the moving video photographing, all of the effective pixels on the image sensing device are used in this embodiment during the still image

photographing to produce signals with as high a resolution as possible. Hence, during the monitoring the television signals need to be generated from the signals coming from the entire pixel area.

The image sensing device of this embodiment has 1200 vertically arranged pixels, and the number of lines of output signals from the image sensing device can be made to match the number of effective scanning lines of NTSC system, which is assumed to have 240 scanning lines, by vertically mixing five pixels (= 1200/240). To make the image sensing device operate in this manner, the one-pixel-row transfer operation is performed five times during each horizontal blanking period in the vertical effective scanning period shown in the pulse timing diagram of Figure 3. With this operation, the signal charges of five pixel rows can be mixed by the horizontal transfer unit 33. As for the transfer operations during the periods T3 and T4 in the vertical blanking period, because the interlaced scanning is carried out, only two pixel rows are transferred during the period T3 on the B field, with no transfer operations performed in other vertical blanking periods (In this embodiment, 1200/240 = 5 with no remainder produced, so no further transfer is necessary; if, however, a remainder occurs, the remaining pixels need only be transferred during the periods T3 and T4).

The charges mixed by the horizontal transfer unit 33 are read out by driving the horizontal transfer unit 33 during the horizontal effective scanning period. With the

above operations, the signal charges of all pixels on the image sensing device can be read out in a manner conforming to the television system. The output signal from the image sensing device 3 is, as during the moving image photographing, adjusted in gain by the gain adjust circuit 5 and converted by the A/D conversion circuit 6 into a digital signal, which is then subjected to the color signal processing and the luminance signal processing in the signal processing circuit 7 before being entered into the vertical interpolation circuit 8. During the static image monitoring, the vertical interpolation circuit 8 performs a vertical gravity center correction on the received signals.

Figure 6 shows combinations of pixels to be cyclically mixed on the A field and the B field and also the vertical position of the gravity center of the mixed signals. In the interlaced scanning, scanning lines of the A field and the B field are located at the centers of adjoining scanning lines on other field. Hence, the signal samplings in the camera system for the two fields must be 180 degrees out of phase in the vertical direction. In the operating state of this embodiment, however, because five pixels are mixed together, the gravity centers of the output signals for the A field and the B field are deviated 36 degrees (= 1/2 pixel or 1/10 the line-to-line distance on the same field) from the ideal sampling phase difference of 180 degrees, as shown in Figure 6. To correct this requires generating a signal from two adjoining output lines by interpolation. For example, if we let an nth

output line on a field be Sn and an (n+1)th output line on the same field be Sn+1, then a signal Sn' obtained by calculating Sn'=(Sn × 9/10) + (Sn+1 × 1/10) is one whose gravity center is shifted by 1/10 output line from the gravity center of the nth output line toward the (n+1)th output line. The above calculation can also be performed on the signals for the B field to correct the gravity center deviation of sampling. In this embodiment, however, to equalize the effects of interpolation of the A field and the B field, the following calculations are performed to correct the nth output line by 1/20 line toward the (n-1) line on the A field and by 1/20 line toward the (n+1)th line on the B field.

A field: Sn' = (Sn × 19/20) + (Sn-1 × 1/20)

B field: Sn' = (Sn × 19/20) + (Sn+1 × 1/20)

While this embodiment performs the interpolation based on the calculation of two adjoining lines of output signals, a greater number of lines may be used for the interpolation processing. The output signal of the vertical interpolation circuit 8 is supplied to the horizontal interpolation circuit 9, which in this operating state does nothing but passes the signal. Then, as in the case of the moving image photographing, the signal is encoded by the encoder circuit 12 into a television signal, which is then converted by the D/A conversion circuit 13 into an analog signal for output. As described above, the television signals can be generated from all of the pixel area of the image sensing device also during the static

image mode.

Next, the operation performed when the recording is requested by the record button 15 will be described. During the monitoring in the static mode, the signals are mixed together inside the image sensing device to reduce the number of signals and thereby generate television signals. During recording, however, the mixing processing is not performed and all the pixel signals need to be read out independently of each other in order to produce high resolution signals. To realize this, the one-pixel-row transfer operation is performed only once during each horizontal blanking period in the vertical effective scanning period shown in the pulse timing diagram of Figure 3. This causes only the signal charges for one pixel row to be transferred into the horizontal transfer unit 33, which is then driven to read out the signal charges for one pixel row. Repeating this operation the number of times equal to the number of vertically arranged pixel rows enables the signal charges of all pixel rows to be read out independently of each other. The transfer operation is not done during the periods T3 and T4 in the vertical blanking period.

The signal charges thus read out are adjusted in gain by the gain adjust circuit 5 and converted by the A/D conversion circuit 6 into digital signals, which are then subjected to the color signal processing and the luminance signal processing in the signal processing circuit 7, after which the signals are supplied through the vertical inter-

polation circuit 8 and the horizontal interpolation circuit 9 to the recording unit 10 where they are recorded. At this time, no interpolation processing is performed by the vertical interpolation circuit 8 or horizontal interpolation circuit 9. The recording unit 10 may compress the signals in the JPEG (Joint Photographic Expert Group) format, for example. Because during the static image recording, no television signal can be generated, an image immediately before starting the recording or a single color image is output as the television signal for monitoring purpose. With the above operation, high resolution signals obtained from all the pixels of the image sensing device can be recorded. Although in this embodiment the recording unit is used commonly for the moving video mode and for the static image mode, dedicated recording units may be provided separately for these modes.

As explained above, since there is no limit on the number of vertically arranged pixels in this embodiment, an image sensing device with a large enough pixel number even for still images can be used to photograph highly detailed still images and satisfactory moving images.

Further, the signal mixing and the vertical signal transfer during the vertical blanking period allow the signals from the image sensing device with a large number of pixels to be read out in a manner that conforms to the television system. This in turn can reduce image quality degradation and realize the moving image photo-

graphing with an image stabilizing function and the monitoring during still image photographing.

Only the output signals from that horizontal segment which virtually corresponds to the television system's aspect ratio with respect to the vertical segment are extracted and output over the entire horizontal effective scanning period of the television system. This ensures that the output signals obtained conform to the television system's aspect ratio regardless of the extracted vertical segment position.

Further, the image sensing device is driven in such a way as to shift the position of the pixels to be cyclically mixed together every display cycle of the television system in order to output interlaced signals. With this arrangement, the interlaced scanning can be performed even when an image sensing device with a large number of pixels is used.

Further, the output signals produced by the mixing are interpolated so that the gravity centers of the output signals interlaced every display cycle have a phase difference of 180 degrees in the vertical direction. This ensures that the interlaced output signals have no deviation from the ideal 180-degree phase difference during interlacing even when an interlace phase deviation would normally occur, as when odd numbered pixels are mixed together.

In this embodiment, the image sensing device has 1200 vertically arranged pixels, and four pixels are mixed

together during the moving video mode and five pixels during the static image mode. Because the area of image-stabilization pixels may or may not be used and set to any desire size, the number of pixels to be cyclically mixed together in each mode needs only to be equal to or less than the integral part of a quotient of the number of vertically arranged pixels divided by the number of television system's effective scanning lines (in the above example, 5 or less). (The number of vertically arranged pixels does not need to be divisible and, in the above example, may be more than 1200).

The number of vertically arranged pixels for static image photographing needs only to be three or more times the number of effective scanning lines on each field of the television system. In this embodiment the vertically adjoining pixels are mixed together to reduce the number of output lines from the image sensing device during the vertical effective scanning period. The number of lines of output signals can also be reduced by a so-called culling operation, by which only one line of signal charges of pixels is read out for every predetermined number of lines.

While in this embodiment the vertical transfer unit of the image sensing device is formed as a CCD that is driven by three phase pulses for each pixel, the image sensing device may have any desired structure as long as it can realize the mixing or culling of pixels that meets the above conditions.

Although this embodiment described the case of NTSC system, the invention can also be applied to other television systems, such as PAL standard, with different numbers of effective scanning lines.

In summary, a variety of constructions essentially equal in the working principle to this embodiment can be realized by the use of an image sensing device that has an arbitrary number of vertically arranged pixels N three or more times the number of effective scanning lines M of each field of the television system and which allows the vertical mixing or culling of that number of pixels which is at least one of integers equal to or less than the integral part of a quotient of N divided by M (a number of lines of output signals corresponds to 1/K the number of vertically arranged pixels N of the image sensing device).

Next, another embodiment of the present invention will be described by referring to Figure 7 showing the configuration of the embodiment. The configuration shown in Figure 7 differs from that of Figure 1 in that it has a view angle change switch 18. In Figure 7 constitutional elements identical with those shown in Figure 1 are assigned like reference numbers and explanations on the constitutional elements performing the same operations as those in Figure 1 are omitted here.

The operations of the moving video mode, the monitoring during the static image mode and the static image recording are similar in normal condition to the operations of the previous embodiment which was explained with reference to the configuration diagram of Figure 1. An operation performed when during the moving video mode a

request to change the angle of view is made by the view angle change switch 18 will be described.

In the normal condition of this embodiment, as explained in the previous embodiment, the mixing of four vertically arranged pixels, the vertical transfer during the vertical blanking period and the horizontal interpolation processing are performed to extract an area of 960 pixels in height and 1280 pixels in width from the entire pixel area to generate television signals. When a view angle change (which means a zooming function without image quality degradations in the vertical direction) is requested by the view angle change switch 18, three vertically arranged pixels are mixed together and the signals from the excess vertically arranged pixels are read out during the vertical blanking periods before and after the vertical effective scanning period.

In this embodiment, signals of 480 pixels (= 1200 - 240×3) or 160 lines of output signals after mixing (= 480/3) need to be read out during the vertical blanking period. This allows the signals of 720 vertically arranged pixels to be read out as 240 lines of output signals conforming to the television system. To carry out this reading requires, in the pulse timing diagram of Figure 3, transferring the signals of three pixel rows during each horizontal blanking period in the vertical effective scanning period and also transferring a total of 480 pixel rows (= 160 lines of output signals) during the T3 and T4 periods in the vertical blanking period. The combinations

of pixels to be cyclically mixed together are changed from one field to another to achieve the interlaced scanning.

The output signals of the image sensing device 3 are supplied to the gain adjust circuit 5. Because the signal level produced as a result of the 3-pixel mixing is 3/4 the signal level of the 4-pixel mixing, the again of the gain adjust circuit 5 is increased to 4/3 the gain of the 4-pixel mixing to make the 3- and 4-pixel-mixed input signal levels to the subsequent circuit equal. Then, the signals are processed by the A/D conversion circuit 6 and the signal processing circuit 7 before being supplied to the vertical interpolation circuit 8. The combinations of pixels to be cyclically mixed on the A field and the B field and the vertical positions of the gravity centers of the mixed signals are shown in Figure 8. As in the static image monitoring of the previous embodiment, the phase difference between the two fields is 180 degrees. Because the sampling phases of the fields are deviated from the ideal 180-degree phase difference, the vertical position of the gravity centers are corrected by the vertical interpolation circuit 8. The amount of phase deviation in this operating state is 60 degrees (= 1/2 pixel or 1/6 the line-to-line distance on the same field). To correct the phase deviation evenly on the both fields, the following calculations should be performed.

A field: $Sn' = (Sn \times 11/12) + (Sn-1 \times 1/12)$

B field: $Sn' = (Sn \times 11/12) + (Sn+1 \times 1/12)$

As described earlier, the interpolation process-

ing may use three or more output lines. Next, the horizontal interpolation circuit 9 horizontally expands the signals from that horizontal segment which corresponds to the 4-to-3 aspect ratio with respect to the 720 vertically arranged pixels (i.e., signals from a horizontal 960-pixel segment (=1600 × 720/1200) in this operating state) so that the expanded signals can be output during the entire horizontal effective scanning period. With the above operation, an area of 720 pixels in height and 960 pixels in width can be extracted from the light receiving surface.

Next, when the view angle change is requested again by the view angle change switch 18, two vertically arranged pixels are mixed together, an area of 480 vertically arranged pixels is read out during the vertical effective scanning period, and the horizontal interpolation circuit 9 expands the signals from the horizontal 640-pixel segment and outputs the expanded signals during the entire horizontal effective scanning period to extract an area of 480 pixels in height and 640 pixels in width. (During the two-pixel mixing, because the interlace phase deviation does not occur, the gravity center position correction by the vertical interpolation circuit 8 is not performed.) If a further view angle change is requested by the view angle change switch 18, the operation is restored to a normal state where four vertically arranged pixels are mixed together.

As a result of the above operation, the area extracted from the light receiving surface of the image

sensing device can be changed to three different areas: (A) 960 pixels high by 1280 pixels wide, (B) 720 pixels high by 960 pixels wide and (C) 4880 pixels high by 640 pixels wide. That is, the angle of view can be changed to three different angles. With the area A produced by the 4-pixel mixing taken as a reference, the area B produced by the 3-pixel mixing can provide an image enlarged by 1.33 times and the area C produced by the 2-pixel mixing can provide an image enlarged by two times. It should be noted here that because the three different areas are chosen by changing the number of pixel to be cyclically mixed together in order to make the number of the effective output lines from the imaging device agree with the number of the effective scanning lines of the television system, the angle of view can be changed while maintaining a good image with no image quality degradation in the vertical direction, when compared with an ordinary so-called digital zoom which generates effective scanning lines of signals by interpolating a small number of output lines. During the monitoring of a static image, too, it is possible to perform the similar operation of changing the angle of view by changing the number of pixel rows to be cyclically mixed together.

As described above, in addition to the advantages provided by the previous embodiment, this embodiment can also realize the view angle change with little image quality degradation even for still images by using an image sensing device with a large number of pixels and changing

the number of pixels to be cyclically mixed together.

Further, because changes in signal level caused when the number of pixels to be cyclically mixed is changed are absorbed by the gain adjust means, the input signal level to the subsequent signal processing means can be kept constant.

While in this embodiment, the view angle change is performed by the view angle change switch 18, the angle of view may be changed continuously by a zoom switch. In this case, when the magnification factor does not reach the value that is obtained by changing the pixel mixing, the digital zoom performs the ordinary interpolation processing. In this embodiment, when the magnification factor is 1 or more and less than 1.33, the 4-pixel mixing is performed; for the factor of 1.33 or more and less than 2, the 3-pixel mixing is done; and for the factor of 2 or higher, the 2-pixel mixing is carried out. The mixing operation may be interlocked with an optical zooming mechanism.

Regardless of the number of pixels in the image sensing device, the structure of the image sensing device or the television system employed, this embodiment, as in the previous embodiment, may also use an image sensing device that has an arbitrary number of vertically arranged pixels N three or more times the number of effective scanning lines M of each field and which allows the vertical mixing or culling of those numbers of pixels which are at least two of integers equal to or less than the integral

part of a quotient of N divided by M. The use of this image sensing device can form a variety of constructions essentially equal in the working principle to this embodiment.

Next, a further embodiment of the present invention will be described. The overall configuration of this embodiment is similar to that of Figure 1, except that the inner structure of the image sensing device 3 is different. The configuration of the image sensing device in this embodiment is shown in Figure 10. In Figure 10, denoted 30 are pixels formed of photodiodes, which are arranged horizontally and vertically in a grid pattern. On these grid-arrayed pixels three types of color filters that pass yellow (Ye), green (G) and cyan (Cy), respectively, are arranged in so-called vertical stripes.

In this embodiment, the image sensing device has an array of pixels measuring 864 pixels vertically and 1152 pixels horizontally. A vertical transfer unit 32 is a CCD which is driven by six phase pulses V1, V2, V3, V4, V5, V6. This CCD has a two-gate structure in which each pixel corresponds to two phase pulses and six gates corresponding to the six phase pulses are repeated for every three pixels. Transfer gates 31 for transferring the signal charge of each pixel to the vertical transfer unit 32 are commonly connected to respective gates of the vertical transfer unit 32 corresponding to the pulses V1, V3, V5. An operation to transfer the signal charge from each pixel to the vertical transfer unit 32 in response to peak values

of pulses applied to the commonly connected gates and an operation to transfer the charge vertically are performed separately.

A horizontal transfer unit 33 horizontally transfers the charges supplied from the vertical transfer units 32 and outputs them successively through an output amplifier 34 from the output terminal. This image sensing device, unlike the one in the previous embodiment, cannot vertically transfer all pixels independently of each other, but can mix together the signal charges of three vertically adjoining pixels inside the vertical transfer unit 32 before transferring them.

First, the operation performed in this embodiment during the moving video mode will be explained. In the image sensing device of this embodiment the effective number of vertically arranged pixels is 864. If three pixels are vertically mixed, the signals of the 720 (=240×3) of the 864 vertically arranged pixels can be used as the effective signals and the remaining 144 (= 864 - 720) pixels can be used as the image-unstability correction pixel area.

Figure 11 shows the timings of vertical drive pulses for the image sensing device of Figure 10 during this operation mode, with V1, V2, V3, V4, V5, V6 representing the six phase drive pulses applied to the respective gates of the CCD or vertical transfer unit 32. In Figure 11, during a period T1 included in the vertical blanking period, the drive pulses V1, V3 and V5 are held high to

cause the signal charge of each pixel to be transferred to under the V1, V3 and V5 gates of the vertical CCD. Then, the V2 and V4 pulses are changed from low level to middle level to mix the charges of the adjoining three pixels. After the mixing, the V5 pulse is changed from middle level to low level to hold the mixed signal charges under the V1, V2, V3, V4 gates.

Next, a series of operations performed during a period T2 (changing the drive pulses from middle level to low level or from low level to middle level in the order of V1, V2, V3, V4, V5 and V6) causes one mixed output line (3 pixel rows) to be transferred and held again under the V1, V2, V3, V4 gate. By repeating this series of operations, a desired number of output lines of mixed signal charges can be transferred.

In Figure 11, during a period T3 included in the vertical blanking period before the vertical effective scanning period and during a period T4 included in the vertical blanking period after the vertical effective scanning period, the transfer operation for one output line is repeated a total of 144 times to transfer 144 output lines of signal charges not used for image forming to the horizontal transfer unit 33 at high speed during the vertical blanking periods. During subsequent periods T5 and T6 in the vertical blanking periods, the horizontal transfer unit 33 is driven for predetermined periods to output the signal charges transferred to the horizontal transfer unit 33 from the output terminal.

Next, in the vertical effective scanning period of Figure 11, the one-output-signal-line transfer operation is performed during each horizontal blanking period. Then, during the horizontal effective scanning period, the horizontal transfer unit 33 is driven to read out the signal charges from the horizontal transfer unit 33. With this operation the signal charges of three pixels mixed together can be read out in a way conforming to the television system. As shown in Figure 11, the signals for the A field are mixed by changing the V2 and V4 pulses to middle level after transferring the signals from the pixels to the vertical transfer unit 32. The signals for the B field, on the other hand, are mixed by changing the V2 and V6 pulses to middle level. With this mixing method, the combinations of pixels to be cyclically mixed together can be changed from one field to another, thereby realizing the interlaced scanning. The output signals from the image sensing device are processed in the similar manner to that of the previous embodiment. A vertical interpolation circuit 8 performs the gravity center correction, as in the 3-pixel mixing in the previous embodiment, and a horizontal interpolation circuit 9 performs interpolation processing to match the aspect ratio with that of the television system.

Next, the operation during the monitoring in the static image mode will be explained. It is assumed that the still image photographing is done by using all effective pixels of the image sensing device, as in the previous

embodiment. The image sensing device of this embodiment has 864 vertically arranged pixels and, when 3-pixel mixing is done as in the moving video taking, the number of output lines is 288 (=864/3), which means that these signal lines cannot be read out in a manner conforming to the television system. Hence, during the monitoring in the static image mode, vertical 6-pixel mixing is performed. The 6-pixel mixing can be achieved by transferring to the horizontal transfer unit 33 in each horizontal blanking period two output lines of signal charges each of which line has been generated by vertically mixing three pixels within the vertical transfer unit 32. The 6-pixel mixing can reduce the number of output lines from the image sensing device down to 144 (= 864/6) lines. The output signals of the image sensing device that were reduced to 144 output lines are interpolated by the vertical interpolation circuit 8 to transform the 144 output lines of signals into 240 lines of signals, which conform to the television system. To generate 240 lines of signals from the 144 lines requires interpolation processing that generates five lines from three lines (144/240 = 3/5).

Figure 12 shows how the interpolation is performed using two adjoining output lines. Let three output lines of the image sensing device be n, n+1 and n+2. The five output lines of signals can be generated from the following calculations.

$$n' = n$$

$$n' + 1 = n/2 + (n+1)/2$$

$$n' + 2 = n + 1$$

$$n' + 3 = (n+1)/2 + (n+2)/2$$

$$n' + 4 = n + 2$$

Three or more output lines of signals may be used for interpolation processing. With the above operation, television signals can be generated by using signals of all pixels of the image sensing device also during the monitoring in the static image mode.

Next, the operation performed when the recording is requested by the record button 15 will be explained. In the recording process, the mixing processing is not performed and signals of all pixels need to be read independently of each other in order to obtain high-resolution signals. To realize this, the aperture 2 is first closed and then, during the period T2 in the pulse timing diagram of Figure 11, only the V1 pulse is raised to high level to transfer the signal charge of only the pixel adjacent to the V1 gate to the vertical transfer unit 32. Then, the vertical transfer unit 32 and the horizontal transfer unit 33 are successively driven to read out the signal charges. Similarly, the V3 pulse is raised to high level to read the signal charge of the pixel adjacent to the V3 gate, followed by raising the V5 pulse to high level to read the signal charge of the pixel adjacent to the V5 gate. With the above processing, the signal charges of all pixels can be read out independently in three successive operations. The signal charges thus read out are recorded in the recording unit 10. At this time, they are

rearranged properly to reconstruct the pixel arrangement on the light receiving surface of the image sensing device.

As described above, this embodiment offers the following advantages. If the number of vertically arranged pixels is not an integral multiple of the number of scanning lines of the television system, the signals conforming to the television system can be generated from the whole area of effective pixels by performing the pixel mixing and the vertical interpolation.

In this embodiment, as in the previous embodiment, regardless of the number of pixels in the image sensing device, the structure of the image sensing device or the television system employed, a variety of constructions essentially equal in the working principle to this embodiment can be realized by using an image sensing device that has an arbitrary number of vertically arranged pixels N three or more times the number of effective scanning lines M of each field and which allows the vertical mixing or culling of that number of pixels which is greater by at least one than the integral part of a quotient of N divided by M.

Next, a further embodiment of the present invention will be explained. This embodiment differs from the previous embodiments in that the image sensing device have different arrangements of color filters. Figures 13A and 13B show arrangements of color filters in this embodiment. These color filters in both examples are arranged in vertical stripes and, regardless of the number of pixels to

be vertically mixed or culled, the R, G, B primary color signals can be generated from one line of output signals. Figure 13A shows a color filter arrangement on the image sensing device in which white filters (W = passing all colors) are used instead of the green (G) filters used in the previous embodiment. The R, G, B signals can be obtained by the following calculations.

$$R = W - Cy$$

$$G = Ye + Cy - W$$

$$B = W - Ye$$

When this color filter arrangement is used, a higher sensitivity can be obtained than the color filter arrangement of the previous embodiment. Figure 13B show a color filter arrangement that uses, in stead of complementary colors, color filters that pass the primary colors R, G, B. This color filter arrangement can directly produce the primary color signals, R, G, B and can provide a camera with good color purity and good color S/N.

With the above color filter arrangements, it is possible to produce color signals corresponding to the three kinds of color filters from each line of output signals at all times no matter how many pixels are vertically mixed or culled. Therefore, color signals conforming to the television system can be generated easily.

CLAIMS

1. A camera comprising:

an image sensor having an array of pixels arranged vertically and horizontally in a grid pattern;

a processor to form image signals with one or more predetermined view angles by using pixels of the image sensor in a static image mode and a moving video mode, the processor configured to:

form image signals by using a first set of pixels of the image sensor corresponding to a first view angle during recording in the static image mode; and

form image signals by using a second set of pixels of the image sensor corresponding to a second view angle recording in the moving video mode, wherein the second view angle is different from the first view angle;

an image-instability detector configured to detect an amount of image-instability of the camera and configured to change a position of the second set of pixels to account for image-instability detected by the image-instability detector; and

a display configured to;

display a still image corresponding to image signals formed based on the first set of pixels; and

display a moving image corresponding to image signals formed based on the second set of pixels.

2. The camera according to claim 1,

wherein the position of the second set of pixels is changed to perform instability correction caused by vertical movement of the camera.

3. The camera according to claim 1,

wherein the position of the second set of pixels is changed to perform instability correction caused by horizontal movement of the camera.

4. The camera according to claim 1,

wherein the position of the second set of pixels is changed to perform instability correction caused by vertical and horizontal movement of the camera.

5. The camera according to claim 1,

wherein the processor is further configured to perform white balance processing on one or more of the first or second set of pixels.

6. The camera according to claim 1,

wherein the processor is further configured to perform luminance signal processing on one or more of the first or second set of pixels.

7. The camera according to claim 1,

wherein the processor is further configured to perform color signal processing on one or more of the first or second set of pixels.

8. The camera according to claim 1, further comprising

an interpolator for performing interpolation operations on one or more of the first or second set of pixels.

9. The camera according to claim 1, further comprising

an encoder for encoding the still image with a first encoding format and for encoding the moving image with a second encoding format, wherein the first encoding format is different from the second encoding format.

10. The camera according to claim 1, further comprising

a memory for recording the still image after it is encoded by a first encoding method and for recording the moving image after it is encoded by a second encoding method that is different from the first encoding method.

11. An operating method for a camera comprising:

receiving light with an image sensor having an array of pixels arranged vertically and horizontally in a grid pattern;

forming image signals with one or more predetermined view angles by using pixels of the image sensor in a static image mode and a moving video mode, including:

forming image signals by using a first set of pixels of the image sensor corresponding to a first view angle during recording in the static image mode; and

forming image signals by using a second set of pixels of the image sensor corresponding to a second view angle recording in the moving video mode, wherein the second view angle is different from the first view angle;

detecting an amount of image-instability of the camera and changing a position of the second set of pixels to account for image-instability that is detected;

displaying a still image corresponding to image signals formed based on the first set of pixels; and

displaying a moving image corresponding to image signals formed based on the second set of pixels.

12. The method according to claim 1,

wherein in the changing a position of the second set of pixels, the position of the second set of pixels is changed to perform instability correction caused by vertical movement of the camera.

13. The method according to claim 1,

wherein in the changing a position of the second set of pixels, the position of the second set of pixels is changed to perform instability correction caused by horizontal movement of the camera.

14. The method according to claim 1,

wherein in the changing a position of the second set of pixels, the position of the second set of pixels is changed to perform instability correction caused by vertical and horizontal movement of the camera.

15. The method according to claim 1, further including

performing white balance processing on one or more of the first or second set of pixels.

16. The method according to claim 1,further including

performing luminance signal processing on one or more of the first or second set of pixels.

17. The method according to claim 1, further including

performing color signal processing on one or more of the first or second set of pixels.

18. The method according to claim 1, further including

performing interpolation operations on one or more of the first or second set of pixels.

19. The method according to claim 1, further including

an encoder for encoding the still image with a first encoding format and for encoding the moving image with a second encoding format, wherein the first encoding format is different from the second encoding format.

20. The method according to claim 1, further including

recording the still image after it is encoded by a first encoding step and recording the moving image after it is encoded by a second encoding step that is different from the first encoding step.

ABSTRACT OF THE DISCLOSURE:

An electric camera includes an image sensing device with a light receiving surface having N vertically arranged pixels and an arbitrary number of pixels arranged horizontally, N being equal to or more than three times the number of effective scanning lines M of a display screen of a television system, a driver to drive the image sensing device to vertically mix or cull signal charges accumulated in individual pixels of K pixels to produce, during a vertical effective scanning period of the television system, a number of lines of output signals which corresponds to 1/K the number of vertically arranged pixels N of the image sensing device, K being an integer equal to or less than an integral part of a quotient of N divided by M, and a signal processing unit having a function of generating image signals by using the output signals of the image sensing device.

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申請データシート(37 CFR 1.76)を使った実用及び意匠登録出願宣言書(37 CFR 1.63)

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

発明の名称 Title of Invention	ELECTRIC CAMERA

下記発明者である私は、つぎのことがらを宣言します。

As the below named inventor, I hereby declare that:

本宣言は

This declaration is directed to:

☐ 添付されている、あるいは

The attached application, or

_____に、米国出願あるいは PCT 国際出願番号_____として出願されているものに宛てられています。

☒ United States application or PCT international application number 13/681495 fled on November 20, 2012 .

上記の出願は私自身、あるいは私が権限を譲与したものによって行われたものです。

The above-identified application was made or authorized to be made by me.

私は本出願書中にあらわれるもともとの発明者、あるいはもともとの共同発明者です。

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

私は本宣言書において故意に虚偽の申し立てを行った場合は 18 U.S.C. 1001 により、罰金あるいは最高五(5)年の禁固刑、あるいはその両方による罰則の対象となることを認めます。

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

私は、特許請求の範囲を含む上記の明細書を確認し内容を理解しています。

I have reviewed and understand the contents of the above-identified application, including the claims.

私は、連邦規則法典第 37 編規則 1.56 に定義されている、特許性について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

発明者の正式氏名:
LEGAL NAME OF INVENTOR: Takahiro NAKANO

署名:
Signature: Takahiro Nakano

日付(任意):
Date (Optional): Dec. 17, 2012

備考:出願データシート(PTO/AIA/14 あるいはその同等用紙)は、発明の自主独立体全体の命名を含め、本用紙に添付すること。なお残余の発明者ごとにこの用紙の写しを使用する。

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional copy of the present form for each additional inventor.

E 5037-05

申請データシート(37 CFR 1.76)を使った実用及び意匠登録出願宣言書(37 CFR 1.63)

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

発明の名称 Title of Invention	ELECTRIC CAMERA

下記発明者である私は、つぎのことがらを宣言します。
As the below named inventor, I hereby declare that:

本宣言は
This declaration is directed to:

☐ 添付されている、あるいは
The attached application, or

_____に、米国出願あるいは PCT 国際出願番号_____として出願されているものに宛てられています。

☒ United States application or PCT international application number 13/681495 filed on November 20, 2012 .

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I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

発明者の正式氏名:
LEGAL NAME OF INVENTOR: Ryuji NISHIMURA

署名:
Signature: Ryuji Nishimura

日付(任意):
Date (Optional): Dec. 18 / 2012

備考:出願データシート(PTO/AIA/14 あるいはその同等用紙)は、発明の自主独立体全体の命名を含め、本用紙に添付すること。なお残余の発明者ごとにこの用紙の写しを使用する。
Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional copy of the present form for each additional inventor.

F5037-05

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本宣言は
This declaration is directed to:

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The attached application, or

_____に、米国出願あるいは PCT 国際出願番号_____として出願されているものに宛てられています。

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I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

発明者の正式氏名:
LEGAL NAME OF INVENTOR: Toshiro KINUGASA

署名:
Signature: Toshiro Kinugasa

日付(任意):
Date (Optional): 12/19/12

備考:出願データシート(PTO/AIA/14 あるいはその同等用紙)は、発明の自主独立体全体の命名を含め、本用紙に添付すること。なお残余の発明者ごとにこの用紙の写しを使用する。
Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional copy of the present form for each additional inventor.

CERTIFICATE OF TRANSLATION

I, the below-named translator, of 6-6, Marunouchi 1-chome, Chiyoda-ku, Tokyo, Japan hereby declare that I am conversant with the Japanese and English languages and that to the best of my knowledge and belief the attached Declaration includes a true and accurate translation into English of the Japanese text contained in the Declaration.

Dated July 17, 2014 Signature of Translator: Takeshi Kanai

FIG.1

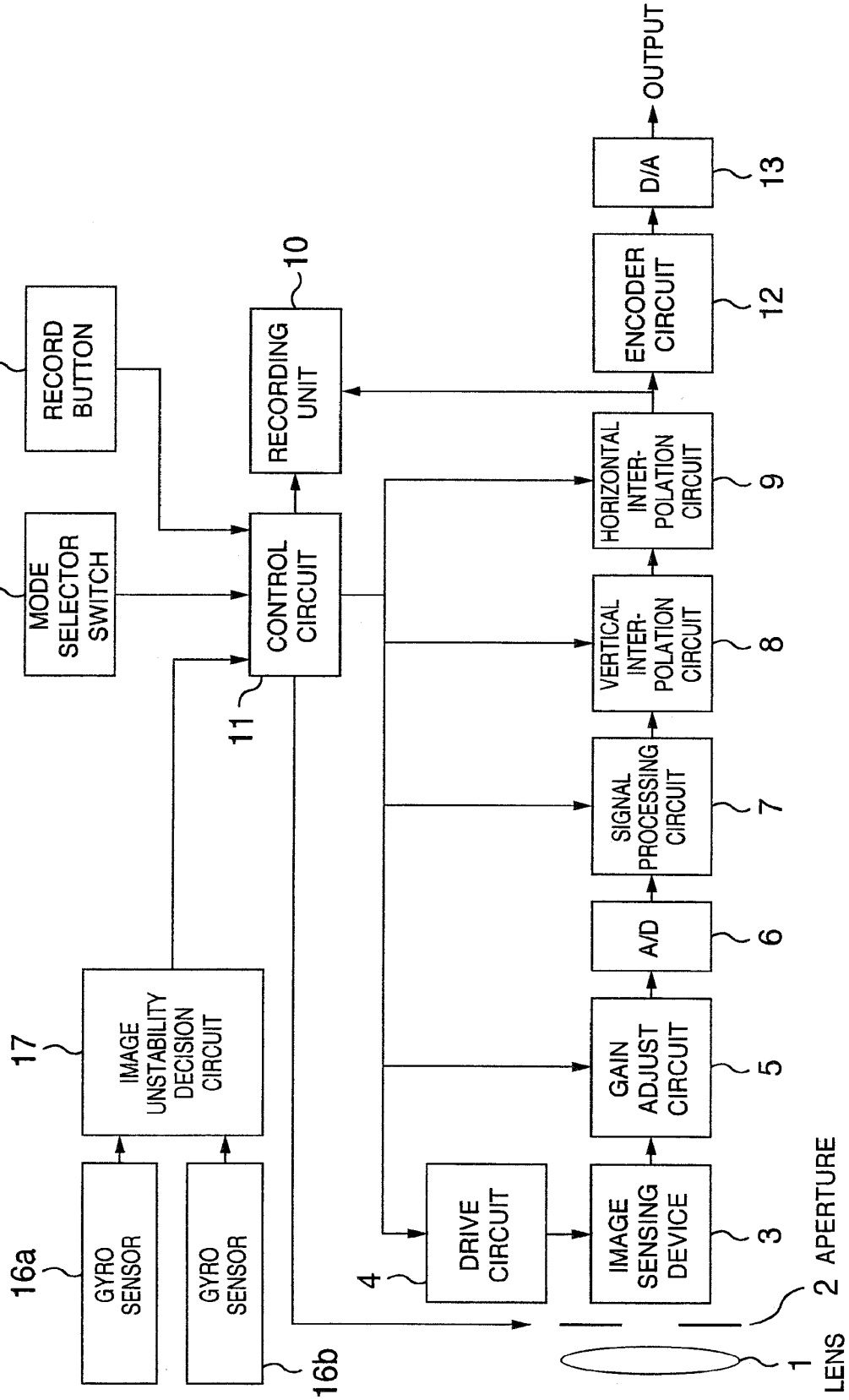

LENS
1
APERTURE
2
IMAGE SENSING DEVICE
3
DRIVE CIRCUIT
4
GAIN ADJUST CIRCUIT
5
A/D
6
SIGNAL PROCESSING CIRCUIT
7
VERTICAL INTER-POLATION CIRCUIT
8
HORIZONTAL INTER-POLATION CIRCUIT
9
RECORDING UNIT
10
CONTROL CIRCUIT
11
ENCODER CIRCUIT
12
D/A
13
OUTPUT
RECORD BUTTON
15
MODE SELECTOR SWITCH
14
IMAGE UNSTABILITY DECISION CIRCUIT
17
GYRO SENSOR
16a
GYRO SENSOR
16b

FIG.2

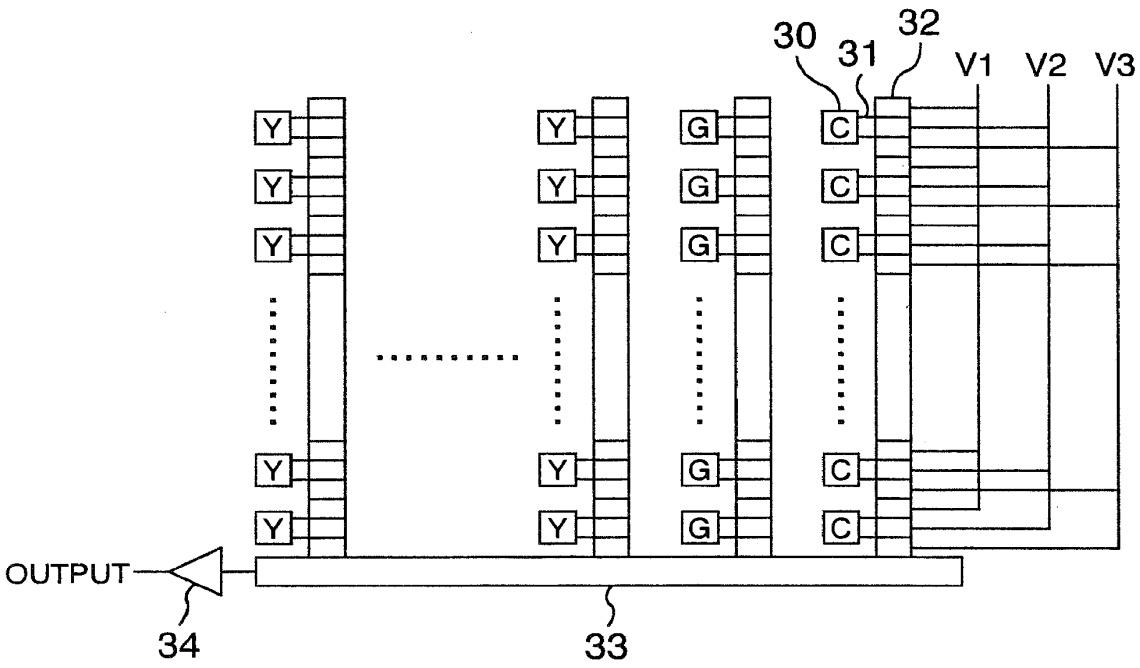

30
31
32
V1
V2
V3
Y
G
C
OUTPUT
34
33

FIG.4

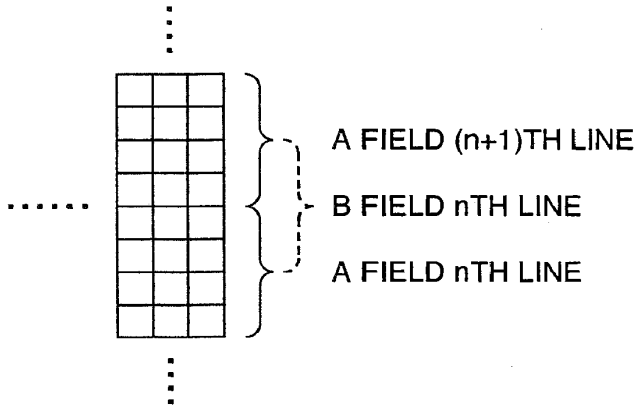

A FIELD (n+1)TH LINE
B FIELD nTH LINE
A FIELD nTH LINE

FIG.3

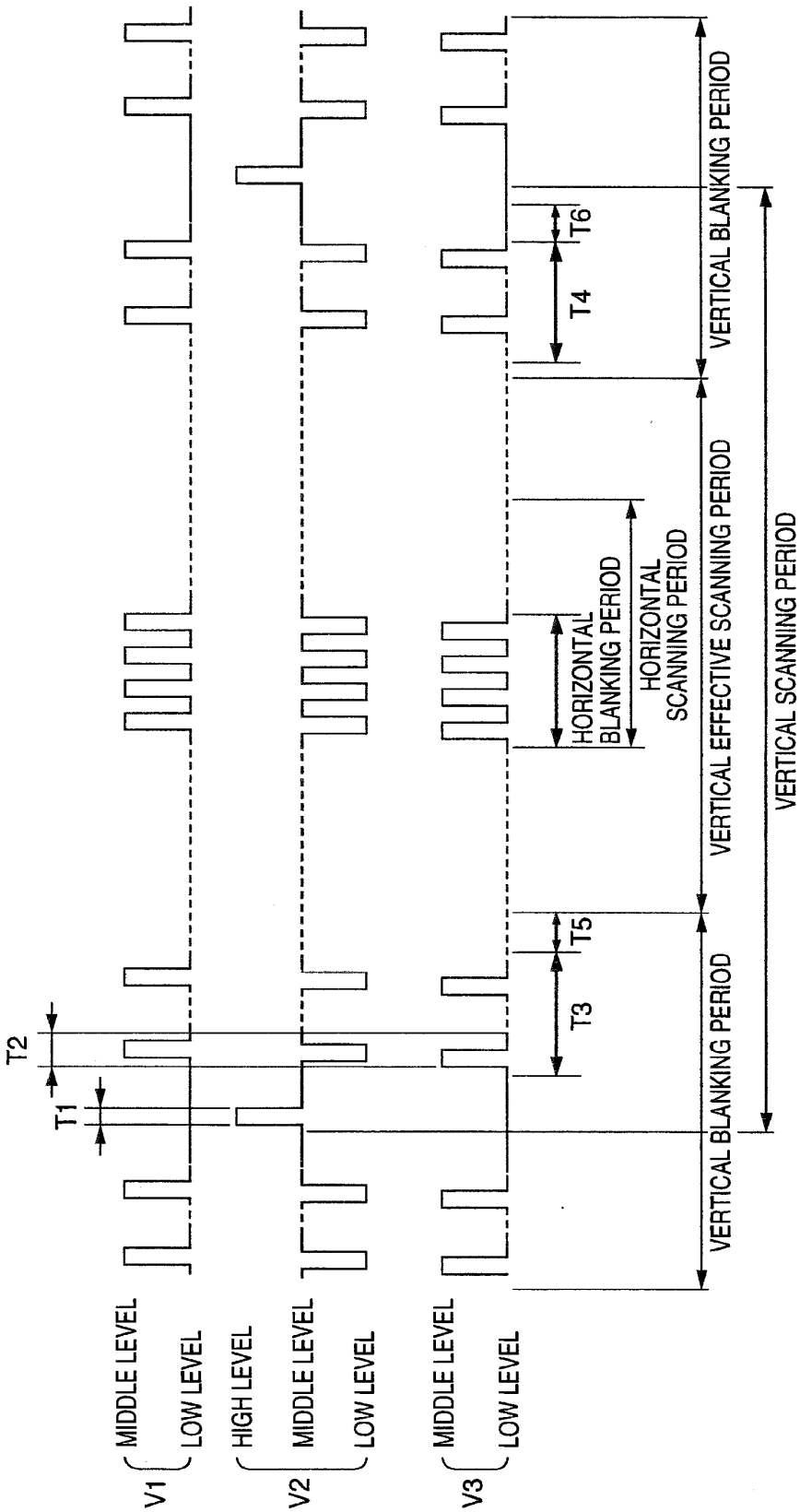

V1
MIDDLE LEVEL
LOW LEVEL
V2
HIGH LEVEL
MIDDLE LEVEL
LOW LEVEL
V3
MIDDLE LEVEL
LOW LEVEL
T1
T2
T3
T4
T5
T6
HORIZONTAL BLANKING PERIOD
HORIZONTAL SCANNING PERIOD
VERTICAL BLANKING PERIOD
VERTICAL EFFECTIVE SCANNING PERIOD
VERTICAL BLANKING PERIOD
VERTICAL SCANNING PERIOD

FIG.5

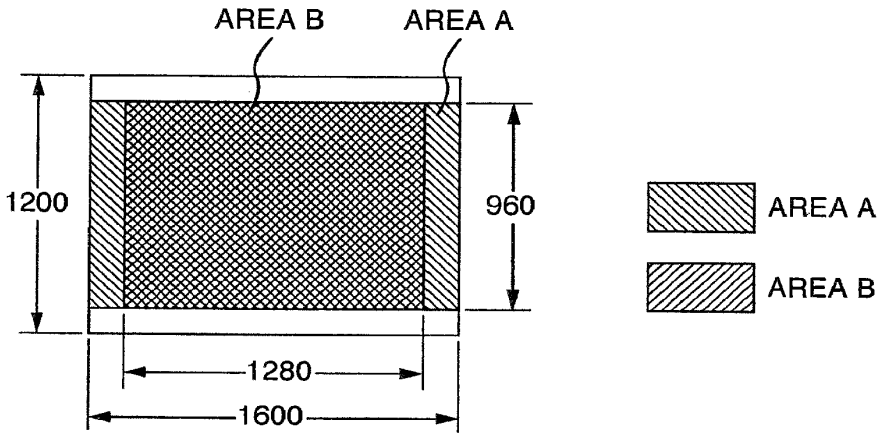

AREA B
AREA A
1200
960
1280
1600
AREA A
AREA B

FIG.6

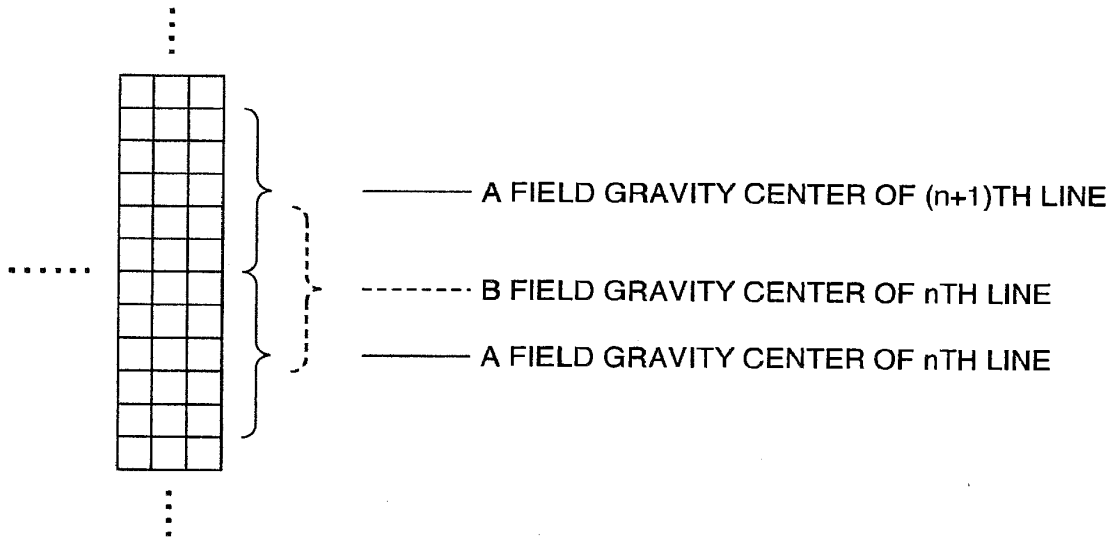

A FIELD GRAVITY CENTER OF (n+1)TH LINE
B FIELD GRAVITY CENTER OF nTH LINE
A FIELD GRAVITY CENTER OF nTH LINE

FIG.7

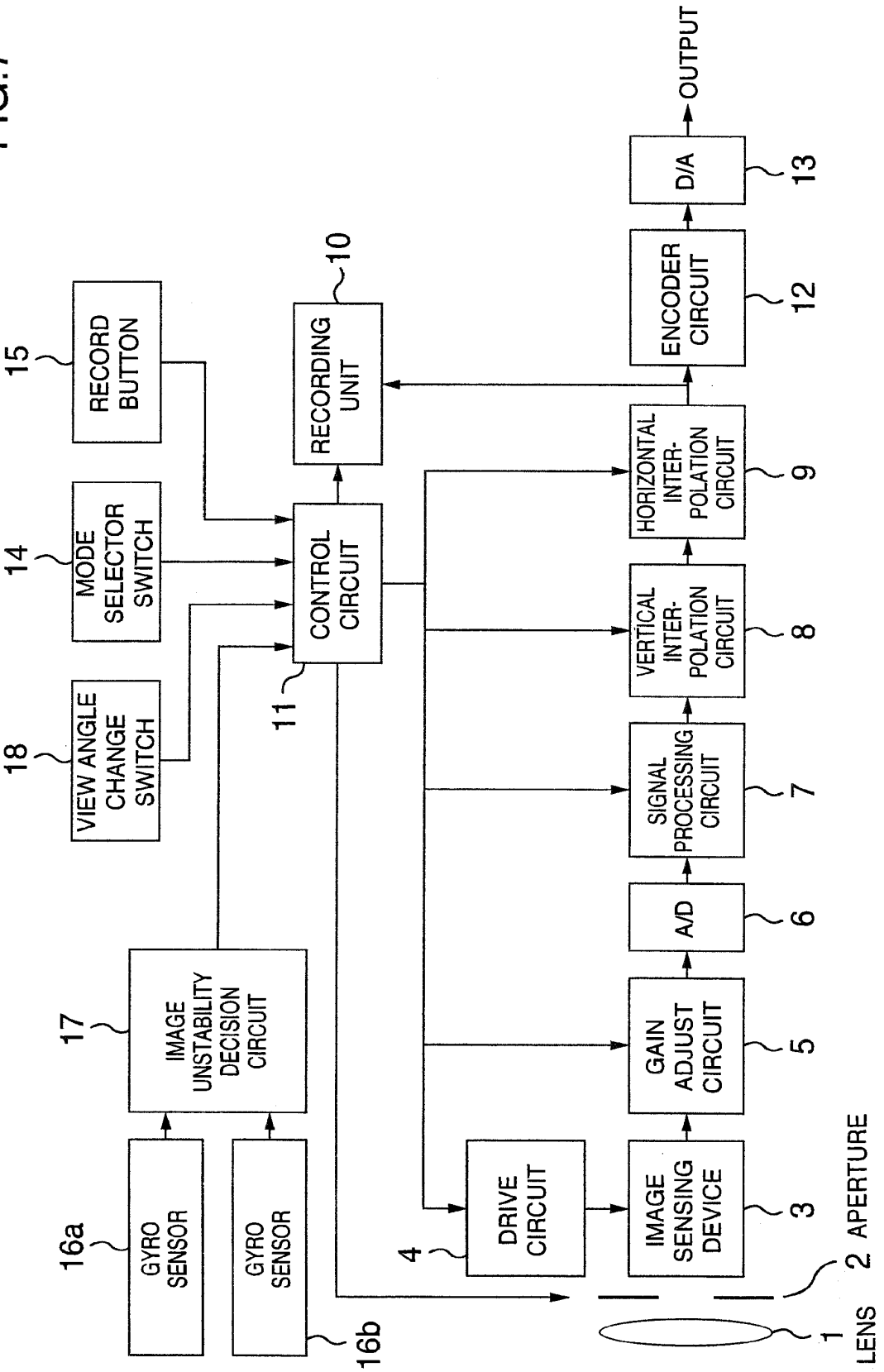

LENS
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APERTURE
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DRIVE CIRCUIT
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ENCODER CIRCUIT
12
D/A
13
OUTPUT
RECORD BUTTON
15
MODE SELECTOR SWITCH
14
VIEW ANGLE CHANGE SWITCH
18
IMAGE UNSTABILITY DECISION CIRCUIT
17
GYRO SENSOR
16a
GYRO SENSOR
16b

FIG.8

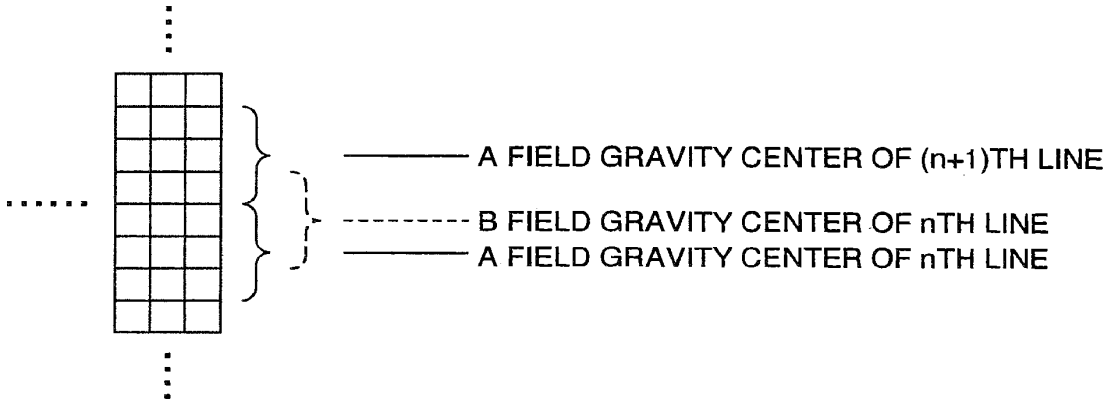

A FIELD GRAVITY CENTER OF (n+1)TH LINE
B FIELD GRAVITY CENTER OF nTH LINE
A FIELD GRAVITY CENTER OF nTH LINE

FIG.9

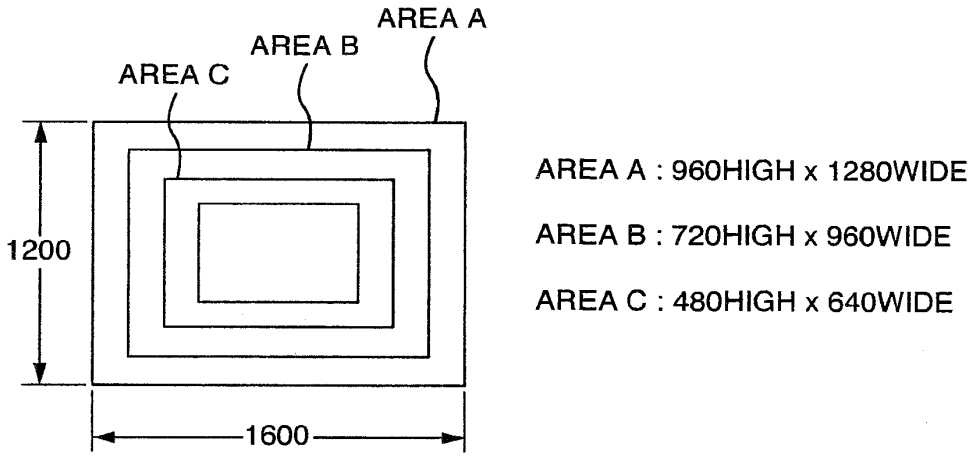

AREA A
AREA B
AREA C
1200
1600
AREA A : 960HIGH x 1280WIDE
AREA B : 720HIGH x 960WIDE
AREA C : 480HIGH x 640WIDE

FIG.10

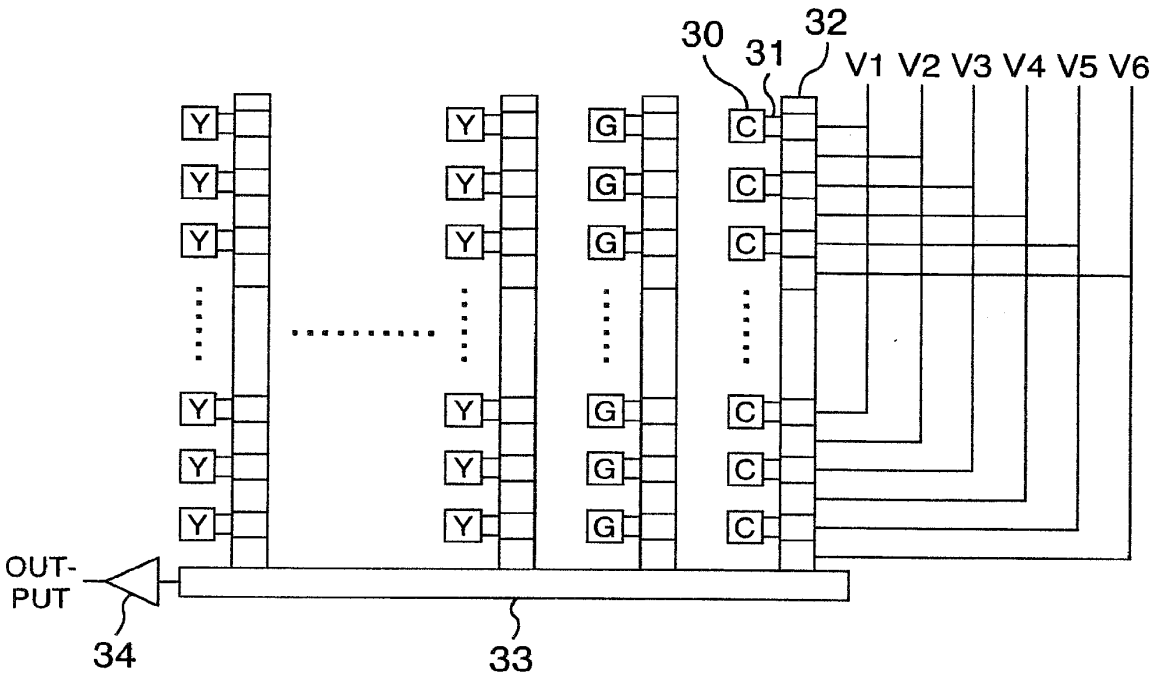


FIG.12

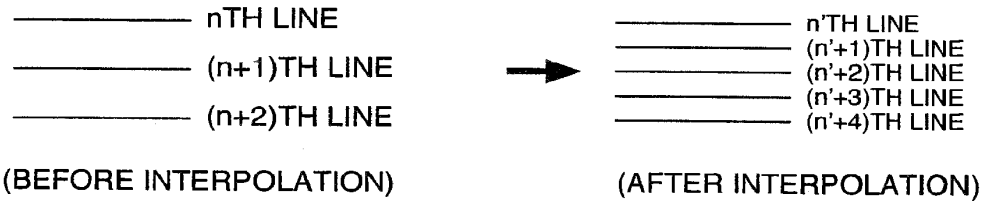


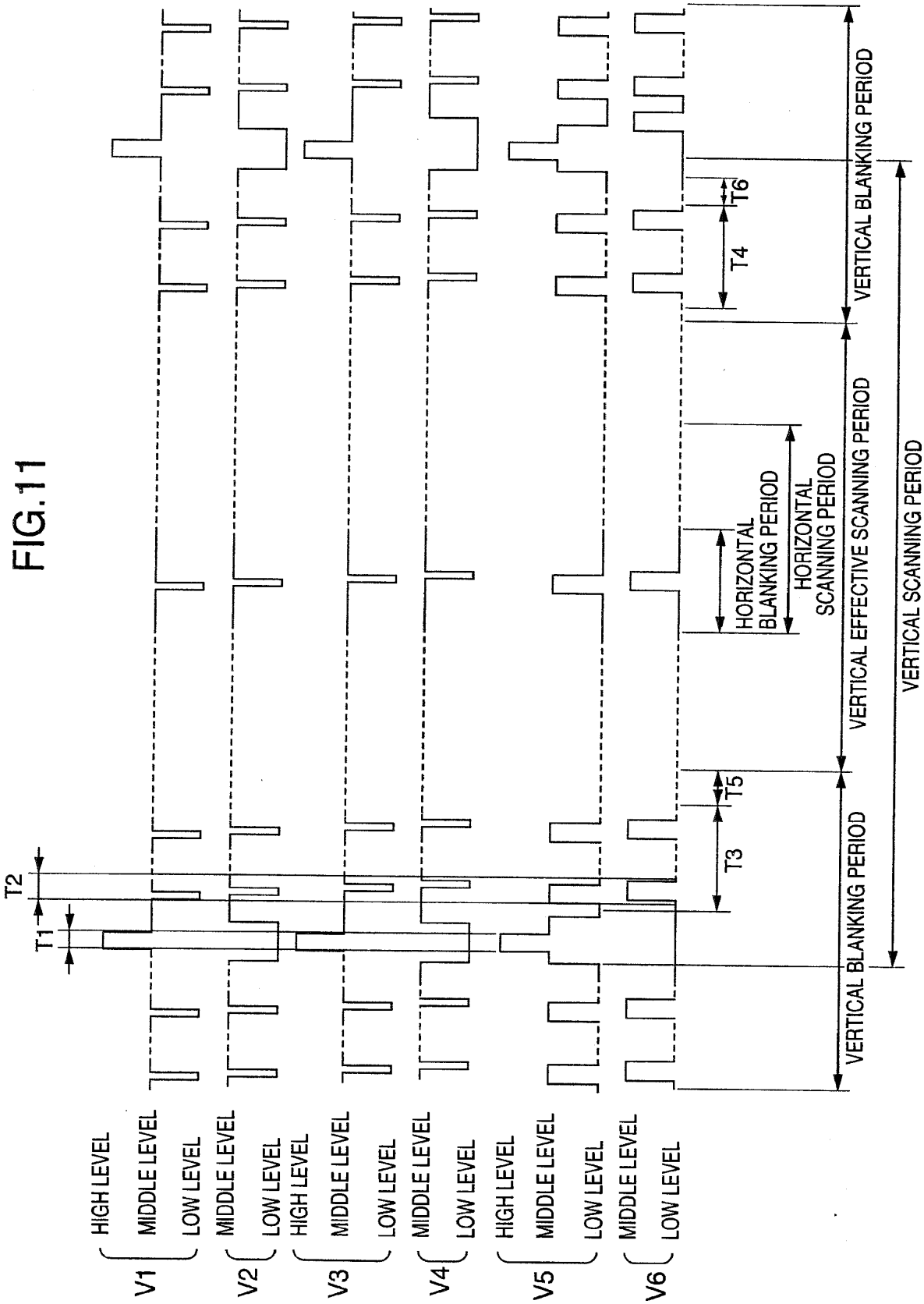
FIG.13A

Ye	W	Cy
Ye	W	Cy
Ye	W	Cy
Ye	W	Cy
Ye	W	Cy

FIG.13B

R	G	B
R	G	B
R	G	B
R	G	B
R	G	B

FIG.11


V1
V2
V3
V4
V5
V6
HIGH LEVEL
MIDDLE LEVEL
LOW LEVEL
T1
T2
T3
T4
T5
T6
HORIZONTAL BLANKING PERIOD
HORIZONTAL SCANNING PERIOD
VERTICAL BLANKING PERIOD
VERTICAL EFFECTIVE SCANNING PERIOD
VERTICAL BLANKING PERIOD
VERTICAL SCANNING PERIOD

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly/Krista Hargrove
Attorney Docket Number:	ASA-9606-09

Filed as Large Entity

Filing Fees for Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	300	300
UTILITY SEARCH FEE	1111	1	660	660
UTILITY EXAMINATION FEE	1311	1	760	760
REQUEST FOR PRIORITIZED EXAMINATION	1817	1	4000	4000
Pages:				
Claims:				
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
PROCESSING FEE, EXCEPT PROV. APPLS.	1830	1	140	140
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**5860**

Electronic Acknowledgement Receipt	
EFS ID:	32407423
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly
Filer Authorized By:	
Attorney Docket Number:	ASA-9606-09
Receipt Date:	23-APR-2018
Filing Date:	
Time Stamp:	15:26:06
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$5860
RAM confirmation Number	042418INTEFSW15263900
Deposit Account	501417
Authorized User	John Mattingly
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	TrackOne Request	9606-09-Trac1.pdf	125149 082e05ab9be46eefc6a7e52498fcd1817878aade	no	2
Warnings:					
Information:					
2	Application Data Sheet	9606-09-ads.pdf	1793722 cfd07d0a0ba680e90f520c9ac0b2e622401573be	no	9
Warnings:					
Information:					
3	Power of Attorney	9606-09-POA.pdf	434285 74fd9a561c9ec30322958f94fc772d99fbe7762a	no	5
Warnings:					
Information:					
4		9606-09-prelim.pdf	18811 ed8e7cc578cdb701947a6afaaf22b461b745cce3	yes	3

Multipart Description/PDF files in .zip description

Document Description	Start	End
Preliminary Amendment	1	1
Specification	2	2
Applicant Arguments/Remarks Made in an Amendment	3	3

Warnings:					
Information:					
5	Transmittal Letter	9606-09-IDS.pdf	16003 96f553526c105a9d238cf35084f1ece036aefd4f	no	2

Warnings:					
Information:					
6	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08.pdf	613666 8fedbacaf3f5efb454c49c2a6c22f4e094f6f5fa	no	8
Warnings:					
Information:					
7	Transmittal Letter	9606-09-NoticeOfIPR.pdf	18962 1855b36452e01ade12e2a0306fdb8051a5c1d4c4	no	1
Warnings:					
Information:					
8	Transmittal Letter	9606-09-NoticeRelatedPatentsLitigation.pdf	19959 01fa579ad60f5c074fa5c6eb67f3b5aefb6ec7bb	no	2
Warnings:					
Information:					
9	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-litigation.pdf	1035254 2ed3581a4bbae5ade9ba9e0299481546f9789714	no	5
Warnings:					
Information:					
10		9606-09-spec.pdf	2436425 d599bddaca303b53a3984d07cf80e8176d3ae25f	yes	44

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Specification	1	38
Claims	39	43
Abstract	44	44

Warnings:	
Information:	

11	Oath or Declaration filed	9606-09-AIA-declarations.pdf	225995 8967b89f7744acc370f51df6695e92adc2262e0a	no	4
Warnings:					
Information:					
12	Drawings-only black and white line drawings	9606-09-drawings.pdf	195922 6182feb1f3a8bb9581b75b10e012918c47013fa3	no	8
Warnings:					
Information:					
13	Fee Worksheet (SB06)	fee-info.pdf	40241 111057c8dd2cf62ba6bc042f7529cdbaaa8a8d86	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	6974394		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Doc Code: TRACK1.REQ
Document Description: TrackOne Request

PTO/AIA/424 (04-14)

CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION UNDER 37 CFR 1.102(e) (Page 1 of 1)

First Named Inventor:	T. NAKANO	Nonprovisional Application Number (if known):	
Title of Invention:	ELECTRIC CAMERA		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1) and the prioritized examination fee set forth in 37 CFR 1.17(c) have been filed with the request. The publication fee requirement is met because that fee, set forth in 37 CFR 1.18(d), is currently $0. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.

2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims, and that any request for an extension of time will cause an outstanding Track I request to be dismissed.

3. The applicable box is checked below:

I. ☑ Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)

i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.

---OR---

(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.

ii. An executed inventor's oath or declaration under 37 CFR 1.63 or 37 CFR 1.64 for each inventor, **or** the application data sheet meeting the conditions specified in 37 CFR 1.53(f)(3)(i) is filed with the application.

II. ☐ Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)

i. A request for continued examination has been filed with, or prior to, this form.
ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature /JOHN R. MATTINGLY/	Date April 23, 2018
Name (Print/Typed) JOHN R. MATTINGLY	Practitioner Registration Number 30293

Note: *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.**

☑ *Total of 1 forms are submitted.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-09
	Application Number	
Title of Invention	ELECTRIC CAMERA	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Takahiro		NAKANO	

Residence Information (Select One) US Residency ● Non US Residency Active US Military Service

City	Tokyo	Country of Residence [i]	JP

Mailing Address of Inventor:

Address 1	c/o Hitachi, Ltd., Intellectual Property Group
Address 2	6-1, Marunouchi 1-chome
City	Chiyoda-ku, Tokyo
State/Province	
Postal Code	100-8220
Country [i]	JP

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Ryuji		NISHIMURA	

Residence Information (Select One) US Residency ◉ Non US Residency Active US Military Service

City	Tokyo	Country of Residence [i]	JP

Mailing Address of Inventor:

Address 1	c/o Hitachi, Ltd., Intellectual Property Group
Address 2	6-1, Marunouchi 1-chome
City	Chiyoda-ku, Tokyo
State/Province	
Postal Code	100-8220
Country [i]	JP

Inventor 3 Remove

Legal Name

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-09
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Prefix	Given Name	Middle Name	Family Name	Suffix
	Toshiro		KINUGASA	

Residence Information (Select One) US Residency ◉ Non US Residency Active US Military Service

City	Tokyo	Country of Residence [i]	JP

Mailing Address of Inventor:

Address 1	c/o Hitachi, Ltd., Intellectual Property Group		
Address 2	6-1, Marunouchi 1-chome		
City	Chiyoda-ku, Tokyo	State/Province	
Postal Code	100-8220	Country [i]	JP

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	24956		
Email Address	ptomail@mmiplaw.com	Add Email	Remove Email

Application Information:

Title of the Invention	ELECTRIC CAMERA		
Attorney Docket Number	ASA-9606-09	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	8	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

[i]

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-09
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	24956		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)	
	Continuation of	15386656	2016-12-21	

Prior Application Status	Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
15386656	Continuation of	14661227	2015-03-18	9544517	2017-01-10

Prior Application Status	Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14661227	Continuation of	14264243	2014-04-29	9100604	2015-08-04

Prior Application Status	Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14264243	Continuation of	13681495	2012-11-20	8736729	2014-05-27

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-09
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13681495	Continuation of	12845266	2010-07-28	8339493	2012-12-25
Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12845266	Continuation of	10660710	2003-09-12	8059177	2011-11-15
Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
10660710	Division of	09520836	2000-03-08	6765616	2004-07-20

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)
2000-006064	JP	2000-01-11	

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-09
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-09
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	Maxell, Ltd.		
Mailing Address Information For Applicant:			
Address 1	1, Koizumi, Oyamazaki, Oyamazaki-cho Otokuni-gun		
Address 2			
City	Kyoto	**State/Province**	
Country	JP	Postal Code	618-8525
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-09
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/John R. Mattingly/			Date (YYYY-MM-DD)	2018-04-23
First Name	John R.	Last Name	Mattingly	Registration Number	30293

Additional Signature may be generated within this form by selecting the Add button. Add

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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-09
	Application Number	
Title of Invention	ELECTRIC CAMERA	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc Code: PA..
Document Description: Power of Attorney

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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	To be assigned
Filing Date	April 23, 2018
First Named Inventor	T. NAKANO
Title	ELECTRIC CAMERA
Art Unit	
Examiner Name	
Attorney Docket Number	ASA-9606-09

SIGNATURE of Applicant or Patent Practitioner

Signature	/JOHN R. MATTINGLY/	Date (Optional)	April 23, 2018
Name	JOHN R. MATTINGLY	Registration Number	30293
Title (if Applicant is a juristic entity)	ATTORNEY		
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Doc Code: PA
Document Description: Power of Attorney

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出願人による委任状
POWER OF ATTORNEY BY APPLICANT

私はここに、添付の伝送書もしくは下記枠内で特定された出願に対して、現時点より前に与えられたすべての委任状を破棄します。
I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

出願番号 Application Number	出願日 Filing Date

(注記：PTO/AIA82Aに同じ情報が明記されている場合、上の枠内は空欄でも可)
(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ 私は、下記顧客番号に関連する特許弁護士を、当方の弁護士あるいは代理人に指名し、添付の伝送書（PTO/AIA/82A）内もしくは上記に記載の特許出願に関連した米国特許商標庁との業務の全てを同弁護士あるいは代理人に委任します。
I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 24956

又は
OR

☐ 私は、添付のリスト(PTO/AIA/82C)に記載の特許弁護士を、当方の弁護士あるいは代理人に指名し、添付の伝送書（PTO/AIA/82A）内もしくは上記に記載の特許出願に関連した米国特許商標庁との業務の全てを同弁護士あるいは代理人に委任します。（注記：PTO/AIA/82C を記入すること。）
I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

添付の伝送書又は上記枠内にて特定された出願に対する郵便物送付先を下記のいずれかに登録または変更してください。
Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ 上記顧客番号に付随する住所
The address associated with the above-mentioned Customer Number

又は
OR

☐ 顧客番号に付随する住所
The address associated with Customer Number:

又は
OR

事務所または個人名 Firm or Individual Name					
住所 Address					
市 City		州 State		郵便番号 Zip	
国 Country					
電話番号 Telephone		メールアドレス Email			

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/82B (07-13)
Approved for use through 11/30/2014. OMB 0651-0051
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出願人による委任状
POWER OF ATTORNEY BY APPLICANT

私は出願人であり（出願人が法人の場合、出願人名を下記枠内に記入）：
I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Maxell, Ltd.

☐ 発明者もしくは共同発明者である（下記役職の明記は不要）
Inventor or Joint Inventor (title not required below)

☐ 死亡したもしくは成年被後見人である発明者の法定代理人である（下記役職の明記は不要）
Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ 被譲渡人もしくは発明者が譲渡する義務を負う人物である
Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ 上記以外で、十分な独占的所有権を示す人物である（例：37 CFR 1.46(b)(2)に基づく申請が本出願において認められた、又は本書類と共にその申請がなされている場合）（出願人が法人の場合、署名者の役職を明記すること）
Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

特許出願人の署名
SIGNATURE of Applicant for Patent

下記署名者（役職は下記に記載）は出願人の代理人と認められている（出願人が法人の場合等）
The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

署名 Signature	Kazuhiro Kaizaki	署名日（任意） Date (Optional)	Oct. 17. 2017
氏名 Name	Kazuhiro Kaizaki		
役職 Title	Vice President		

注記: 署名 - 本書類は37 CFR 1.33に基づき署名されなければならない。署名の要件および証明に関しては37 CFR 1.4を参照。出願人が複数いる場合は、複数の書類を使うこと。

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ 提出書類 計＿＿＿＿＿枚。
Total of _____ forms are submitted.

Privacy Act Statement

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4. 本記録システムの記録は、契約を履行するために同記録を必要とする本庁の契約業者に対し、通常使用の範囲として開示される場合があります。情報を受け取る側は、5. U.S.C. 552a(m)に基づき、1974年プライバシー法修正法の規定要件を遵守しなければなりません。
5. 本記録システム内の、特許協力条約に基づき出願された国際出願に関する記録は、通常使用の範囲として、特許協力条約に従い世界知的所有権機関に開示される場合があります。
6. 本記録システムの記録は、通常使用の範囲として、国家安全保障(35 U.S.C. 181)および原子力法(42 U.S.C. 218(c))に拠る検討目的で、他の連邦政府機関に開示される場合があります。
7. 本記録システムの記録は、通常使用の範囲として、44 U.S.C 2904および2906に基づき、記録管理方法およびプログラムに対する改善を提案するという米一般調達局長官(GSA)の職務の一部として実施される記録監査において、GSAまたはその委任による代理人に対し開示される場合があります。この開示は、上記目的による記録監査を規定するGSA法規およびその他関連する(GSAまたは商務省)指令に従って行われます。この開示は、個人を特定する目的に使用されてはなりません。
8. 本記録システムの記録は、通常使用の範囲として、特許出願公開後(35. U.S.C 112(b))、または特許発行後(35 U.S.C. 151)に一般に開示される場合があります。さらに、同記録が、放棄されたもしくは処理が集結している特許出願に記載されており、かつ公開後の出願、一般審査に公開された出願、または発行済み特許の中で参照されている場合には、37. CFR 1.14の制限に従い、通常使用の範囲として、一般に開示される場合があります。
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Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 15/959,774

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	300
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	660
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	760
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*			OR	x 100 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*				x 460 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1720

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/959,774	04/23/2018	2676	1720	ASA-9606-09	20	2

CONFIRMATION NO. 2614

FILING RECEIPT

24956
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314



Date Mailed: 05/17/2018

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Takahiro NAKANO, Tokyo, JAPAN;
Ryuji NISHIMURA, Tokyo, JAPAN;
Toshiro KINUGASA, Tokyo, JAPAN;

Applicant(s)

Maxell, Ltd., Kyoto, JAPAN;

Power of Attorney: The patent practitioners associated with Customer Number 24956

Domestic Priority data as claimed by applicant

This application is a CON of 15/386,656 12/21/2016
which is a CON of 14/661,227 03/18/2015 PAT 9544517
which is a CON of 14/264,243 04/29/2014 PAT 9100604
which is a CON of 13/681,495 11/20/2012 PAT 8736729
which is a CON of 12/845,266 07/28/2010 PAT 8339493
which is a CON of 10/660,710 09/12/2003 PAT 8059177
which is a DIV of 09/520,836 03/08/2000 PAT 6765616

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
JAPAN 2000-006064 01/11/2000 No Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 05/15/2018

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 15/959,774**

Projected Publication Date: 08/23/2018

Non-Publication Request: No

Early Publication Request: No

Title

ELECTRIC CAMERA

Preliminary Class

358

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

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NOT GRANTED

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Alexandria, Virginia 22313-1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

24956 7590 06/08/2018

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314
UNITED STATES OF AMERICA

EXAMINER	
ART UNIT	PAPER NUMBER
2663	

NOTIFICATION DATE	DELIVERY MODE
06/08/2018	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

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P.O. Box 1450
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Doc Code:
TRACK1.GRANT

Decision Granting Request for Prioritized Examination (Track I or After RCE)	Application No.: 15/959,774

1. THE REQUEST FILED April 23, 2018 IS **GRANTED.**

The above-identified application has met the requirements for prioritized examination
A. ☒ for an original nonprovisional application (Track I).
B. ☐ for an application undergoing continued examination (RCE).

2. **The above-identified application will undergo prioritized examination.** The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:

A. filing a **petition for extension of time** to extend the time period for filing a reply;
B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims**, or a multiple dependent claim;
C. filing a **request for continued examination**;
D. filing a notice of appeal;
E. filing a request for suspension of action;
F. mailing of a notice of allowance;
G. mailing of a final Office action;
H. completion of examination as defined in 37 CFR 41.102; or
I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to Cheryl Gibson-Baylor at (571)272-3213, Office of Petitions. In his/her absence, calls may be directed to Brian W. Brown, (571)272-5338.

Cheryl Gibson-Baylor
/Cheryl Gibson-Baylor/
[*Signature*]

Petitions Paralegal Specialist
(Title)

U.S. Patent and Trademark Office
PTO-2298 (Rev. 02-2012)

Office of Petitions: Decision Count Sheet

Mailing Month: 6

Application No.: 15959774

15959774

For US serial numbers: enter number only, no slashes or commas. Ex: 10123456
For PCT: enter "51+single digit of year of filing+last 5 numbers", Ex. for PCT/US05/12345, enter 51512345

Deciding Official: GIBSON-BAYLOR, CHERYL

Count (1) - Palm Credit 15959774

Decision: GRANT

FINANCE WORK NEEDED
☐ Select Check Box for YES

GRANT

Decision Type: 643 - Track One request

643

Notes:

Count (2)

Decision: n/a

FINANCE WORK NEEDED
☐ Select Check Box for YES

Decision Type: NONE

Notes:

Count (3)

Decision: n/a

FINANCE WORK NEEDED
☐ Select Check Box for YES

Decision Type: NONE

Notes:

Initials of Approving Official (if required)

If more than 3 decisions, attach 2nd count sheet & mark this box ☐

Printed on: 6/5/2018

Office of Petitions Internal Document - Ver. 5.0

Office of Petitions: Routing Sheet



Application No. 15959774

This application is being forwarded to your office for further processing. A decision has been rendered on a petition filed in this application, as indicated below. For details of this decision, please see the document PET.OP.DEC filed on the same date as this document.

- [X] **GRANTED**
- [ ] **DISMISSED**
- [ ] **DENIED**

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

24956 7590 07/09/2018

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314
UNITED STATES OF AMERICA

EXAMINER
NGUYEN, LUONG TRUNG

ART UNIT	PAPER NUMBER
2663	

NOTIFICATION DATE	DELIVERY MODE
07/09/2018	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

Office Action Summary	Application No. 15/959,774	Applicant(s) NAKANO ET AL.	
	Examiner LUONG T. NGUYEN	Art Unit 2663	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 2 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *04/23/2018*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-20* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☐ Claim(s) _____ is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☒ Claim(s) *1-20* are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

1. The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

Election/Restrictions

2. Claims 1, 11 are generic to the following disclosed patentably distinct species:

Species I: Figure 1.

Species II: Figure 7.

The species are independent or distinct because as disclosed the different species have mutually exclusive characteristics for each identified species. In addition, these species are not obvious variants of each other based on the current record.

Applicant is required under 35 U.S.C. 121 to elect a single disclosed species, or a single grouping of patentably indistinct species, for prosecution on the merits to which the claims shall be restricted if no generic claim is finally held to be allowable.

There is a search and/or examination burden for the patentably distinct species as set forth above because at least the following reason(s) apply: the species require a different field of search (e.g., searching different classes/subclasses or electronic resources, or employing different search strategies or search queries); and/or the prior art applicable to one species would not likely be applicable to another species.

Applicant is advised that the reply to this requirement to be complete must include (i) an election of a species or a grouping of patentably indistinct species to be examined even though the requirement may be traversed (37 CFR 1.143) **and (ii) identification of the claims encompassing the elected species** or grouping of patentably indistinct species, including

any claims subsequently added. An argument that a claim is allowable or that all claims are generic is considered nonresponsive unless accompanied by an election.

The election may be made with or without traverse. To preserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the election of species requirement, the election shall be treated as an election without traverse. Traversal must be presented at the time of election in order to be considered timely. Failure to timely traverse the requirement will result in the loss of right to petition under 37 CFR 1.144. If claims are added after the election, applicant must indicate which of these claims are readable on the elected species or grouping of patentably indistinct species.

Should applicant traverse on the ground that the species, or groupings of patentably indistinct species from which election is required, are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the species to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the species unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103 or pre-AIA 35 U.S.C. 103(a) of the other species.

Upon the allowance of a generic claim, applicant will be entitled to consideration of claims to additional species which depend from or otherwise require all the limitations of an allowable generic claim as provided by 37 CFR 1.141.

3. Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be corrected in compliance with 37 CFR 1.48(a) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the

application. A request to correct inventorship under 37 CFR 1.48(a) must be accompanied by an application data sheet in accordance with 37 CFR 1.76 that identifies each inventor by his or her legal name and by the processing fee required under 37 CFR 1.17(i).

Conclusion

4. Any inquiry concerning this communication or earlier communications from the examiner should be directed to LUONG T. NGUYEN whose telephone number is (571)272-7315. The examiner can normally be reached on 7:30AM - 5:00PM, MONDAY -THURSDAY.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, TWYLER HASKINS can be reached on (571) 272-7406. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2663
07/02/18

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15959774	NAKANO ET AL.
	Examiner	Art Unit
	LUONG T NGUYEN	2663

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/02/2018								
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UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09

CONFIRMATION NO. 2614

24956
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

PUBLICATION NOTICE



Title:ELECTRIC CAMERA

Publication No.US-2018-0241958-A1
Publication Date:08/23/2018

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently https://portal.uspto.gov/pair/PublicPair. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2663
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	1	Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,339,493, Inter Partes Review No. IPR2018-00904 dated June 20, 2018	
	2	Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2018-00908 dated June 20, 2018	
	3	Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2018-00909 dated June 20, 2018	
	4	Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,059,177, Inter Partes Review No. IPR2018-00910 dated June 20, 2018	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

X That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2018-09-07
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	33652495
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	07-SEP-2018
Filing Date:	23-APR-2018
Time Stamp:	11:49:14
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	IPR2018-00904.pdf	1022267 6e4d13ce10a3b4df4e1d502dcaa13709c5228 4e4	no	86

Warnings:

Information:					
2	Non Patent Literature	IPR2018-00908.pdf	695798 7181f61f7d67dc30e5b78750e6bfa9a6e6551c94	no	78
Warnings:					
Information:					
3	Non Patent Literature	IPR2018-00909.pdf	2421885 1cc436688f61a11dd24b7cf0c632690bdfeaa35a	no	83
Warnings:					
Information:					
4	Non Patent Literature	IPR2018-00910.pdf	2564475 f805bde3091795c7be8351c572a0807f6e5b3a1b	no	82
Warnings:					
Information:					
5	Transmittal Letter	9606-09-NoticeofIPR.pdf	20447 c468a665748cacab9821352f058b5a2e6c8d5d94	no	2
Warnings:					
Information:					
6	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-IPR.pdf	1034460 e98fc1bf18dafabaf1f2c8b4d17d45a86ae54ebf	no	4
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
		Total Files Size (in bytes):	7759332		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Atty. Docket No. ASA-9606-09

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: 15/959,774	Confirmation No.	: 2614
Applicant	: Maxell, Ltd.	TC/GAU	: 2663
Filed	: April 23, 2018	Examiner	: NGUYEN, L. T.
Title	: ELECTRIC CAMERA		

Customer No.: 24956

NOTICE OF RELATED PATENTS INVOLVED IN *INTER PARTES* REVIEW

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

September 7, 2018

Sir:

Applicant notifies the Office that three related patents, from which the above-identified application claims priority under 35 U.S.C. 120, are involved in the following *Inter Partes* Review proceedings:

1. 8,339,493 which matured from application 10/660,710
2. 9,100,604 which matured from application 13/681,495 and
3. 8,059,177 which matured from application 09/520,836.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 8,339,493, *Inter Partes* Review No. IPR2018-00904.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 9,100,604, *Inter Partes* Review No. IPR2018-00908.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 9,100,604, *Inter Partes* Review No. IPR2018-00909.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 8,059,177, *Inter Partes* Review No. IPR2018-00910.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly, Reg. No. 30,293
(703) 684-1120

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2663
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

X That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2018-09-07
Name/Print	John R. Mattingly	Registration Number	30,293

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
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(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2663
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

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	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	1	TIA/EIA/IS-95-A +TSB74 (February 27, 1996) ("IS 95")	
	2	"Retrieval and Browsing of Images Using Image Thumbnails," by Harvey A. Cohen, published in the Journal of Visual Computing and Image Representation, Vol. 8, No. 2, June 1997, pp. 226-234	
	3	SONY DCS F55/F55E Manual	
	4	SONY DCS-F55 specification sheet	
	5	SONY MVC-FD81 Manual	
	6	SONY MVC-FD88/FD83 Manual	
	7	SONY MVC-FD91 Manual	
	8	SONY DCS-F55/F55E Service Manual (Ver. 1.1, 7-1999)	
	9	SONY MVC-FD91 Service Manual (Ver. 1.0, 10-1998)	
	10	A. Abidi "Direct-Conversion Radio Transceivers for Digital Communications," IEEE Journal of Solid-State Circuits, Vol. 30, No. 12, Dec. 1995	
	11	F. Adachi et.al. "Wideband DS-CDMA for Next-Generation Mobile Communications Systems," published Sept, 1998 IEEE Communications Magazine	

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	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	12	F. Cheng, "A New Approach to Dynamic Range Enhancement," Oct. 1994	
	13	S. Manji and W. Zhuang, "Reverse Link Power Control for Packetized DS-CDMA in a Slowly Rayleigh Fading Environment," published in Dept. of Electrical and Computer Engineering, University of Waterlo, Canada	
	14	A. Salmasi and K. Gilhousen, "On the System Design Aspects of Code Division Multiple Access (CDMA) Applied to Digital Cellular and Personal Communications Networks" IEEE 1991 (57-62)	

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	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

X That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2018-09-07
Name/Print	John R. Mattingly	Registration Number	30,293

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Electronic Acknowledgement Receipt

EFS ID:	33652727
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	07-SEP-2018
Filing Date:	23-APR-2018
Time Stamp:	11:50:14
Application Type:	Utility under 35 USC 111(a)

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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	JP6-60158.pdf	217875 484fabfea3491045183070 2b2c80f9e40f48db3c	no	6

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2	Foreign Reference	WO98-28843.pdf	906765 41a75eb507aca81f4f2d5b4260ee9721c78a5395	no	21
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4	Foreign Reference	EP0587954.pdf	1154257 d2501f66c0ed7cf88a05678ac0e18e9fd1e23e61	no	16
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5	Non Patent Literature	NPL1-E52018-06-12-Asus1stAmendedInvalidityContentions.pdf	1267883 7fa52d7435ba02de401b853cff270bd1e3b96fb3	no	101
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6	Non Patent Literature	NPL2-DigitalStillCameraImageFileFormatStandardv21.pdf	19256586 80a008dbcd24edc40b1f53183418e62c76c41a22	no	172
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7	Non Patent Literature	NPL3-MPEGCAMMP-EG1AInstructionManual.pdf	17899261 6131ac2f0b6dc4baa107aadfb594a265f4be8e2b	no	101
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13	Non Patent Literature	NPL9-JPEGFileInterchangeFormatv1-02.pdf	1319317 8f80ef88380ee330a1e24e0854112db9b9748bc4	no	9
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26	Non Patent Literature	NPL19-Low-PowerMPEG-2CODECLSIforConsumerCameras.pdf	699630 ab6ad23ef7552ed965a68940aba629d4b625e286	no	6
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Warnings:					
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55	Non Patent Literature	NPL56-SONYMVC-FD88-FD83MANUAL-000197-000328.pdf	1564100 8416ae059af3ac5f22a0da82c99527cf1682f975	no	132
Warnings:					
Information:					
56	Non Patent Literature	NPL57-SONYMVC-FD91-000329-000428.pdf	1309799 3dcac26b5aca80c766d552750859b7c3a9b0ad7e	no	100
Warnings:					
Information:					

57	Non Patent Literature	NPL33-UserInterfaceIssues.pdf	5491319 049c223c77e53f7f56d2aacd1fbd97bb36d957a5	no	11
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58	Transmittal Letter	9606-09-NoticeofIPR.pdf	20447 c468a665748cacab9821352f058b5a2e6c8d5d94	no	2
Warnings:					
Information:					
59	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-Litigation.pdf	1040862 f78bb598a6dd5b0f70488a48896abf9bfa9c5bfb	no	19
Warnings:					
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60	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-Litigation-2.pdf	1035278 a6444c06293c355049f1b813339954d4512fe1a7	no	5
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		Total Files Size (in bytes):	436074450		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Espacenet

Bibliographic data: JPH0660158 (A) — 1994-03-04

PICTURE FILE STORAGE MEDIUM AND PICTURE FILE DEVICE

Inventor(s): OBA AKIHIKO; MATSUMOTO KIYOSHI ± (OBA AKIHIKO, ; MATSUMOTO KIYOSHI)

Applicant(s): HITACHI LTD ± (HITACHI LTD)

Classification: **- international:** ***G06T1/00; G06T9/00; H04N5/92;*** (IPC1-7): G06F15/62; G06F15/66; H04N5/92

- cooperative:

Application number: JP19920213957 19920811

Priority number(s): JP19920213957 19920811

Abstract of JPH0660158 (A)

PURPOSE:To quicken the operation when compressed picture information is retrieved visually by recording information of a low frequency component of the picture compression information in a management information storage area on which recording addresses of picture information or the like are stored. CONSTITUTION:When the retrieval of picture is commanded by a host computer, an optical disk drive reads management information 3 of certain picture information and stores the information to the host computer. The optical disk drive reads low frequency component information 4 of the compressed picture information from the picture information whose management information 3 is read continuously and transfers the information 4 to a picture information processing section. The picture information processing section expands the low frequency component information of the compressed picture information and displays the result onto a monitor. Since the picture is recognized by using only the low frequency component of the picture information based on the visual characteristic of human being, whether or not the picture is the desired picture is discriminated from the picture displayed on the monitor. When the desired picture is not obtained, the similar operation is repeated to succeeding picture information.

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号

特開平6－60158

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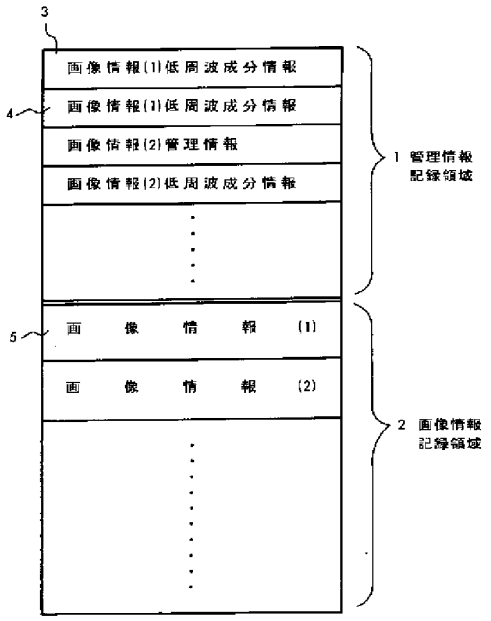
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(54)【発明の名称】　画像ファイル用記憶媒体および画像ファイル装置

(57)【要約】
【目的】圧縮された画像情報をビジュアルに検索する動作を高速化した画像ファイル装置を提供する。
【構成】画像情報の記録アドレスなどが記録されている管理情報記録領域１に、圧縮画像情報の低周波成分情報４を記録した画像ファイル用記憶媒体。
【効果】圧縮された画像情報をビジュアルに検索を行う時、画像表示動作が従来例に比較して簡易で高速にできるため、検索がスムーズに行える。

図　1



【特許請求の範囲】
【請求項１】画像情報を直交変換を用いて周波数成分に変換し、前記画像情報を圧縮して記録する記憶媒体であって、前記画像圧縮情報を前記記憶媒体に記録するときに、前記画像圧縮情報の低周波成分の情報を、前記記憶媒体の前記画像情報のアドレス情報などが記録されている管理情報記録領域に記録することを特徴とする画像ファイル用記憶媒体。
【請求項２】請求項１において、前記画像圧縮情報の低周波成分の情報が画像の管理情報と連続して記録されている画像ファイル用記憶媒体。
【請求項３】請求項１における画像ファイル用記憶媒体に記録されている前記画像圧縮情報の低周波成分の情報を用いて、画像検索する画像ファイル装置。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は主に動画，静止画などの画像情報を圧縮して記録再生する光ディスク，磁気ディスクなどの画像ファイル用記憶媒体及び画像ファイル装置に関する。
【０００２】
【従来の技術】静止画，動画などの莫大な容量と高速転送速度を必要とする画像情報を蓄積，伝送するために画像情報圧縮（高能率符号化）の研究が盛んに行われている。これらの圧縮した画像情報の各情報機器での互換性を保つために、国際標準の規格もまとまりつつある。現状では、静止画の圧縮方式の規格はＪＰＥＧ（JointPhotographic Experts Group）、動画の圧縮方式の規格はＭＰＥＧ（MovingPicture Experts Group)が認められている。いずれの規格も、ＤＣＴ（離散コサイン変換）で画像情報を周波数成分に変換し、最適なビット配分をすることにより画像情報の圧縮を図っている。このため、現在はＤＣＴによる画像の圧縮が主流であり、将来的にも画像圧縮技術の主流になると考えられている。このように、画像情報を蓄積するには画像圧縮技術は必須であり、画像ファイル装置のメモリに記憶できる画像情報の量も膨大になってきている。このため、膨大な画像情報の中から所望の画像を高速に得るための検索方法が望まれており、特に画像情報に適したビジュアルな高速検索方法が必要とされている。
【０００３】従来、画像情報を光ディスク，磁気ディスクなどの記憶媒体に記録再生する画像ファイル装置では、画像情報を記録する場合、スキャナ，カメラなどから入力した画像情報が圧縮，符号化されて記憶媒体に記録されるとともに、その画像情報が記録されているアドレスなどの管理情報が記憶媒体に記録される。
【０００４】図４は従来の画像ファイル装置における記憶媒体のボリューム構造を示す。１は記録されている画像情報のアドレスなどを記録する管理情報記録領域、２は圧縮した画像情報の記録領域である。
【０００５】図５はこのような画像ファイル装置で、画像をモニタ上に表示し、ビジュアルに画像の検索を行う手順に示す。まず、任意の一つの画像情報の記録アドレス情報が管理情報記録領域から再生ヘッドで読み出され、それに基づき画像情報記録領域の所定のアドレスに再生ヘッドがアクセス（５１）し、そこで圧縮された全画像情報が読み出され（５２）、この全画像情報が伸張され（５３）、モニタ上に画像が表示される。このモニタ上に表示された画像が所望の画像でないならば、次の画像について同じ動作を繰り返す。
【０００６】
【発明が解決しようとする課題】上記従来技術は一つの画像情報について、管理情報の読み出し，画像情報領域へのアクセス，全画像情報の読み出し，全画像情報の伸張，画像のモニタへの表示を行い、所望の画像が得られるまでこの動作を繰り返す。この中で特に画像情報領域へのアクセス，全画像情報の伸張は他の動作に比較して時間がかかるため、所望の画像を検索するまでに多大な時間を要するという問題があった。また、複数の縮小画像を画面に表示して検索を行うマルチ画面検索においても、同様の理由から多大な時間を要していた。
【０００７】本発明の目的は、圧縮された画像情報をビジュアルに検索する動作を高速化した画像ファイル装置を提供することにある。
【０００８】
【課題を解決するための手段】本発明は、上記目的を達成するために、画像情報を離散コサイン変換などの直交変換を用いて周波数成分に変換し、前記画像情報を圧縮して記録する記憶媒体において、画像情報の記録アドレスなどが記録されている管理情報記録領域に、前記画像圧縮情報の低周波成分の情報を記録したものである。
【０００９】
【作用】人間の視覚特性から、画像を認識するには画像の低周波成分だけを表示すれば十分である。このことから、本発明の画像ファイル用記憶媒体を用いると、画像圧縮情報の低周波成分の情報が管理情報記録領域に記録されているため、圧縮された画像情報をビジュアルに検索する時、画像情報領域へのアクセス，全画像情報の伸張が不要になり、従来、多大な時間を要した検索時間を大幅に高速化することができる。
【００１０】
【実施例】図１は本発明の一実施例を示す画像ファイル用記憶媒体のボリューム構造である。１は管理情報記録領域、２は画像情報記録領域であり、管理情報記録領域１には画像情報５の記録アドレス、検索項目などの管理情報３と圧縮画像情報の低周波成分情報４が図示のように、順次、記録される。管理情報３と圧縮画像情報の低周波成分情報４との順序は特に規定はなく、管理情報記録領域１に記録されていればよい。
【００１１】図２は本発明による光ディスクを用いた画

像ファイル装置の構成例である。画像入力装置はカメラ１１、及びスキャナ１２，画像出力装置はモニタ９、及びプリンタ１０，情報の記録再生は記憶媒体に光ディスクを用いた光ディスクドライブ８で行う。カメラ１１もしくはスキャナ１２から入力した画像情報は、画像処理部７で圧縮を行うとともに、検索表示に十分な低周波成分を抽出し、ホストコンピュータ６から指定される画像情報の管理情報とともに、光ディスクに記録される。また、光ディスクから再生した圧縮画像情報を伸張する作業も、画像処理部７で行う。これら全ての装置は専用バス１３でホストコンピュータ６に接続され、ホストコンピュータ６がシステム全体の制御を行う。

【００１２】このように構成された画像ファイル装置において、本発明による図１のボリューム構造の光ディスクを用いた場合のビジュアルな画像検索動作を説明する。

【００１３】図３は本発明の画像検索動作の概略フローチャートである。まず最初にホストコンピュータ６により画像検索の指示を行うと、光ディスクドライブ８である一つの画像情報の管理情報３を読み出し、この情報はホストコンピュータ６に記憶される。連続して光ディスクドライブ８では管理情報を読み出した画像情報の圧縮画像情報の低周波成分情報４を読み出し、画像情報処理部７へ転送する。画像情報処理部７では圧縮画像情報の低周波成分情報を伸張し、モニタ９に表示する。

【００１４】人間の視覚特性より、画像情報の低周波成分だけで画像を認識することができるため、モニタ９に表示された画像で所望の画像かどうかを判断することができる。ここで、所望の画像が得られなかった場合は、次の画像情報について同様の動作を行い、所望の画像が得られるまで繰り返す。モニタ９上で画像検索を行い所望の画像が得られたときは、ホストコンピュータ６は選定された画像の管理情報３から、光ディスクドライブ８へ画像情報５の記録アドレスを指示し、所望の画像情報５を読み出す。読み出された画像情報はモニタ９に１画面表示するか、またはプリンタ１０で紙に印刷する。

【００１５】以上が圧縮された画像情報をビジュアルな検索方法によって所望の画像を得るまでの概略である。本実施例と従来例による画像検索動作を示す図５とを比較すると、本発明では画像情報領域へのアクセスが不要になり、画像情報の読みだし、伸張も全画像情報の一部で済むため、画像検索が非常に高速に行えることが分かる。

【００１６】なお本実施例では光ディスクを記憶媒体に用いたが、磁気ディスクなど他の記憶媒体にも同様に適用できる。また、例えば、複数枚の縮小した画像情報を画面に表示して検索するマルチ画面検索など、本実施例と異なる画像検索方法でもビジュアルな画像検索方法であれば本発明の効果は得られる。

【００１７】

【発明の効果】本発明によれば、離散コサイン変換などの直交変換を用いて周波数成分に変換し圧縮された画像情報を、ビジュアルに検索を行う時、画像表示動作が従来例に比較して簡易で高速にできるため、検索がスムーズに行える。

【図面の簡単な説明】

【図１】本発明の一実施例を示す画像ファイル用記憶媒体の説明図。

【図２】画像ファイル装置のブロック図。

【図３】本発明による画像検索動作のフローチャート。

【図４】従来の画像ファイル用記憶媒体の説明図。

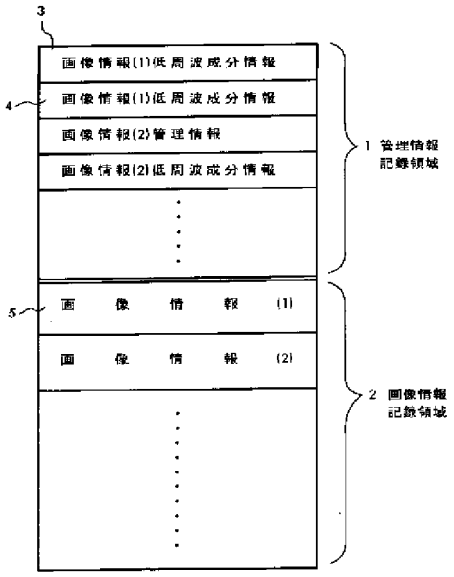
【図５】従来例による画像検索動作のフローチャート。

【符号の説明】

１…管理情報記録領域、２…画像情報記録領域、３…管理情報、４…圧縮画像情報の低周波成分情報、５…画像情報。

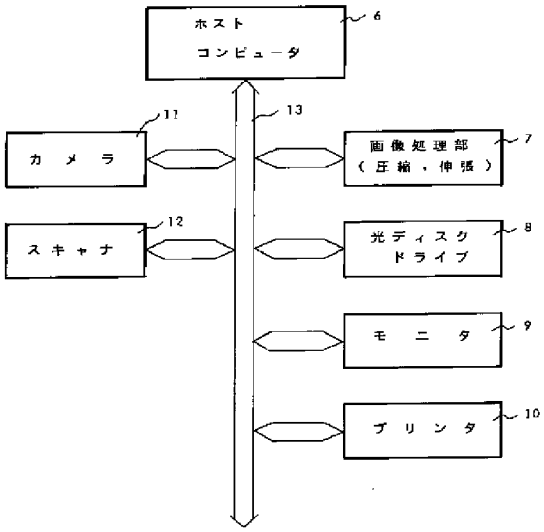
【図１】

図　1



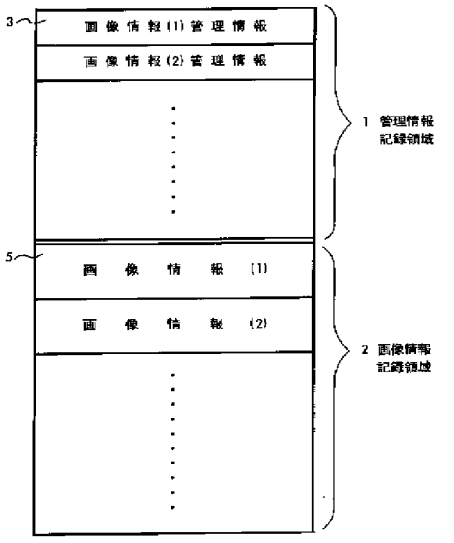
【図２】

図　2



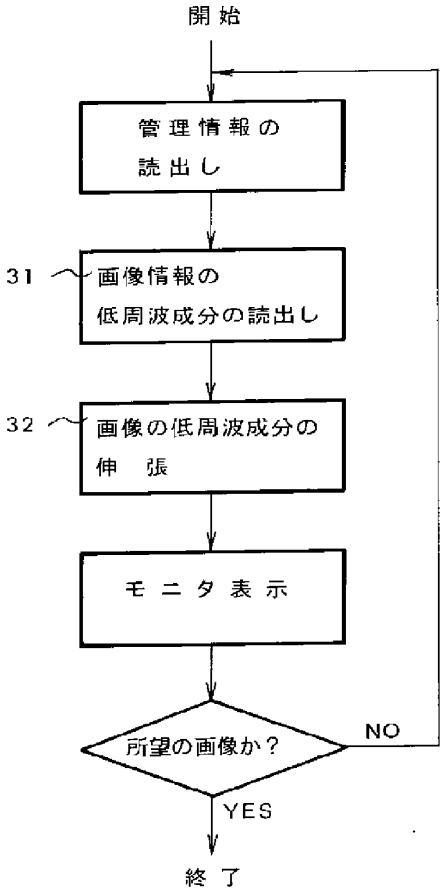
【図４】

図　4



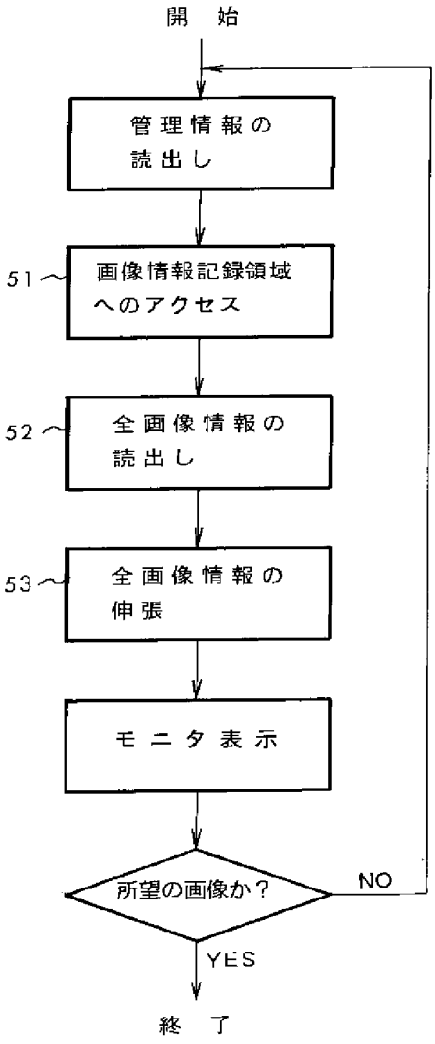
【図3】

図　3


開始
管理情報の読出し
31
画像情報の低周波成分の読出し
32
画像の低周波成分の伸張
モニタ表示
所望の画像か？
NO
YES
終了

【図5】

図　5


開始
管理情報の読出し
51
画像情報記録領域へのアクセス
52
全画像情報の読出し
53
全画像情報の伸張
モニタ表示
所望の画像か？
NO
YES
終了

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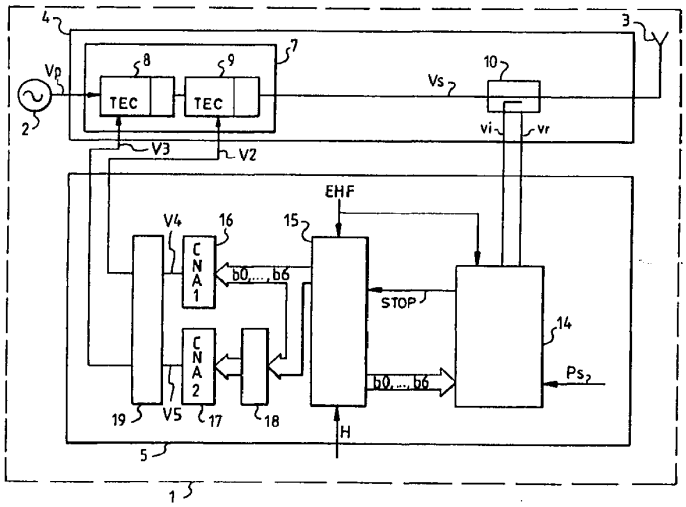
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(54) Title: METHOD FOR REGULATING POWER WITHOUT ANALOG CONTROL LOOP AND RELATED DEVICE

(54) Titre: PROCEDE DE REGULATION DE PUISSANCE SANS BOUCLE D'ASSERVISSEMENT ANALOGIQUE ET DISPOSITIF ASSOCIE

(57) Abstract

The invention concerns methods and devices for regulating power and formatting a high frequency signal transmitted by a portable radio. The device is made up of a power line (4) controlled by a formatting and regulating device (5) and connected to a radio antenna (3) by a directional waveguide coupler (10). The method consists in measuring a power level transmitted by the power line (4) and then in gradually increasing amplification gain of the power line (4) to increase the transmitted power up to a predetermined power value (Ps). The method consists then in maintaining the amplification gain at the resulting value when the transmitted power has reached the predetermined power and finally in reducing the gain to zero at the end of the broadcast. The invention is particularly applicable to radio broadcast systems such as portable radios.



(57) Abrégé

L'invention concerne les procédés et dispositifs de régulation de puissance et de mise en forme d'un signal haute fréquence émis par une radio portable. Le dispositif est composé d'une chaîne de puissance (4) contrôlée par un dispositif de mise en forme et de régulation (5) et couplée à une antenne radio (3) par un coupleur directionnel (10). Le procédé consiste à mesurer un niveau de puissance émise par la chaîne de puissance (4) puis à augmenter progressivement un gain d'amplification de la chaîne de puissance (4) pour augmenter la puissance émise jusqu'à une valeur de puissance déterminée (Ps). Le procédé consiste ensuite à maintenir le gain d'amplification à la valeur obtenue lorsque la puissance émise a atteint la puissance déterminée puis finalement à ramener le gain à zéro en fin d'émission. Application, en particulier, à des systèmes de transmission radio tels que des radios portables.

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PROCEDE DE REGULATION DE PUISSANCE SANS BOUCLE D'ASSERVISSEMENT ANALOGIQUE ET DISPOSITIF ASSOCIE.

La présente invention concerne un procédé et un dispositif de régulation de puissance et de mise en forme sans boucle d'asservissement analogique d'un signal émis par un émetteur radio.

Elle permet notamment la régulation et la mise en forme d'un signal Haute Fréquence, noté HF, avant transmission par une antenne d'une radio portable.

Dans les différents types de transmission radio, dont l'évasion de fréquence (EVF) est un cas particulier, il est nécessaire de maîtriser différents paramètres de l'onde émise :

- la montée en puissance qui doit être mise en forme afin de limiter la largeur et l'amplitude du spectre parasite généré,
- la durée de cette mise en forme de façon à garantir une onde parfaitement stabilisée dès les premiers bits d'information à transmettre,
- la maîtrise de l'amplitude de l'onde émise,
- la descente en puissance qui doit aussi être maîtrisée en forme et en temps pour des raisons identiques à la montée.

Il est connu pour réaliser une régulation de puissance et une mise en forme d'un signal émis par une chaîne d'émission d'un appareil de communication radio des dispositifs mettant en œuvre des procédés d'asservissement de gain dont un synoptique est représenté sur la figure 1. La chaîne d'émission 1, représentée à l'intérieur d'une ligne fermée en pointillé, comprend un générateur de fréquences 2 couplé à une antenne radio 3 par une chaîne de puissance 4 contrôlée par un dispositif de mise en forme et de régulation 5. La chaîne de puissance 4 comprend en entrée un atténuateur variable 6 suivi d'un bloc d'amplification 7 formé d'un premier amplificateur 8 en série avec un deuxième amplificateur 9, couplé à l'antenne radio 3 par un coupleur directionnel 10. Le dispositif de mise en forme et de régulation 5 comprend un dispositif de blocage 11 qui, à partir d'un signal d'entrée EHF, génère un signal de contrôle du premier amplificateur 8. Le dispositif de mise en forme et de régulation 5 comprend aussi une boucle d'asservissement 12 connectée en entrée au coupleur directionnel 10 et à un dispositif de génération de consigne 13 et connecté

en sortie à l'atténuateur variable 6 et au deuxième amplificateur 9. Selon cette disposition, le procédé mis en œuvre se déroule suivant la description qui suit. Un signal pilote Vp généré par le générateur de fréquences 2 est mis en forme et amplifié, sous la forme d'un signal Vs, par la chaîne de puissance 4 contrôlée par le dispositif de mise en forme et de régulation 5. Le coupleur directionnel 10 délivre en permanence une information de tension incidente vi et une information de tension réfléchie vr. L'information de tension incidente vi est une mesure de la puissance émise en sortie du bloc d'amplification 7 à destination de l'antenne radio 3 et l'information de tension réfléchie vr est une mesure de la puissance reçue sur l'antenne radio 3 due à la présence d'un brouilleur non représenté. L'information de tension incidente vi et l'information de tension réfléchie vr sont comparées à une consigne Vc, générée par le dispositif de génération de consigne 13, par la boucle d'asservissement 12. La consigne Vc, réalisée par un filtrage du signal de commande EHF représentant l'enveloppe du signal à émettre, définit le niveau de régulation de la chaîne de puissance 4. En fonction de ce niveau de régulation, la boucle d'asservissement 12 ajuste le niveau du signal de sortie Vs de la chaîne de puissance 4 en contrôlant l'atténuateur variable 6 par une commande d'atténuation V1 et en contrôlant le deuxième amplificateur 9 par une commande de gain V2. Durant les intervalles de temps où il n'y a pas d'émission, le signal de commande EHF est à zéro et le dispositif de blocage 11 bloque le premier amplificateur 8 par une commande de blocage V3.

Un tel procédé a pour avantage d'effectuer une analyse de l'onde émise durant toute la durée d'émission assurant un asservissement permanent de la régulation de puissance. Par contre, un tel procédé présente certains inconvénients dont les plus importants sont le risque d'accrochage lié à la présence d'une boucle d'asservissement et le risque d'étouffement en présence d'un brouilleur à proximité. Par ailleurs, le dispositif mettant en œuvre le procédé présente une certaine rigidité due à une réalisation toute analogique et sa réalisation doit tenir compte des contraintes liées à la taille des composants analogiques.

Le but de l'invention est de pallier les inconvénients précités.

A cet effet, l'invention a pour objet un procédé de régulation de puissance et de mise en forme d'un signal transmis par une antenne radio

d'un émetteur radio, en présence ou non d'un signal de brouillage reçu par l'antenne radio, après amplification, par une chaîne de puissance comprenant au moins un premier et un deuxième transistor du type à effet de champ équipé d'une grille, d'un signal pilote généré par un générateur de fréquence caractérisé en ce qu'il consiste :

- à interdire toute émission en bloquant le premier transistor en dehors des périodes d'émission définies par un signal extérieur,
- à autoriser une émission en débloquant le premier transistor au moyen d'une commande d'autorisation à émettre,
- à amplifier progressivement en début d'émission pendant un temps déterminé le signal pilote en commandant l'état de conduction du deuxième transistor par l'évolution suivant une première loi déterminée d'une commande de gain appliquée sur la grille du deuxième transistor jusqu'à ce que le signal transmis ait atteint un niveau de puissance déterminé correspondant à un gain d'amplification donné de la chaîne de puissance,
- à maintenir le gain d'amplification donné durant l'émission en suspendant l'évolution du niveau de la commande de gain pendant l'émission,
- à diminuer progressivement en fin d'émission le niveau de puissance du signal transmis en commandant l'état de conduction du deuxième transistor par l'évolution suivant une deuxième loi déterminée de la commande de gain,
- à bloquer à nouveau le premier transistor en fin d'émission.

Elle a également pour objet un dispositif pour la mise en œuvre du procédé.

L'invention a principalement pour avantages qu'elle réalise une régulation de puissance et une mise en forme sans boucle d'asservissement analogique et qu'elle supprime le risque d'étouffement en présence d'un brouilleur à proximité. Elle a aussi pour avantage de pouvoir être adaptée facilement à différents appareils du fait de boîtiers numériques programmables qui remplacent un certain nombre de composants analogiques. L'utilisation des boîtiers numériques permet aussi de réduire le nombre de composants et l'encombrement du dispositif.

L'invention sera bien comprise et ses avantages et autres caractéristiques ressortiront lors de la description suivante présentée à titre d'illustration non limitative et faite en regard des figures annexées qui représentent :

- la figure 1, un synoptique d'une chaîne d'émission selon un dispositif connu,
- la figure 2, un synoptique d'une chaîne d'émission d'un dispositif selon l'invention, et
- la figure 3, des chronogrammes de différents signaux du dispositif.

Sur les différentes figures, les éléments homologues sont représentés avec une même référence.

Le procédé selon l'invention consiste à mesurer une puissance émise par un amplificateur d'un émetteur radio et à augmenter progressivement le niveau d'une commande de gain d'amplification tant que la puissance émise mesurée ne répond pas aux conditions d'exploitation de l'émetteur radio. Les conditions d'exploitation, pré-programmées lors de la fabrication du dispositif mettant en œuvre le procédé ou sélectionnées par un opérateur, consistent essentiellement en un niveau de puissance émise pour une fréquence donnée du signal émis. Une fois les conditions d'exploitation remplies, le niveau de la commande de gain est maintenu constant pendant la durée d'émission pour assurer une puissance émise constante. En fin d'émission, le niveau de la commande de gain est diminué progressivement de manière à ramener la puissance émise à zéro sans variation brutale du signal émis. La commande de gain résulte de la mise en forme des sorties d'un compteur assurant des temps de montée et de descente de la commande de gain maîtrisables. La commande de gain contrôle le gain d'amplification en commandant la tension appliquée sur la grille de transistors du type à effet de champ notés TEC, ou FET suivant l'appellation anglo-saxonne ; ces transistors du type TEC sont les éléments essentiels de l'amplificateur de l'émetteur radio. Le procédé selon l'invention consiste aussi à détecter la présence d'un brouilleur à proximité de l'antenne radio afin de modifier les conditions d'exploitation de l'émetteur radio.

La compréhension du procédé sera complète après la description suivante d'un dispositif mettant en œuvre le procédé.

La figure 2 représente un synoptique d'une chaîne d'émission d'un dispositif selon l'invention. La chaîne d'émission 1, représentée à l'intérieur d'une ligne fermée en pointillé, comprend un générateur de fréquences 2 couplé à une antenne radio 3 par une chaîne de puissance 4 contrôlée par un dispositif de mise en forme et de régulation 5. La chaîne de puissance 4 comprend en entrée un bloc d'amplification 7 formé d'un premier amplificateur 8 en série avec un deuxième amplificateur 9 couplé à l'antenne radio 3 par un coupleur directionnel 10. Le dispositif de mise en forme et de régulation 5 comprend un dispositif de contrôle de niveau 14 connecté en entrée au coupleur directionnel 10 par une information de tension incidente vi et une information de tension réfléchie vr et connecté à un dispositif de comptage 15, en entrée par un bus de bits b0, ..., b6 et en sortie par un signal de contrôle STOP. Le dispositif de comptage 15 est connecté à un premier convertisseur numérique analogique 16 par un bus de bits b0, ..., b6 et est couplé à un deuxième convertisseur numérique analogique 17 par l'intermédiaire d'un circuit de combinaison 18. Le dispositif de mise en forme et de régulation 5 comprend aussi un dispositif sommateur 19 intercalé entre le premier convertisseur numérique analogique 16 et le deuxième amplificateur 9 et entre le deuxième convertisseur numérique analogique 17 et le premier amplificateur 8. Le premier amplificateur 8 et le deuxième amplificateur 9 sont chacun réalisés avec au moins un transistor du type TEC polarisé par un circuit de polarisation. Une première sortie du dispositif sommateur 19 dénommée commande d'autorisation à émettre V3, contrôle le point de polarisation du premier amplificateur 8. Une deuxième sortie du dispositif sommateur 19, dénommée commande de gain V2, contrôle le point de polarisation du deuxième amplificateur 9. Selon cette disposition, le générateur de fréquences 2 génère un signal pilote Vp à une fréquence déterminée fonction de la fréquence du signal à transmettre.

La mise en forme et la régulation de puissance du signal transmis par l'antenne radio 3 sont illustrées par la figure 3 qui représente des chronogrammes de différents signaux du dispositif. Ces chronogrammes correspondent à un cas général de fonctionnement du dispositif qui se déroule suivant la description suivante. Un signal enveloppe EHF résultant par exemple d'une action d'un opérateur qui aura choisi d'émettre un signal

pendant une durée T à un niveau de puissance Ps, passe d'un état inactif à un état actif à un instant t0. Ce changement d'état entraîne un passage à l'état inactif du signal de contrôle STOP généré par le dispositif de contrôle de niveau 14 et un positionnement du dispositif de comptage 15 en mode de comptage à partir de la valeur zéro. Ainsi, le dispositif de comptage 15 compte à partir de zéro au rythme d'une horloge H générée par un oscillateur non représenté et une valeur de comptage est codée sur le bus de bits b0, ..., b6. La valeur de comptage, codée par le bus de bits b0, ..., b6 est convertie sous forme analogique par le premier convertisseur numérique analogique 16 et le deuxième convertisseur numérique analogique 17. La sortie V4 du premier convertisseur numérique analogique 16 et la sortie V5 du deuxième convertisseur numérique analogique 17 ont l'allure d'une rampe. La sortie V5 du deuxième convertisseur numérique analogique 17 suit la même rampe que la sortie V4 du premier convertisseur numérique analogique 16. Mais la rampe correspondant à la sortie V5 du deuxième convertisseur numérique analogique 17 démarre seulement après le passage à 1 du septième bit b6 qui est combiné avec chacun des autres bits b0 à b5 dans le circuit de combinaison 18. Le résultat de la combinaison de chacun des bits b0 à b5 avec le septième bit b6 est transmis au deuxième convertisseur numérique analogique 17. La sortie V4 du premier convertisseur numérique analogique 16 et la sortie V5 du deuxième convertisseur numérique analogique 17 sont combinées par le dispositif sommateur 19 pour générer la commande d'autorisation à émettre V3 et la commande de gain V2. La disposition et la combinaison des deux convertisseurs numériques analogiques, 16 et 17, permettent d'augmenter la dynamique de la commande de gain V2 sans augmenter le nombre de bits en sortie du dispositif de comptage 15. La commande d'autorisation à émettre V3 contrôle l'état du premier amplificateur 8 en imposant un niveau déterminé de tension sur la grille du transistor du type TEC du premier amplificateur 8. Si le premier amplificateur 8 comporte plusieurs transistors du type TEC, la commande d'autorisation à émettre V3 est appliqué préférentiellement à tous les transistors du type TEC du premier amplificateur 8. Ainsi, entre les temps t0 et t5, la commande d'autorisation à émettre V3 est à un état actif, le premier amplificateur 8 fonctionne suivant un état dit saturé et le gain de tension du premier amplificateur 8 est fixe et

fonction du circuit de polarisation du transistor du type TEC du premier amplificateur 8. Lorsque la commande d'autorisation à émettre V3 est à un état inactif, avant le temps t0 et après le temps t5, le premier amplificateur 8 fonctionne suivant un état dit bloqué ; dans cet état le gain de tension du premier amplificateur 8 est nul, l'émission d'un signal est interdite. La commande de gain V2 résulte d'une addition du signal de sortie V4 du premier convertisseur numérique analogique 16 avec le signal de sortie V5 du deuxième convertisseur numérique analogique 17. La commande de gain V2 contrôle le gain de tension du deuxième amplificateur 9 en imposant un niveau de tension variable sur la grille du transistor du type TEC du deuxième amplificateur 9. Ainsi, la mise en conduction du deuxième amplificateur 9 est progressive entre les temps t0 et t2, le gain de tension du deuxième amplificateur 9 varie entre les temps t0 et t2. Au temps t1, le septième bit b6 passe d'un état inactif à un état actif, par conséquent la pente de la rampe que suit la commande de gain V2 est multipliée par deux. Au temps t2, le niveau de puissance mesuré P par la première information vi, a atteint le seuil Ps de puissance désirée. Le dispositif de contrôle de niveau 14 positionne le signal de contrôle STOP à un état actif pour stopper le comptage du dispositif de comptage 15. Au temps t2, le dispositif de comptage 15 a compté jusqu'à une valeur déterminée N à laquelle correspond un niveau déterminé V2s de la commande de gain V2. A partir du temps t2, le dispositif de comptage 15 suspend le comptage à cette valeur N tant que le signal de contrôle STOP est à un état actif. Au temps t3, le signal enveloppe EHF passe à un état inactif signifiant la fin d'émission. Entre les temps t2 et t3, le dispositif de comptage 15 reste en attente à la valeur N codée sur les bits b0 à b6. Dans ces conditions, la commande de gain V2 conserve la même valeur V2s qu'il avait au temps t2 et ceci pendant un intervalle de temps compris entre les temps t2 et t3. Ainsi, le niveau de puissance mesuré P au temps t2 par la première information vi reste constant pendant l'intervalle de temps compris entre les temps t2 et t3. Au temps t3, le changement d'état du signal enveloppe EHF, d'un état actif à un état inactif, entraîne le passage à un état inactif du signal de contrôle STOP et le passage en mode décomptage du dispositif de comptage 15. Entre les temps t3 et t5, le dispositif de comptage 15 décompte au rythme de l'horloge H. Au temps t4 le septième bit b6 passe d'un état actif à un état inactif, par

conséquent la pente de la rampe que suit la commande de gain V2 est divisée par deux. Au temps t5, le dispositif de comptage 15 a décompté jusqu'à zéro. Le dispositif de contrôle de niveau 14 détecte le passage à zéro en décodant le bus de bits b0, ..., b6. Après détection du passage à zéro, il positionne le signal de contrôle STOP à un état actif pour bloquer le dispositif de comptage 15 à la valeur zéro et maintenir ainsi simultanément la commande d'autorisation à émettre V3 et la commande de gain V2 à un niveau déterminé pour bloquer le premier amplificateur 8 et le deuxième amplificateur 9 jusqu'à l'émission suivante.

Le choix de la fréquence de l'horloge H est fonction des temps de montée et de descente désirés du signal émis, ainsi plus les temps de montée et de descente sont petits pour une dynamique donnée de la commande de gain V2 plus la fréquence de l'horloge H est grande. Le choix du nombre de bits nécessaires pour coder la dynamique maximale de la commande de gain V2 est effectué en fonction du pas de régulation voulu. Ainsi, plus le pas de régulation est petit, plus la puissance émise est proche du seuil Ps de puissance désiré plus le nombre de bits de codage est grand.

Dans le but de sécuriser le dispositif selon l'invention, un temps limite TL de montée en puissance est programmé initialement dans le dispositif de contrôle de niveau 14. Ce temps TL borne l'intervalle de temps compris entre les temps t0 et t2. Ainsi, le temps TL est le temps maximum alloué à la chaîne de puissance 4 pour atteindre le gain d'amplification nécessaire pour émettre un signal ayant la puissance Ps désirée. Toujours dans le but de sécuriser le dispositif selon l'invention, un niveau maximal de puissance émise autorisé est déterminé et programmé dans le dispositif de contrôle de niveau 14. Le niveau maximal de puissance émise autorisé est programmé sous le forme d'une valeur M de comptage du dispositif de comptage 15 à laquelle correspond un niveau de la commande de gain V2 dont la valeur permet d'obtenir ce niveau maximal de puissance émise. Ainsi seule cette valeur M est programmée initialement dans le dispositif de contrôle de niveau 14 pour limiter la puissance émise. Une évolution intéressante du dispositif selon l'invention consiste à programmer un niveau maximal de puissance émise pour chaque fréquence du spectre d'émission.

En plus du fonctionnement général, différents cas particuliers de fonctionnement peuvent se produire.

Un premier cas particulier de fonctionnement se produit quand, à la fin de l'intervalle de temps défini par le temps limite TL, le niveau de puissance émise mesuré P par la première information vi est toujours inférieur au niveau de puissance désiré Ps. Dans ce cas, le comptage du dispositif de comptage 15 est stoppé au temps TL à une valeur N atteinte et l'émission se poursuit comme dans le cas général en remplaçant sur les chronogrammes de la figure 3 le temps t2 par le temps TL.

Un deuxième cas particulier se produit quand il existe un brouilleur proche. Dans ce cas, pendant les instants où l'émission est interdite, avant le temps t0 ou après le temps t5, la valeur de puissance mesurée par la deuxième information vr correspond à la puissance d'un signal reçu sur l'antenne émis par une source qualifiée de brouilleur. La détection d'un brouilleur a lieu quand la deuxième information vr dépasse un seuil déterminé. Dans ces conditions, le niveau de puissance mesuré par la première information vi pendant les instants d'émission risque d'être erroné car entaché de la puissance du signal reçu sur l'antenne dû à la présence d'un brouilleur. Dans ce cas, après détection d'un brouilleur le dispositif de contrôle de niveau 14 ne tient pas compte de la première information vi mais tient compte d'une valeur de comptage programmée initialement dans le dispositif de contrôle de niveau 14 et il autorise le comptage du dispositif de comptage 15 jusqu'à ce que ce dernier ait atteint la valeur de comptage programmée. Dans ces conditions, le niveau de puissance émise est garanti en présence du brouilleur. Il n'y a pas d'étouffement du signal émis.

Dans une variante au procédé, le dispositif de comptage 15 est réalisé avec un boîtier programmable programmé pour générer un signal numérique de forme sinusoïdale ou de forme exponentielle et plus généralement, il est programmé pour générer toute forme décrite par un programme implanté dans le boîtier programmable.

Ainsi, le gain d'amplification de la chaîne de puissance 4 suit, en fonction du choix de l'opérateur ou en fonction des conditions d'exploitation (par exemple le dispositif de comptage 15 est configuré automatiquement en fonction d'une forme d'onde émise choisie par l'opérateur), une courbe ayant l'allure d'un créneau dont les flans sont une rampe ou un bout de sinusoïde ou un bout d'exponentielle par exemple.

Dans une autre variante au procédé, la commande d'autorisation à émettre V3 est le résultat de la superposition d'une rampe à une valeur constante de tension (négative dans le cas où le transistor du type TEC utilisé est bloqué avec une tension négative sur la grille, la source étant à la masse). Dans ces conditions, le déblocage et le blocage du signal HF émis est effectué, sans changement brusque, par le premier amplificateur 8.

REVENDICATIONS

1. Procédé de régulation de puissance et de mise en forme d'un signal transmis par une antenne radio (3) d'un émetteur radio, en présence ou non d'un signal de brouillage reçu par l'antenne radio (3), après amplification, par une chaîne de puissance (4) comprenant au moins un premier et un deuxième transistor du type à effet de champ équipé d'une grille, d'un signal pilote (V_p) généré par un générateur de fréquence (2) caractérisé en ce qu'il consiste :

- à interdire toute émission en bloquant le premier transistor en dehors des périodes d'émission définies par un signal extérieur (EHF),
- à autoriser une émission en débloquant le premier transistor au moyen d'une commande d'autorisation à émettre (V3),
- à amplifier progressivement en début d'émission pendant un temps déterminé le signal pilote (V_p) en commandant l'état de conduction du deuxième transistor par l'évolution suivant une première loi déterminée d'une commande de gain (V2) appliquée sur la grille du deuxième transistor jusqu'à ce que le signal transmis ait atteint un niveau de puissance déterminé correspondant à un gain d'amplification donné de la chaîne de puissance (4),
- à maintenir le gain d'amplification donné durant l'émission en suspendant l'évolution du niveau de la commande de gain (V2) pendant l'émission,
- à diminuer progressivement en fin d'émission le niveau de puissance du signal transmis en commandant l'état de conduction du deuxième transistor par l'évolution suivant une deuxième loi déterminée de la commande de gain (V2),
- à bloquer à nouveau le premier transistor en fin d'émission.

2. Procédé selon la revendication 1, caractérisé en ce que pour sécuriser le procédé d'une part le niveau de puissance transmis augmente en début d'émission pendant un temps déterminé qui est limité et d'autre part le niveau de puissance du signal transmis est limité.

3. Procédé selon l'une quelconque des revendications 1 et 2, caractérisé en ce qu'il consiste à mesurer un signal de brouillage (vr) reçu par l'antenne radio (3) pendant des intervalles de temps où il n'y a pas d'émission pour détecter un dépassement d'un seuil déterminé de brouillage de manière à augmenter le gain d'amplification de la chaîne de puissance (4) jusqu'à atteindre une puissance émise dont la valeur est initialement programmée.

4. Dispositif de régulation de puissance et de mise en forme d'un signal transmis par une antenne radio (3) d'un émetteur radio comprenant une chaîne de puissance (4) contrôlée par l'intermédiaire d'une commande d'autorisation à émettre (V3) et d'une commande de gain (V2) générées par un dispositif de mise en forme et de régulation (5) comprenant un dispositif de comptage (15) pour la mise en œuvre du procédé selon l'une quelconque des revendications 1 à 3 caractérisé en ce que la chaîne de puissance (4) comprend au moins un premier et un deuxième transistor du type à effet de champ équipé d'une grille commandée soit par la commande d'autorisation à émettre (V3), soit par la commande de gain (V2), les deux transistors étant destinés à amplifier et mettre en forme le signal transmis pendant des périodes d'émission définies par un signal extérieur (EHF), ce signal extérieur (EHF) déclenchant le comptage du dispositif de comptage (15) en début d'émission et le décomptage du dispositif de comptage (15) en fin d'émission, et en ce que l'évolution de la commande de gain (V2) peut être suspendue par une mise en attente du dispositif de comptage (15) déclenchée en fonction de critères déterminés.

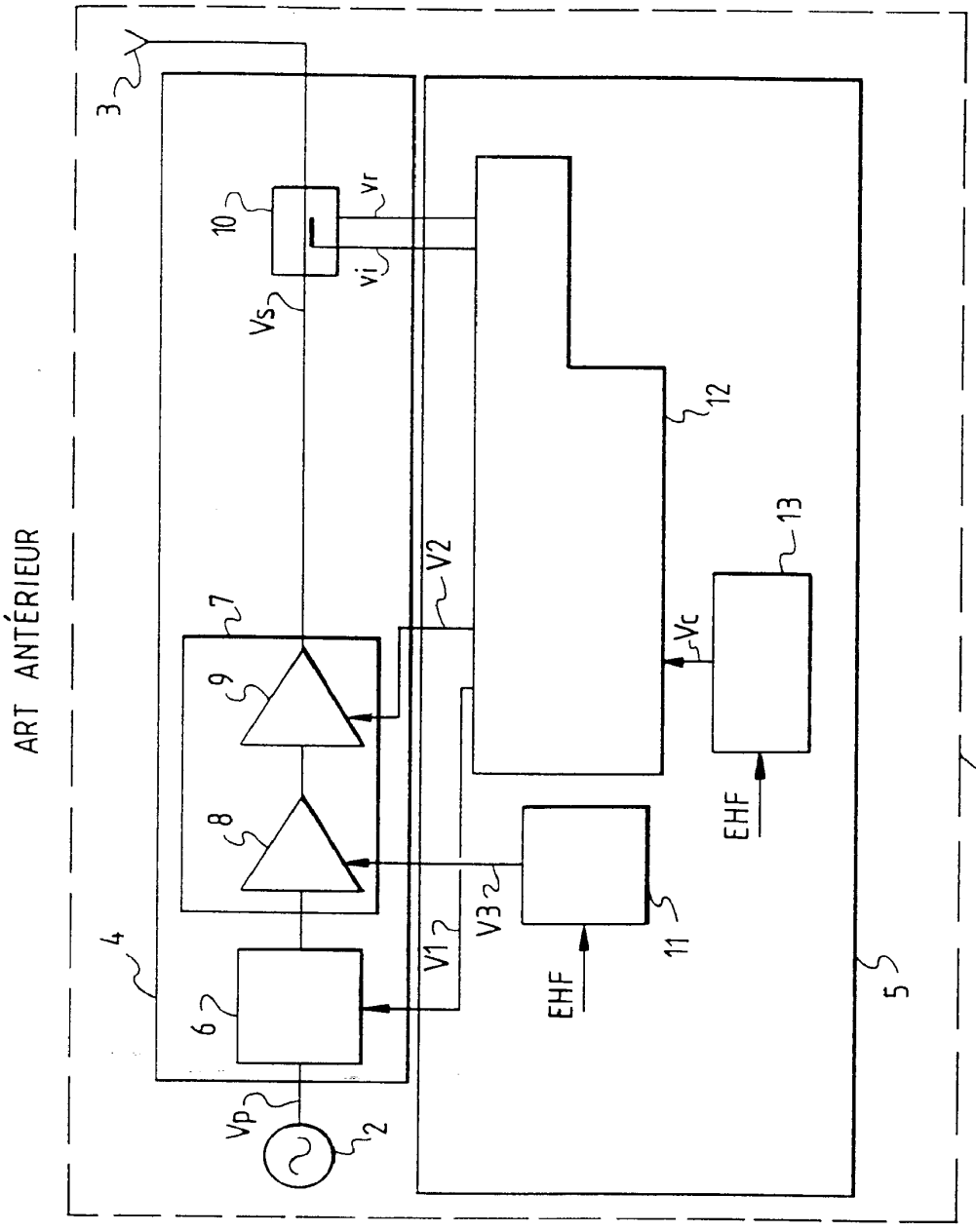

ART ANTÉRIEUR
3
10
Vr
Vi
Vs
12
13
V2
Vc
7
9
8
EHF
4
6
V1
V3
11
EHF
5
1
Vp
2

FIG.1

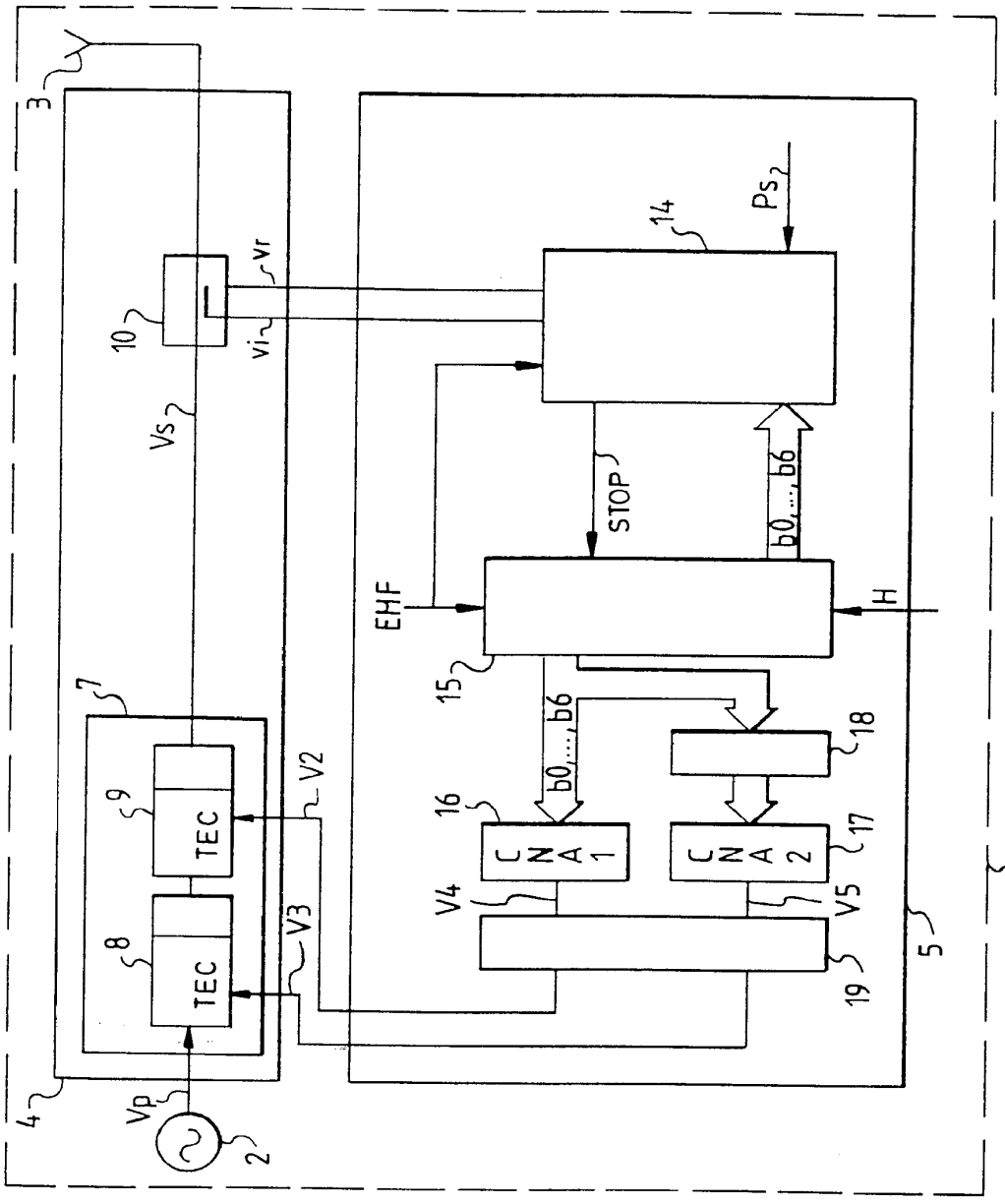

3
14
Ps2
10
Vr
Vi
Vs
STOP
b0,...,b6
EHF
H
15
7
9
TEC
V2
16
b0,...,b6
18
8
TEC
V3
CNA 1
CNA 2
17
V4
V5
19
5
1
4
Vp
2

FIG.2

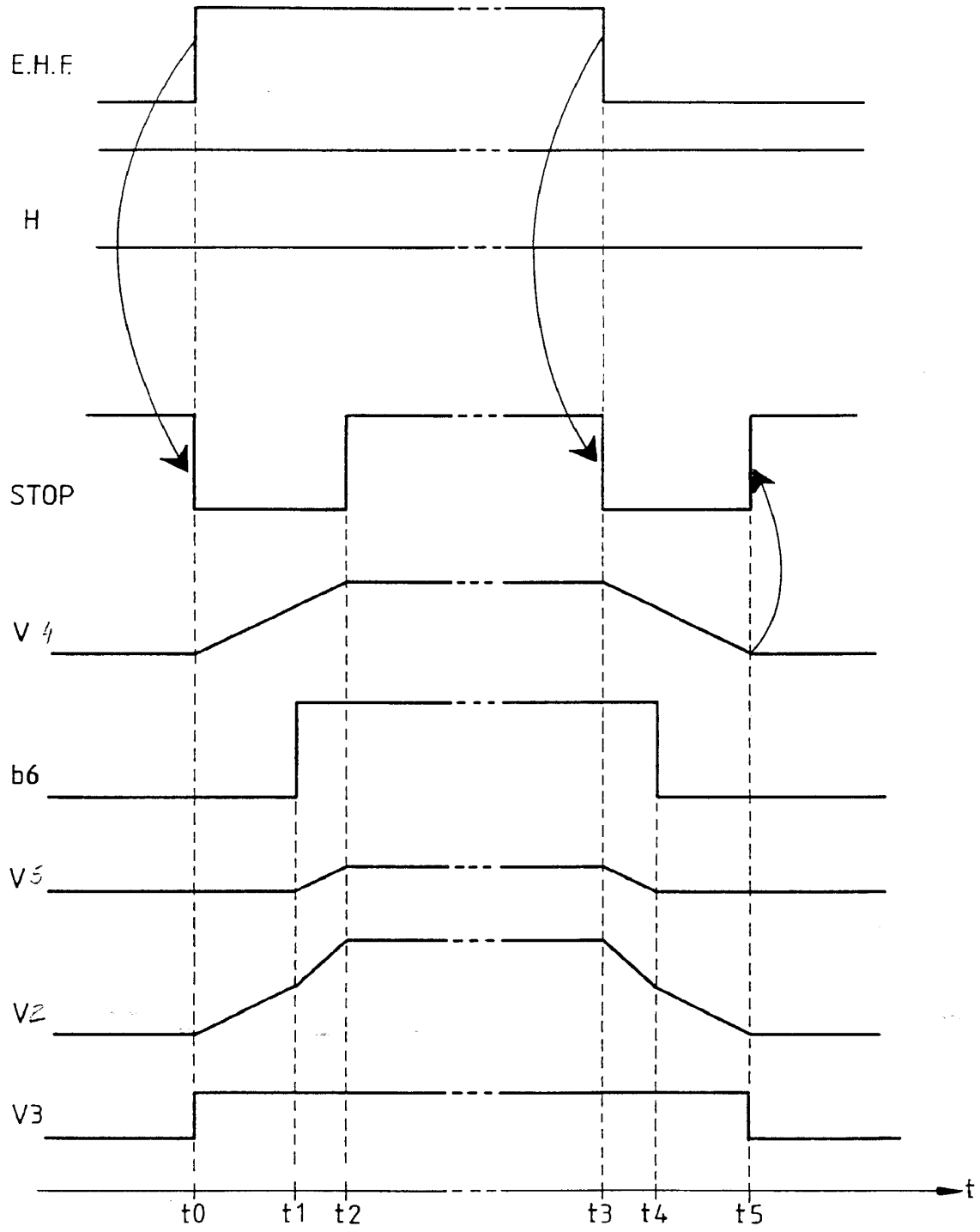


FIG.3

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/FR 97/02315

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H03G3/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H03G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 337 006 A (MIYAZAKI SHINICHI) 9 August 1994 see the whole document ---	1,2,4
A	EP 0 688 108 A (MITSUBISHI ELECTRIC CORP) 20 December 1995 see the whole document ---	1,2,4
A	EP 0 654 899 A (THOMSON CSF) 24 May 1995 see the whole document -----	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
9 April 1998	22/04/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Blaas, D-L

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter nal Application No
PCT/FR 97/02315

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5337006 A	09-08-94	AU 648916 B	05-05-94
		AU 2041592 A	21-01-93
		CA 2074115 A,C	20-01-93
		DE 69218314 D	24-04-97
		DE 69218314 T	14-08-97
		EP 0523718 A	20-01-93
		JP 5191180 A	30-07-93
		KR 9600351 B	05-01-96
EP 0688108 A	20-12-95	JP 8008768 A	12-01-96
		US 5566363 A	15-10-96
EP 0654899 A	24-05-95	FR 2712751 A	24-05-95

Form PCT/ISA/210 (patent family annex) (July 1992)

RAPPORT DE RECHERCHE INTERNATIONALE

Dem Internationale No
PCT/FR 97/02315

A. CLASSEMENT DE L'OBJET DE LA DEMANDE
CIB 6 H03G3/30

Selon la classification internationale des brevets (CIB) ou à la fois selon la classification nationale et la CIB

B. DOMAINES SUR LESQUELS LA RECHERCHE A PORTE

Documentation minimale consultée (système de classification suivi des symboles de classement)
CIB 6 H03G

Documentation consultée autre que la documentation minimale dans la mesure où ces documents relèvent des domaines sur lesquels a porté la recherche

Base de données électronique consultée au cours de la recherche internationale (nom de la base de données, et si cela est réalisable, termes de recherche utilisés)

C. DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie °	Identification des documents cités, avec, le cas échéant, l'indication des passages pertinents	no. des revendications visées
X	US 5 337 006 A (MIYAZAKI SHINICHI) 9 août 1994 voir le document en entier	1,2,4
A	EP 0 688 108 A (MITSUBISHI ELECTRIC CORP) 20 décembre 1995 voir le document en entier	1,2,4
A	EP 0 654 899 A (THOMSON CSF) 24 mai 1995 voir le document en entier	1

☐ Voir la suite du cadre C pour la fin de la liste des documents

☒ Les documents de familles de brevets sont indiqués en annexe

° Catégories spéciales de documents cités:

"A" document définissant l'état général de la technique, non considéré comme particulièrement pertinent

"E" document antérieur, mais publié à la date de dépôt international ou après cette date

"L" document pouvant jeter un doute sur une revendication de priorité ou cité pour déterminer la date de publication d'une autre citation ou pour une raison spéciale (telle qu'indiquée)

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"T" document ultérieur publié après la date de dépôt international ou la date de priorité et n'appartenant pas à l'état de la technique pertinent, mais cité pour comprendre le principe ou la théorie constituant la base de l'invention

"X" document particulièrement pertinent; l'invention revendiquée ne peut être considérée comme nouvelle ou comme impliquant une activité inventive par rapport au document considéré isolément

"Y" document particulièrement pertinent; l'invention revendiquée ne peut être considérée comme impliquant une activité inventive lorsque le document est associé à un ou plusieurs autres documents de même nature, cette combinaison étant évidente pour une personne du métier

"&" document qui fait partie de la même famille de brevets

1

Date à laquelle la recherche internationale a été effectivement achevée	Date d'expédition du présent rapport de recherche internationale
9 avril 1998	22/04/1998

Nom et adresse postale de l'administration chargée de la recherche internationale	Fonctionnaire autorisé
Office Européen des Brevets, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Blaas, D-L

Formulaire PCT/ISA/210 (deuxième feuille) (juillet 1992)

RAPPORT DE RECHERCHE INTERNATIONALE

Renseignements relatifs . membres de familles de brevets

Dem Internationale No
PCT/FR 97/02315

Document brevet cité au rapport de recherche	Date de publication	Membre(s) de la famille de brevet(s)	Date de publication
US 5337006 A	09-08-94	AU 648916 B	05-05-94
		AU 2041592 A	21-01-93
		CA 2074115 A,C	20-01-93
		DE 69218314 D	24-04-97
		DE 69218314 T	14-08-97
		EP 0523718 A	20-01-93
		JP 5191180 A	30-07-93
		KR 9600351 B	05-01-96
EP 0688108 A	20-12-95	JP 8008768 A	12-01-96
		US 5566363 A	15-10-96
EP 0654899 A	24-05-95	FR 2712751 A	24-05-95

Formulaire PCT/ISA/210 (annexe familles de brevets) (juillet 1992)

Espacenet

Bibliographic data: JPH09275351 (A) — 1997-10-21

PLURAL-MODE MOBILE RADIO EQUIPMENT

Inventor(s): ITO FUMIO; NAKAYAMA KEIICHI ± (ITO FUMIO, ; NAKAYAMA KEIICHI)

Applicant(s): MATSUSHITA ELECTRIC IND CO LTD ± (MATSUSHITA ELECTRIC IND CO LTD)

Classification: **- international:** ***H04B1/04; H04B1/40; H04W52/02; H04W88/02;*** (IPC1-7): H04B1/04; H04B1/40; H04Q7/38
- cooperative: Y02D70/40

Application number: JP19960110568 19960408

Priority number(s): JP19960110568 19960408

Also published as: CN1169089 (A)

Abstract of JPH09275351 (A)

PROBLEM TO BE SOLVED: To provide a mobile radio equipment operated for plural mobile communication systems in which increase in current consumption of power amplifiers is suppressed by bypassing an isolator with respect to a mobile communication system not needing any isolator. SOLUTION: Signals received from I, Q modulation input terminals 14, 15 respectively pass trough low-pass filters 12, 13, modulated by an orthogonal modulator 11, given to a variable gain amplifier 10, in which the gain is adjusted, the resulting signal passes through a low-pass filter 9 and converted into a radio frequency by a transmission mixer 7. Then the signal is given to a variable gain amplifier 6, in which the gain is adjusted and the result is given to a power amplifier 5. The output of the power amplifier 5 is selected so as to be led to an isolator 3 or bypass the isolator 3 by a high frequency switch 4 selected depending on a mobile communication system. Then the transmission wave is given to a shared equipment 2 and sent from an antenna 1 as a radio wave to a radio base station.

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号

特開平9－275351

(43)公開日　平成９年(1997)10月21日

(51)Int.Cl.[6]		識別記号	庁内整理番号	ＦＩ			技術表示箇所
Ｈ０４Ｂ	1/04			Ｈ０４Ｂ	1/04	Ｅ	
	1/40				1/40		
Ｈ０４Ｑ	7/38				7/26	１０９Ｇ	

審査請求　未請求　請求項の数１　ＦＤ　（全　３　頁）

(21)出願番号　特願平8－110568

(22)出願日　平成８年(1996)４月８日

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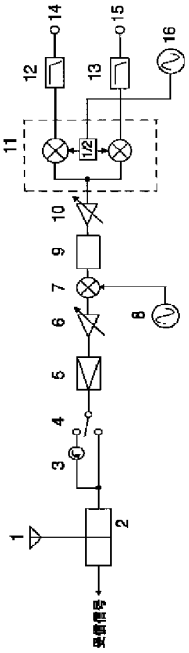
(74)代理人　弁理士　役　昌明　（外２名）

(54)【発明の名称】　複数モード移動無線機

(57)【要約】

【課題】　アイソレータが不要な移動通信システムに対してはアイソレータをバイパスすることにより、電力増幅器の消費電流の増大を抑えた複数の移動通信システムで動作する移動無線機を提供する。

【解決手段】　Ｉ、Ｑ変調入力端子14、15から入力された信号はそれぞれの低域通過フィルタ12、13を通過し、直交変調器11で変調され、可変利得増幅器10で利得調整され、低域通過フィルタ９を通過後、送信ミキサ７で無線周波数に変換される。その後、可変利得増幅器６で利得調整された後、電力増幅器５に入力される。電力増幅器５の出力は、移動通信システムによって切り替わる高周波スイッチ４によりアイソレータ３を介在させるか、バイパスさせるかの切り替えが行なわれる。その後、送信波は共用器２に入力され、アンテナ１から電波として無線基地局へ送信される。



【特許請求の範囲】
【請求項１】　異なった通信方式を使用する複数の移動通信システムに対し、変復調方式を前記複数の移動通信システムにより切り替えてアクセスできるようにした複数の通信方式で動作する移動無線機において、電力増幅器の出力側に前記複数の移動通信システムによって切り替わる高周波スイッチを設け、アイソレータが必要とされる移動通信システムに対してはアイソレータを介在させ、アイソレータが不要な移動通信システムに対してはアイソレータをバイパスさせることを特徴とする複数モード移動無線機。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、変復調方式を切り替えて複数の移動通信システムで動作するようにした複数モード移動無線機に関し、特にアイソレータが不要な移動通信システムに対してはアイソレータをバイパスして、電力増幅器の消費電流の増大を抑えた複数の移動通信システムで動作する移動無線機に関する。
【０００２】
【従来の技術】図２は従来の技術による、異なった通信方式を使用する複数の移動通信システムで動作する移動無線機の送信回路部の構成を示すものである。以下、この従来例の動作について図２とともに説明する。
【０００３】図２において、送信回路部は、アンテナ１と、共用器２と、アイソレータ３と、電力増幅器５と、可変利得増幅器６と、送信ミキサ７と、第１局部発振器８と、低域通過フィルタ９と、可変利得増幅器10と、直交変調器11と、Ｉ変調入力信号に対する低域通過フィルタ12と、Ｑ変調入力信号に対する低域通過フィルタ13と、Ｉ変調入力端子14と、Ｑ変調入力端子15と、送信変調用局部発振器16とから構成されている。
【０００４】Ｉ、Ｑ変調入力端子14、15から入力された信号は、それぞれの低域通過フィルタ12、13を通過し、直交変調器11で変調され、可変利得増幅器10で利得調整され、低域通過フィルタ９を通過後、送信ミキサ７で無線周波数に変換される。その後、可変利得増幅器６で利得調整された後、電力増幅器５に入力される。電力増幅器５の出力はアイソレータ３を通過した後、共用器２に入力され、アンテナ１から電波として無線基地局へ送信される。
【０００５】
【発明が解決しようとする課題】前記従来の構成においては、アイソレータを用いなければならず、アイソレータの通過損失を無視するわけにはいかない。つまり、アイソレータ前段までにこの損失を考慮した電力増幅レベルが必要であり、アイソレータが不要な移動通信システムに対しても電力増幅器の消費電流を増大させてしまい、通話時間が短くなるという問題があった。
【０００６】本発明は、このような従来の問題を解決するものであり、アイソレータが不要な移動通信システムに対してはアイソレータをバイパスすることにより、電力増幅器の消費電流の増大を抑えた複数の移動通信システムで動作する移動無線機を提供することを目的とするものである。
【０００７】
【課題を解決するための手段】前記の目的を達成するために本発明は、電力増幅器の出力側に高周波スイッチを設け、アイソレータが不要な移動通信システムに対しては、アイソレータをバイパスすることにより、電力増幅器の消費電流の増大を抑えるようにしたものである。
【０００８】
【発明の実施の形態】図１は、異なった通信方式を使用する複数の移動通信システムで動作する本発明の移動無線機の送信回路部のブロック図を示す。以下、この実施の形態の動作について図１とともに説明する。
【０００９】図１において、送信回路部は、アンテナ１と、共用器２と、アイソレータ３と、高周波スイッチ４と、電力増幅器５と、可変利得増幅器６と、送信ミキサ７と、第１局部発振器８と、低域通過フィルタ９と、可変利得増幅器10と、直交変調器11と、Ｉ変調入力信号に対する低域通過フィルタ12と、Ｑ変調入力信号に対する低域通過フィルタ13と、Ｉ変調入力端子14と、Ｑ変調入力端子15と、送信変調用局部発振器16とから構成されている。
【００１０】Ｉ、Ｑ変調入力端子14、15から入力された信号はそれぞれの低域通過フィルタ12、13を通過し、直交変調器11で変調され、可変利得増幅器10で利得調整され、低域通過フィルタ９を通過後、送信ミキサ７で無線周波数に変換される。その後、可変利得増幅器６で利得調整された後、電力増幅器５に入力される。電力増幅器５の出力は、移動通信システムによって切り替わる高周波スイッチ４によりアイソレータ３を介在させるか、バイパスさせるかの切り替えが行なわれる。その後、送信波は共用器２に入力され、アンテナ１から電波として無線基地局へ送信される。
【００１１】この構成において、アイソレータ３を必要としない移動通信システム（例えば、アナログセルラーシステム）に対しては、アイソレータ３をバイパスさせることができるので、アイソレータ３の通過損失（約０．７ｄＢ～１．０ｄＢ）の分だけ電力増幅器５の消費電流を低減させることができ、電池使用時間（通話時間）の長い、複数の通信方式で動作する移動無線機を実現できるものである。
【００１２】
【発明の効果】前記実施の形態の説明から明らかなように本発明は、アイソレータの不要な移動通信システム（例えば、アナログセルラーシステム）においては、アイソレータをバイパスし、電力増幅器の不要な消費電流の増加を抑えるとともに、アイソレータを必要とする移

動通信システム（例えば、デジタル変調セルラーシステム）においてはアイソレータを介在させるようにし、アイソレータの不要な移動通信システムにおいて、通話時間を長くすることができるという効果を有する。

【図面の簡単な説明】

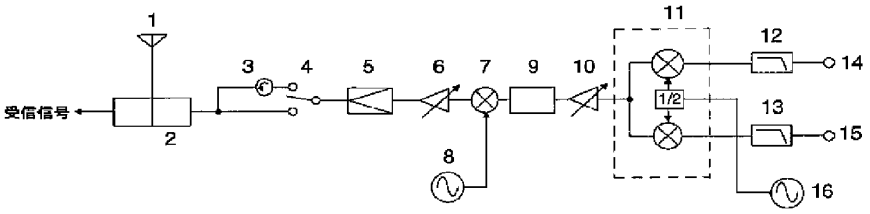
【図１】本発明の移動無線機の送信回路部の実施の形態を示す概略ブロック図、

【図２】従来の移動無線機の送信回路部を示す概略ブロック図である。

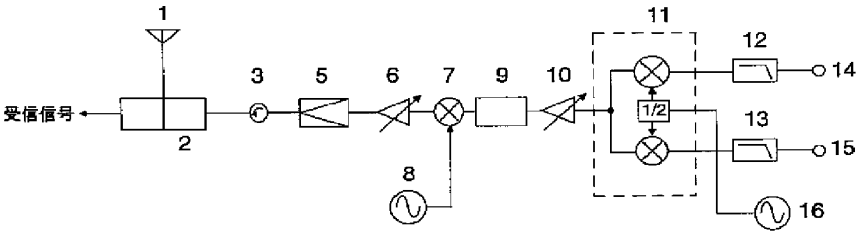
【符号の説明】

１　アンテナ
２　共用器
３　アイソレータ
４　高周波スイッチ
５　電力増幅器
６　可変利得増幅器
７　送信ミキサ
８　第１局部発振器
９、12、13　低域通過フィルタ
10　可変利得増幅器
11　直交変調器
14　Ｉ信号変調入力端子
15　Ｑ信号変調入力端子
16　送信変調用局部発振器

【図１】



【図２】



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(54) Electronic direction finder.

(57) An electronic direction finder (10), having a housing (11) with a major axis (18), has a GPS receiver (28) and directional (31) and omnidirectional (30) antennas and provides an electrical signal (angle A) indicative of the direction of the housing axis (18) with respect to a predetermined compass heading (North). The electrical signal (angle A) is provided by using determined positions of the GPS receiver (28) and one GPS satellite to calculate a compass bearing from the receiver (28) to the one satellite and using the directional antenna (31) to determine the orientation of the housing axis (18) with respect to the satellite. This eliminates using electrical output terrestrial magnetism sensing devices to sense direction finder/receiver orientation with respect to compass direction, and therefore avoids the inaccuracies and costs associated with such magnetism sensing devices.

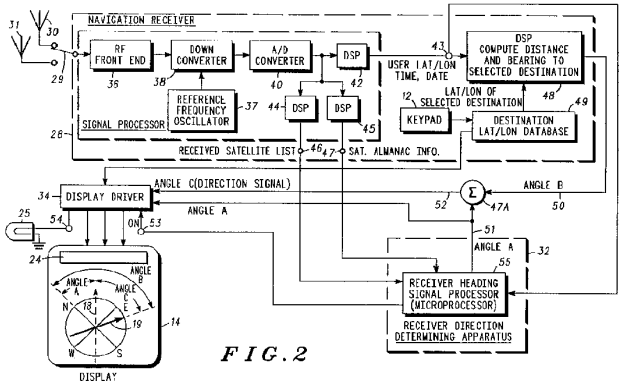


FIG. 2

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Cross Reference to Related Applications

The present invention is related to the apparatus disclosed in copending PCT patent application No. PCT/US92/03152 and entitled, "Electronic Direction Finder". The inventors of that copending application are George L. Lauro and Ralph E. Menick, and the application is assigned to same assignee as the present invention.

Field of the Invention

The present invention is generally directed to the field of electronic direction finders in which bearing/heading information is provided to a user with respect to the user's present heading and/or with respect to the heading which a user should follow to arrive at a desired destination.

Background of the Invention

Conventionally, magnetic compasses are used to sense terrestrial magnetism and provide a visual indication identifying at least one predetermined compass heading such as north, south, east or west. Recently, magnetic flux gate compasses have been utilized to sense terrestrial magnetism and to provide an electronic signal which identifies the predetermined compass direction. Because these devices operate in response to sensed terrestrial magnetism, they are somewhat inaccurate since they are subject to local disturbances and variations of the earth's magnetic field. In addition, the magnetic north sensed by such sensors does not, in general, correspond to the true north compass direction and therefore correction or calibration of the compass output may be required if accurate compass headings are to be achieved.

The electronic direction finder described in the above noted copending patent application utilizes a flux gate compass to provide an electronic signal indicative of the orientation of a global positioning system (GPS) receiver, and its visual display, with respect to a predetermined compass heading such as north. A signal is also generated which determines, which respect to predetermined compass directions, the direction, from the receiver, of a desired destination. The prior direction finder then provides on its display a rotatable pointer which provides a visual indication of the bearing towards a selected desired destination. The sensing of terrestrial magnetism by the flux gate compass determines the orientation of the GPS receiver with respect to compass directions and ensures the proper orientation of the displayed visual arrow to the desired destination.

The electronic direction finder described in the above identified copending patent application represents a substantial improvement over other direction finders currently available. It is contemplated that such a direction finder will be of a size so as to be hand holdable and therefore represent a portable navigation device usable by hikers and other pedestrians as well as usable by boaters. However, terrestrial magnetism sensors such as flux gate compasses are relatively expensive and their cost therefore might prevent the widespread adoption and commercial success of such a hand held GPS receiver. Also, the flux gate compass and its associated circuitry appreciably adds to the total size of a hand held GPS receiver when included therewith. In addition, sensing of terrestrial magnetism would also require calibration to correct for known variations of the earth's magnetic field. Also, such a system would be susceptible to errors in sensed magnetic field cause by local disturbances of the earth's magnetic field.

Thus there is a need for an electronic direction finder apparatus which is relatively inexpensive and small in size and does not utilize a flux gate compass or any sensing of terrestrial magnetism in order to produce an accurate visual display of compass directions and/or the direction to a desired destination.

Some prior direction systems rigidly mount two widely spaced omnidirectional antennas on a vehicle, such as a ship, and calculate the direction of the vehicle heading by calculating the position of each fixed antenna location. This is not practical for a small hand held direction finder device.

Summary of the Invention

In one embodiment of the present invention, an electronic direction finder is provided. The electronic direction finder includes a housing having a major axis; an omnidirectional antenna for receiving signals from at least three satellites; a navigation receiver fixed within the housing and coupled to the omnidirectional antenna for receiving the satellite signals therefrom and in response thereto determining the position of the receiver and also determining the position at least one of the satellites; directional antenna means, having a directional antenna pattern, fixed to and rotatable with the navigation receiver for also providing the satellite signals to the receiver; direction means for determining when the directional antenna pattern is oriented at a predetermined direction with respect to the at least one satellite; and means for providing an electrical signal indicative of the direction of the housing axis with respect to at least one predetermined compass heading when the directional antenna pattern is oriented at the predetermined direction by using the determined positions of the at least one satellite and of the receiver to calculate

a bearing from the receiver to the at least one satellite.

Preferably, the navigation receiver comprises a GPS receiver, the directional antenna means implements a directional antenna pattern having a single narrow band null and the electronic direction finder includes a display for providing a visual indication of the orientation of the housing axis with respect to the predetermined compass heading. In addition, preferably the electronic direction finder also includes means for generating a destination direction signal indicative of a bearing from the position of the receiver toward a desired destination, and the display, in accordance with the destination direction signal, provides a visible image of a pointer which points in the direction of the desired destination.

Brief Description of the Drawings

The present invention can be better understood by reference to the drawings in which:

FIG. 1 is a perspective view of a portable direction finder constructed according to the present invention;

FIG. 2 is a schematic block diagram of the direction finder shown in FIG. 1;

FIG. 3 is a more detailed schematic block diagram of one portion of the direction finder shown in FIG. 2;

FIG. 4 is a schematic diagram which illustrates details of a display driver shown in FIG. 2 and its associated resultant visual displays;

FIG. 5 is a flowchart illustrating the operation of the direction finder shown in FIGs. 1 and 2; and

FIG. 6 illustrates two possible directional antenna patterns which may be provided by a directional antenna shown in FIG. 2.

Description of the Preferred Embodiments

Referring to FIG. 1, a hand held portable direction finder 10 is shown whose housing 11 contains a keypad 12 and a visual display 14. The keypad 12 allows a user to input data regarding the latitude and longitude of the user's present position and the latitude and longitude of desired destinations (sometimes also referred to as waypoints). The keypad also enables the user to define as "HOME" a specific desired destination, which may correspond to the user's present position. The keypad includes a push button 15 that controls the on/off function of the portable direction finder 10 and a push button 16 by which a user may command the direction finder to generate an arrow to point in the direction of either "HOME" or some other specific desired destination. The keypad 12 includes a push button 17 labeled DIR. which corresponds to a direction push button that places the portable direction finder 10 in a direction finding mode. In the direction finding mode, the finder 10 provides a visual display indicative of the direction of a major axis 18 of the direction finder housing 11 with respect to a predetermined compass heading, such as true north. The term "compass heading" is used herein to indicate the navigational direction headings generally provided by a compass. However, the direction finder 10 is not contemplated as including a magnetic or flux gate compass or any other type of device which senses terrestrial magnetism to provide an electrical signal or a visual display indicative of compass headings. Other functions which are not especially pertinent to the basic functions of the finder 10 may also be actuated by the keypad 12.

If desired, a permanent graphic indication of the major axis 18 can be applied to the housing 11, such as by printing an arrow on the display 14 or by notching the housing. However, due to a preferred rectangular shape for the housing 11, this may not be necessary and no such permanent graphic indication is shown in FIG. 1. Fixed within the direction finder 10 is a navigation receiver and other circuits which will be discussed more fully below. These components enable the direction finder 10 to provide a visual arrow indication pointing towards either home or towards any other desired destination as selected by the push button 16.

Referring now to the display 14, this display generates an image of a pointer 19 which preferably is illustrated in the form of an arrow and which will point towards a desired destination, selected by the user, with respect to the user's heading. The term "user's heading" is considered herein to be a direction parallel to the major axis 18 of the direction finder housing 11. Thus, with the user facing in the direction of the axis 18, the pointer 19 shown in FIG. 1 clearly indicates that the user should turn to the right approximately 75° in order to be heading towards a desired destination. If the user is facing directly towards the desired destination the pointer 19 will point directly along the axis 18. In such a pointing system the user does not need to be familiar with compass or navigation terminology in order to determine the direction of a route towards the desired destination.

The display 14 also generates the image of a compass card which indicates at least one compass point or predetermined compass heading such as north (N). In the illustrated embodiment, the compass card includes a circle 20, the compass points N, S, E and W, and a pair of orthogonal line segments 21 and 22 connecting to N to S and E to W, respectively. In response to circuitry within the direction finder 10, the image of the compass card rotates around a center point 23

of the circle 20 so that the compass point N and the line segment 21 line up with the predetermined compass heading of true north. The location of the visual compass point N is indicative of the difference between the direction of true north and the housing axis 18. This arrangement provides the user not only with the easy to read pointer 19, but also with a visual compass display to provide additional navigation information. Because the pointer 19 is overlayed on the image of the compass card, and because the pointer 19 is also rotatable about the card's center 23, the compass heading of the desired destination can be read directly from the display.

It should be noted that the complexity of the compass card visual display may be modified to provide any desired degree of resolution. For example, only a single compass point N and the orthogonal line segments 21 and 22 could be illustrated if less resolution is required, whereas additional compass points may be added along with additional axes corresponding to additional line segments if greater resolution is required.

With the exception of the push buttons 16 and 17, what is shown in FIG. 1 and explained above directly corresponds to the electronic direction finder described in copending PCT patent application No. PCT/US92/03152 to George L. Lauro and Ralph E. Menick entitled, "Electronic Direction Finder" and assigned to the same assignee as the present invention. That copending application describes circuitry within the direction finder which produces the above described displays through the use of a magnetic flux gate compass which senses the earth's magnetic field to provide information regarding the orientation of the major axis 18 with respect to true compass north direction. Because the copending application describes details of the production of such a visual display the entire contents of that application is hereby incorporated by reference so as to minimize the amount of invention description provided herein.

Essentially, the present invention is directed to an improved direction finder in which the need for a flux gate compass or other type of magnetic field sensing compass is eliminated. This reduces the cost of the electronic direction finder, enhances its accuracy by avoiding errors due to local magnetic field disturbances and variations and results in a reduction in size for the direction finder since space does not have to be provided for the flux gate compass. All this is achieved by operation of the circuitry within the direction finder 10 wherein this circuitry is illustrated in FIG. 2 and will be subsequently described.

Before reciting the detailed operation of the circuitry within the direction finder 10 with regard to FIG. 2, it should be noted that FIG. 1 also illustrates, as part of the visual display 14, a display portion 24 which will identify the destination to which the pointer 19 will point. Thus the display portion 24 may comprise destination name graphics such as "HOME" or other terminology identifying the name of a particular destination and/or it may display the latitude and longitude of a specific destination. In addition, the display 14 includes an indicator light 25 adjacent which is the graphic label "REFERENCE SATELLITE LOCK". When the portable direction finder 10 shown in FIG. 1 is oriented such that it can produce an appropriate visual display 14, then indicator light 25 will be actuated so as to provide an indication that the finder 10 can now provide desired pointer arrows to destinations, such as arrow 19, as well as providing an indication of compass headings with respect to the major axis 18 of the direction finder housing. All this will be explained in connection with the operation of the circuitry shown in FIG. 2 which will now be described.

Referring to FIG. 2, the major components of the direction finder 10 comprise the display 14, a navigation receiver 28 fixed within the housing 11 and coupled via a selector switch 29 to either an omnidirectional receiving antenna 30 or a directional receiving antenna 31, a receiver direction determining apparatus 32 and a display driver 34. Generally speaking, the navigation receiver 28 and the receiver direction determining apparatus 32 generate signals that are combined so as to generate a "direction signal". This direction signal is indicative of a bearing towards a desired destination of the user, and the bearing is relative to the user's heading which corresponds to the orientation of the major axis 18 of the direction finder 10. The major axis of the housing 11 coincides with and is sometimes also referred to herein as the major axis of the finder 10. The "direction signal", which in FIG. 2 is identified as angle C, is applied to the display driver 34 which causes the display 14 to generate the image of the rotatable pointer 19 overlayed on the image of a compass card and to cause the pointer 19 to point in the direction of the desired destination.

Referring now to the navigation receiver 28, this preferably is a GPS receiver which may be of conventional construction. Preferably the GPS receiver 28 has a signal processing section that includes an RF front end 36 connected to a down converter mixer 38 which receives a reference frequency signal from an oscillator 37. The output from the down converter 38 is applied to an A/D (analog to digital) converter 40 and from there to a DSP (digital signal processor) 42. The DSP 42 provides an output signal at an output terminal 43 indicative of the user's latitude and longitude which therefore is indicative of the location of the direc-

tion finder 10. The time and date are also customarily provided as part of the output of the DSP 42 and are so indicated in FIG. 2. Conventional GPS receivers all have a digital signal processor corresponding to the DSP 42 which provides the receiver location, time and date signals provided at the terminal 43.

In addition, the GPS receiver 28 includes additional digital signal processors (DPSs) 44 and 45 connected to the output of the A/D converter 40. The DSP 44 provides at a terminal 46 information identifying all of the global positioning satellites which are transmitting signals currently being received by the GPS receiver 28. The DSP 45 provides location information about every GPS satellite at an output terminal 47 which information is conventionally termed "Satellite Almanac Information". This Satellite Almanac Information comprises equations which, when combined with actual time of day, exactly define the location of every GPS satellite. The DSPs 44 and 45 are conventional and are present in every GPS receiver. The GPS satellites repetitively broadcast the satellite almanac equations and that is how the DSP 45 provides this information at the terminal 47. In addition, each GPS satellite broadcasts information identifying its transmitted signals as being transmitted by a specific one of the GPS satellites. In order for the DSP 42 to determine the location of the GPS receiver it compares signals it receives from each one of at least three different GPS satellites and therefore the navigation receiver 28 knows the identity of each transmitting satellite which it is receiving signals from. Therefore the DSP 44 merely provides a list of all of these satellites which are currently sending signals received by the receiver 28, and this is the information provided at terminal 46.

The GPS navigation receiver 28 includes another conventional DSP 48 which receives two inputs, one from the DSP 42 (terminal 43) and a second input from a database 49 that contains the latitudes and longitudes of various waypoints or destinations, as input by the user via the keypad 12. Operating conventionally, the DSP 48 uses those inputs to compute the distance and the bearing, with respect to a compass direction such as north, to the destination selected by the user. The computed bearing to the destination is provided on lead 50 as a signal angle B. The signal angle B is generally indicated on the display 14 as shown in FIG. 2, and angle B represents the bearing angle, relative to due north, to the location of the desired destination. Angle B is not used directly to provide the pointer 19. Instead, it is applied as one input to a conventional combining circuit 47, the other input to which is developed by the receiver direction determining apparatus 32.

Preferably the receiver direction determining apparatus 32 replaces the flux gate compass shown in the above referred to copending patent application. Because of this, the direction finder 10 described herein is smaller, less expensive and less subject to error than the direction finder described in the previously noted copending patent application. The basic function of the receiver direction determining apparatus 32 is to provide a direction angle A signal which is indicative of the orientation of the direction finder 10 (more specifically the orientation of the major axis 18 of the direction finder housing 11) with respect to true north compass direction. Angle A is generally indicated on the display 14 shown in FIG. 2.

The providing of angle A is achieved in the finder 10 without the use of a flux gate compass and in fact without the use of any terrestrial magnetism sensing apparatus. Because of this, there is no need to correct a sensed angle A due to known variations in the earth's magnetic field and there is no way that local unknown disturbances in the earth's magnetic field can affect the accuracy of the angle A. In the prior direction finder, a local disturbance of the magnetic field of the earth, such as the presence of the side panel of a large truck next to the direction finder or the presence of magnetic rocks on the ground located near the direction finder, could cause a substantial error. This is not the case with regard to the present receiver direction determining apparatus 32. Also, the use of a magnetic field sensor in prior direction finders required the use of a magnetic anomaly correction circuit to correct for known variations in the Earth's magnetic field, and such a correction circuit is not needed if receiver direction is derived without sensing terrestrial magnetism. The detailed operation of the receiver direction determining apparatus 32 will be described subsequently.

To develop the signal angle C which represents the direction of the desired destination with respect to the user's heading, the output of the receiver direction determining apparatus, comprising the angle A, is provided on a lead 51 which is connected as a second input to the combining circuit 47. The angle A signal is also provided as an input to the display driver 34. The combining circuit 47 functions such that angle A is subtracted from angle B to produce angle C on a lead 52. The signal representing angle C is the "direction signal" that causes the pointer 19 to point in the direction of the user's desired destination. The relationship between the angles A, B and C is best shown in FIG. 2 with regard to its illustration of the display 14. From this display illustration it is clear that angle A represents the orientation of the major axis 18 of the finder housing 11 with regard to the true compass direction north and angle B represents

the calculated bearing of the desired destination with regard to the true compass direction north. Angle C, which is the difference of angles B and A, represents the direction of the desired destination with respect to the major axis 18 of the direction finder housing 11.

Referring now to the display driver 34, this includes conventional circuitry, such as logic circuitry and/or a microprocessor, for driving the display 14 and for using the signals representing the angles A and C to activate appropriate portions of the display 14. The above noted copending application explains in detail how a display driver, such a the driver 34, can provide suitable visual displays so as to implement all of the displays discussed above. Therefore, substantial discussion of the operation of the display driver 34 will not be provided herein. However, it should be noted that the display driver 34 is only activated when it receives an ON signal at an input terminal 53 wherein the receiver direction determining apparatus 32 provides such a signal. In addition, the display driver, besides providing the visual displays indicated by the display 14 shown in FIG. 2, also provides at an output terminal 54 an excitation signal, which essentially corresponds to the signal at the terminal 53, and this results in illuminating the reference satellite lock lamp 25 shown in FIGs. 1 and 2. It should be noted that the lamp 25 may also be considered as part of the display 14.

Referring now to FIG. 3, the operation of the receiver direction determining apparatus 32 will now be described with respect as to how this apparatus enables the direction finder 10 to produce an electrical signal (angle A) on line 51 indicative of the predetermined direction the finder housing axis 18 with respect to the predetermined compass heading of north. This occurs by the receiver direction determining apparatus 32 using the predetermined positions of at least one satellite and of the receiver 28 to calculate a bearing, with respect to true north, from the receiver to the one satellite. This results in the creation of the angle A signal provided on line 51 when the major axis 18 is aligned in the direction of the predetermined one of the satellites which transmitted GPS information to the receiver 28. The receiver direction determining apparatus 32 essentially comprises a receiver heading circuit or signal processing microprocessor 55. FIG. 3 represents in block form the basic functions of that circuit or the basic functional programming of a microprocessor which implements those functions.

Referring to FIG. 3, the information at terminal 46, which comprises a list of all satellites having GPS signals being received by the GPS receiver 28, is provided to both a satellite null detector 56 and an optimal satellite selector 57. The optimal selector 57 also receives as an input the satellite almanac equation data provided at the terminal 47. The optimal satellite selector 57 also receives from the terminal 43 information as to the location of the GPS receiver and the current time. Based on all of these inputs provided to the optimal satellite selector 57, this component selects as an optimal satellite one satellite close to the horizon as viewed from the GPS receiver location but a few degrees, such as 10, above the horizon wherein the selected satellite is one of the satellites currently transmitting GPS information to the GPS receiver. The calculations provided by the optimal satellite selector are possible because the received almanac data identifies, in conjunction with the current time of day provided at the terminal 43, the location of every satellite. The information at the terminal 46 identifies those satellites that are currently being received by the receiver 28 and therefore this narrows down the list of possible satellites to be selected. Other criteria also may be utilized in selecting the optimal satellite if two satellites are identified as having the same approximate azimuth height above the horizon, such as selecting as the optimal satellite the one of these two satellites which transmits the largest strength signal to the receiver 28. Information identifying which satellite has been selected as the optimal satellite by the selector 57 is provided to both the satellite null detector 56 and a satellite direction calculator 58. The satellite direction calculator 58 also receives an input from the terminal 43 which defines the location of the receiver 28 and the time of day.

Essentially, the satellite null detector 56 receives a list from terminal 46 of all satellites currently transmitting GPS signals received by the navigation receiver 28. It also receives identification information as to the specific one optimal satellite selected by the optimal satellite selector 57. Whenever the satellite null detector 56 determines that the selected satellite identified by the selector 57 is no longer one of the satellites transmitting signals that are received by the receiver 28, it will produce a null detection signal at an output terminal 59 and this is provided as an input to the satellite direction calculator 58. In response to this null detection, the satellite direction calculator 58 will calculate the direction, with respect to true north, between the receiver location and the location of the optimal satellite selected by the selector 57 and provide this bearing data as an output (angle A) at a terminal 60.

The signal at terminal 60 will correspond to the angle A that represents the angle between true north and the axis 18 of the direction finder housing 11. This is because the satellite null detector will produce a null indication when the switch 29 is switched from its omnidirectional antenna 30 to its

directional antenna 31 and the directional antenna pattern of the directional antenna 31 will be positioned such that it has a null directed towards the low horizon satellite selected by the optimal satellite selector 57. At the same time that the satellite null detector 56 activates the satellite direction calculator 58, the satellite null detector 56 will also actuate a display and lock light turn-on driver 61 that provides the turn-on signal to the terminal 53 to actuate the display driver 34. These operations are perhaps best understood by reference to the overall flowchart shown in FIG. 5 and the directional antenna patterns shown in FIG. 6.

Referring to FIG. 5, an overall flowchart 70 of the operation of the direction finder 10 is illustrated. The flowchart begins at a receiver turn-on step 71 corresponding to actuation of the push button 15 which provides power to the GPS receiver 28. With power applied to the receiver 28, initially the switch 29 is connected such that the omnidirectional antenna 30 is connected to the GPS receiver. Thus the receiver 28 receives GPS signals from all satellites which are operational and able to transmit signals to the receiver 28 based on the position of the satellites and the position of the receiver. From block 71, process flow continues to block 72 which determines the navigation receiver position and the time of day. This corresponds to the operation of the DSP 42 which, as is the case in conventional GPS receivers, receives signals from a plurality of at least three GPS satellites and in response thereto provides a signal indicative of the position of the receiver and also provides a time of day signal wherein these signals are provided at the terminal 43 in FIG. 2. After process block 72, control proceeds to process block 73 by which the optimal satellite selector 57 will select one of the satellites transmitting signals to the navigation receiver 28 as an optimal satellite wherein this optimal satellite will be utilized for providing a heading fix for the direction finder 10.

After the process block 73, control passes to a process block 74 which corresponds to the user of the direction finder 10 pressing the direction button 17. This causes the receiver 28 to enter into a direction finder mode. After block 74, as part of the direction finder mode, a process block 75 stores and maintains angle B provided by the DSP 48 and the block 75 switches the RF front end 36 of the GPS receiver from the omnidirectional antenna 30 to the directional antenna 31 via movement of the switch 29.

Referring now to FIG. 6, two somewhat different directional antenna patterns are shown as patterns 100 and 101 each of which representing a single narrow band null antenna pattern with the single narrow band null generally corresponding to the major axis 18 of the direction finder housing 11. Pattern 100 is drawn basically as a completely omnidirectional pattern except for a single very narrow band null which is coincident with the axis 18, whereas pattern 101 has more of a cardiod shape also with single narrow band null coinciding with the axis 18 of the direction finder housing 11. Either of these two antenna patterns can be provided for the directional antenna 31 by conventional directional antenna construction. It should be noted that the directional antenna 31 is contemplated as being fixed to and rotatable with the navigation receiver 28 such that any change in the orientation of the directional antenna 31 and its antenna pattern (100 or 101) corresponds to an identical change in the orientation of the direction finder 10 and the major axis 18.

Referring again to FIG. 5, after the process step 75, control passes to a process step 76 which corresponds to the user rotating the receiver 28 (comprising the direction finder 10) up to a maximum of 360° along the horizon until the user will note that the reference satellite lock light is actuated. This corresponds to the GPS receiver 28 receiving all prior received GPS satellite signals except for satellite signals from the optimal selected satellite which is now directly in-line with the major axis 18 of the direction finder housing. When the direction finder 10 points the major axis 18, coinciding with a directional antenna pattern null, towards the selected optimal satellite, the display and lock light turn-on driver 61 will result in actuating the lamp 25 indicating that the direction finder axis 18 is pointing towards the known selected satellite. Substantially at the same time, the process block 77 in FIG. 5 will calculate the direction finder housing axis 18 direction with respect to a predetermined compass heading based on the known receiver and optimal satellite positions. This is accomplished by the satellite direction calculator 58 which operates in a manner similar to the conventional DSP 48 that computes a bearing direction from the receiver to a selected destination with respect to true north based on the position of the receiver and the position of the selected destination. The only difference with regard to the operation of the satellite direction calculator 58 shown in FIG. 3 is that now the selected destination is the location of the optimal selected satellite. The location of the optimal satellite is known based on the GPS almanac information which is always transmitted to the GPS receiver and defines the positions of all of the GPS satellites at any known time.

After the process block 77 control passes to process block 78 which corresponds to the display 14 providing a visual display of the cardinal compass points such as north, south, east and west, as shown in FIG. 2, with respect to the axis 18. With just this display the user now can identify the

direction of true north just based on the visual display 14 provided by the direction finder 10. In order for this step and all the subsequent steps in the flowchart 70 to be accurate, this will only occur when the direction finder 10 and GPS receiver 28 are maintained with respect to their orientation towards the optimal selected satellite. If this orientation is not maintained, the satellite null detector 56 will no longer provide a null detection signal at the terminal 59 and therefore the display driver 61 will no longer provide an on signal at the terminal 53 actuating the display 14 and the lamp 25. In other words, after satellite lock is obtained, the display 14 will only be correct when the axis 18 of the finder 10 is maintained at its prior lock direction orientation. It is assumed that the latitude and longitude position of the finder 10 is maintained after block 74 to insure no changes to angle B.

After the process block 78, control passes to a process block 79 which allows the user to press the home/destination button 16 when he desires the creation of a vector pointer towards a desired destination, such as HOME or some other destination the location of which has been input into the direction finder 10. After step 79, and assuming that push button 16 has been actuated, control passes to a process block 80 which results in displaying an arrow on the display 14 directed towards the desired destination wherein this arrow corresponds to the arrow 19. At the same time, a process block 81 represents the display portion 24 displaying the name and/or latitude and longitude of the destination to which the arrow 19 is pointing. A final process block 82 indicates that the user may now select other destinations and have a visual display representing the direction to that destination and the name of that destination provided or he may then terminate the direction mode preferably by again actuating the direction push button 17 so as to return the navigation receiver 28 to its omnidirectional antenna and terminate the satellite null detection provided by the satellite null detector 56.

A review of the preceding description reveals that the direction finder 10 functions by utilizing a directional antenna pattern to determine when a major axis of the direction finder housing is orientated at a single predetermined direction with respect to one selected GPS satellite. Then an electrical signal corresponding to the angle A is provided which is indicative of the predetermined direction of the finder housing axis with respect to a predetermined compass heading such as north. The angle A signal is provided by using the determined positions of the selected satellite and the direction finder to calculate the bearing from the the finder 10 to the selected satellite. Preferably the directional antenna pattern 100 or 101 has one narrow band null, and preferably the entire navigation receiver and direction finder 10 is dimensioned so as to be hand holdable. The display 14 and lamp 25 preferably provide a visual indication of when the receiver 28 and finder 10 are oriented at a predetermined direction with respect to the selected satellite. Note that the detection of a loss of a GPS signal by use of a directional antenna pattern having a narrow band null is preferable to the detection of reception of a GPS signal on a high gain narrow band directional antenna pattern. This is because detecting reception of a GPS signal would require a signal lock up time which is not needed to detect a loss of GPS signal. Thus null detection is preferred for the direction determining apparatus 32.

While in the preceding description it is noted that the finder 10 axis 18 coincides with a single null in the directional antenna pattern 100 or 101, obviously as long as any angular difference between the null and the axis is fixed and known, the magnitude of the angle A signal can be corrected to compensate for any such fixed offset. Also, in addition to providing a visual display for the finder housing that indicates true compass direction with respect to the axis 18 of the direction finder 10, clearly the present apparatus can also be used in conjunction with generating at least one destination direction signal indicative of a bearing, with respect to the axis 18, from the position of the receiver towards a desired destination, and the display 14 can provide a visual display, such as the pointer 19, so as to point in the direction of the desired destination. By means of the push button 16, clearly a user can select any one of a plurality of destinations to which the visual pointer 19 will point at, and the rest of the keyboard 12 enables the user to enter data defining the location of such desired destinations since most prior GPS receivers which are part of navigation systems allows the user entry of a plurality of different desired destinations or waypoints. All this is achieved without the use of a flux gate compass or any other terrestrial magnetism sensing apparatus because of the use of the locations of the GPS receiver and a selected satellite in conjunction with the use of a directional antenna. Thus the cost of a magnetic sensing device and the cost of correcting the inherent anomalies provided by such a magnetic sensing device, when such anomalies are correctable, is avoided and a much more accurate and less expensive direction finder is provided.

Note that there is no detailed description of the apparatus shown in FIG. 4 since the above noted copending patent application fully explains how a display driver such as the display driver 34 in FIG. 4 is utilized to produce a display similar to display 14, except for the following. The present display

driver 34 is turned on via the input from terminal 53, and the lighting of the lamp 25 is directly in response to the excitation signal at the terminal 54 which directly corresponds to the signal at the terminal 53. Clearly this requires no additional explanation. In addition, the present display driver 34 provides a visual indication of the name of a selected destination on the display portion 24. The providing of a graphic indication on display portion 24 identifying the name of the selected destination to which the pointer 19 will point is also conventional since any display driver, such as the driver 34, can produce such a visual indication by utilizing techniques as are conventionally used in display monitors. The information as to the name of the destination to be displayed in the portion 24 is provided by the destination database 49 which, in addition to supplying the latitude and longitude information to the DSP 48, also supplies destination name information and/or destination latitude and longitude information to the display driver 34. This connection is shown in FIG. 2.

While we have shown and described specific embodiments of this invention, further modifications and improvements will occur to those skilled in the art. One such modification could be to use different known phasing between fixed antenna elements mounted on the finder 10 to control the generation and automatic sweeping of a directional antenna pattern having a null. The automatic sweeping would cease when the null was pointing at the selected satellite, and the known phasing would determine the angular offset between the axis 18 and the direction of the null. This offset would be used to provide a corrected angle A. All such modifications which retain the basic underlying principles disclosed and claimed herein are within the scope of this invention.

Claims

1. Electronic direction finder (10) comprising:

a housing (11) having a major axis (18);

an omnidirectional antenna (30) for receiving signals from at least three satellites;

navigation receiver (28) fixed within said housing (11) and coupled to said omnidirectional antenna (30) for receiving said satellite signals from said omnidirectional antenna and in response thereto determining (at 43) the position of the receiver (28) and also determining (at 47) the position of at least one of the satellites; said finder (10) characterized by the combination of

directional antenna means (31), having a directional antenna pattern (100 or 101), fixed to and rotatable with said navigation receiver (28) for also providing said satellite signals to said receiver;

direction means (56) for determining when said directional antenna pattern is oriented at a predetermined direction with respect to said at least one satellite; and

means (57,58) for providing an electrical signal (A) indicative of the direction of said housing axis (18) with respect to at least one predetermined compass heading when said directional antenna pattern is oriented at said predetermined direction by using the determined positions of said at least one satellite and of said receiver to calculate a bearing from said receiver to said at least one satellite.

2. Electronic direction finder according to claim 1 wherein said directional antenna pattern (100 or 101) has at least one narrow band null and wherein said direction means (56) determines when said narrow band null is directed towards said at least one satellite.

3. Electronic direction finder according to claim 2 wherein said navigation receiver (28) and housing (11) are dimensioned so as to be hand holdable.

4. Electronic direction finder according to claim 2 which includes display means (14,25) coupled to said navigation receiver (28) for providing a visual indication indicative of when said directional antenna pattern (100 or 101) is oriented at said predetermined direction with respect to said at least one satellite.

5. Electronic direction finder according to claim 4 wherein said display means (14) also includes means (20,21,22,34) for providing, in accordance with said electrical signal (A), a visual indication of the orientation of said housing axis (18) with respect to said one predetermined compass heading.

6. Electronic direction finder according to claim 5 wherein said navigation receiver (28) includes means (47A) for generating at least one destination direction signal (C) indicative of a bearing from the position of the receiver (28) toward a desired destination, and wherein said display means (14), in accordance with the destination direction signal, provides a visible image (19) of a rotatable pointer and causes the pointer to point in the direction of the desired destination.

7. Electronic direction finder according to claim 6 which includes means (16) for a user selecting said desired destination to which said rotatable

pointer will point.

8. Electronic direction finder according to claim 7 which includes means (15,16,17, rest of keyboard 12) for entering data defining the location of said desired destination.

9. Electronic direction finder according to any of claims 1 or 8 wherein said navigation receiver (28) comprises a GPS receiver.

10. Electronic direction finder according to claim 9 which includes an antenna switch means (29) for selectively connecting said navigation receiver (28) to each one of said omnidirectional antenna (30) and said directional antenna means (31).

11. Electronic direction finder according to claim 1 which includes a display means (14) coupled to said navigation receiver (28) for providing, in accordance with said electrical signal (A), a visual indication of the orientation of said housing axis with respect to said one predetermined compass heading.

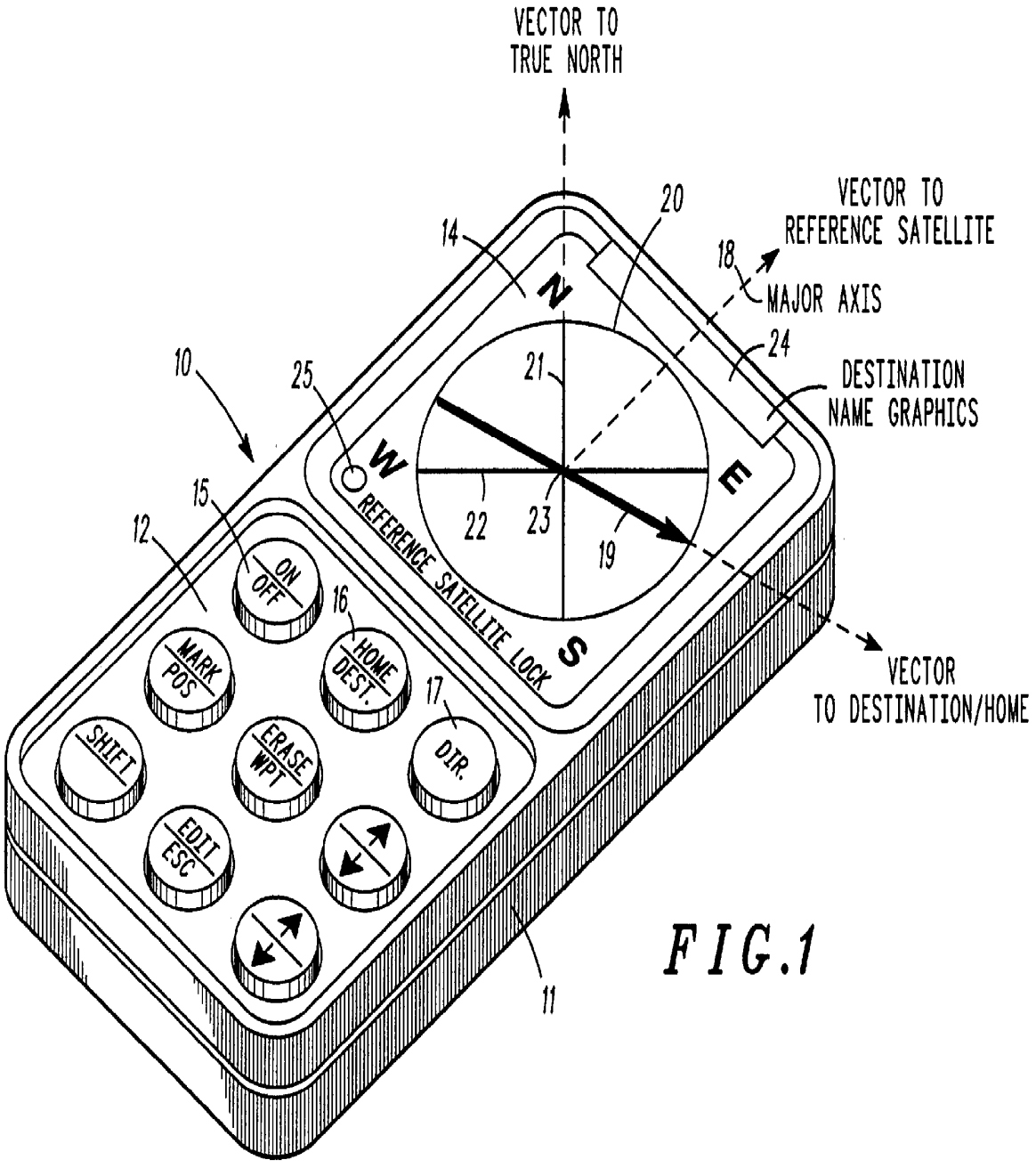


FIG.1

EP 0 587 954 A1

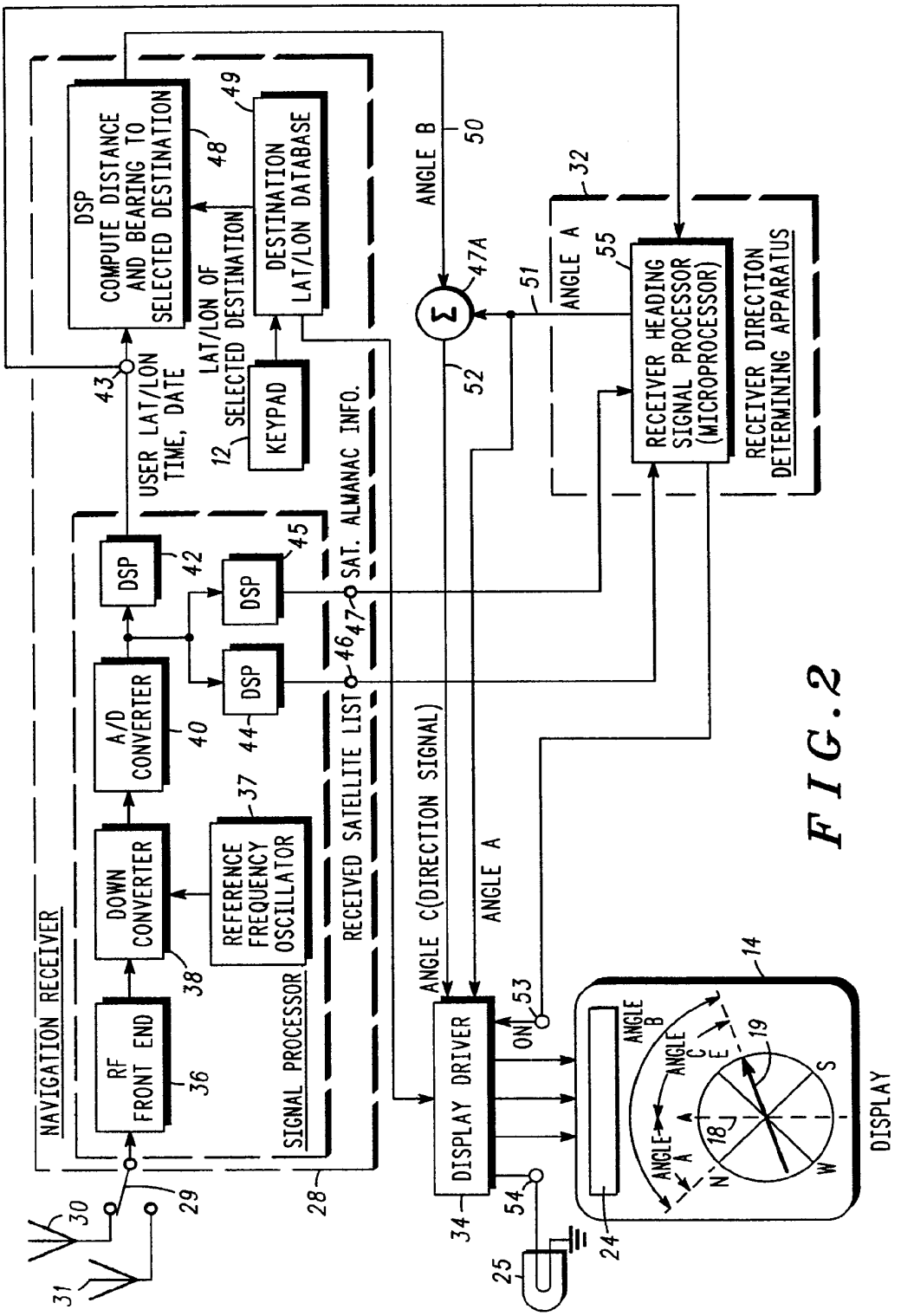
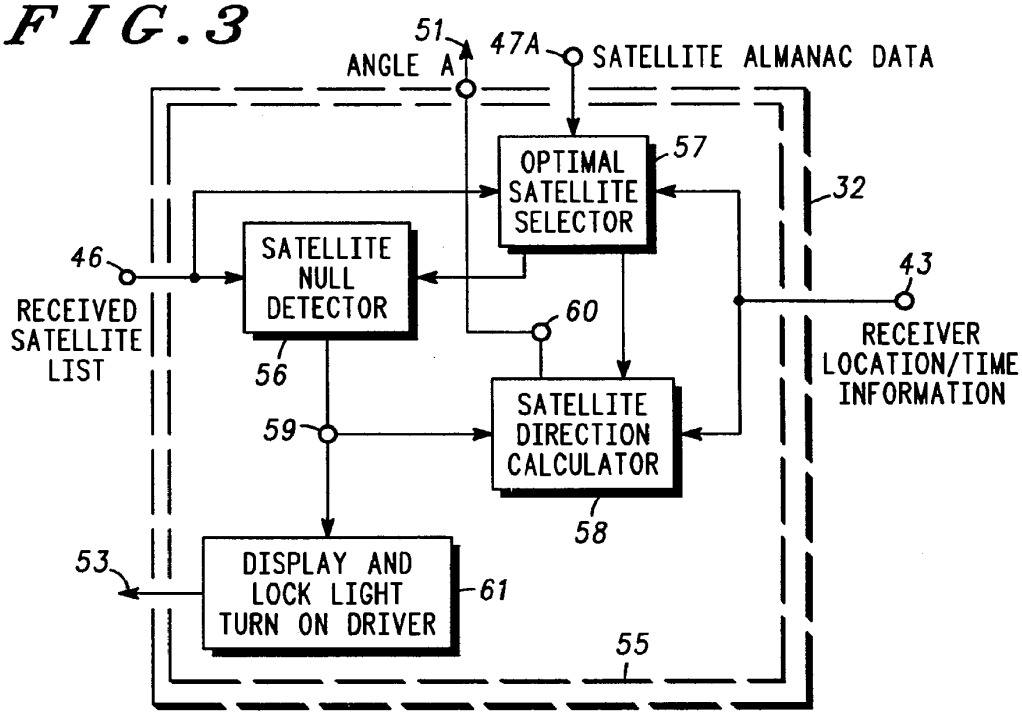

NAVIGATION RECEIVER
RF FRONT END
DOWN CONVERTER
REFERENCE FREQUENCY OSCILLATOR
A/D CONVERTER
DSP
DSP
DSP
DSP
SIGNAL PROCESSOR
DISPLAY DRIVER
KEYPAD
DESTINATION LAT/LON DATABASE
DSP COMPUTE DISTANCE AND BEARING TO SELECTED DESTINATION
RECEIVER HEADING SIGNAL PROCESSOR (MICROPROCESSOR)
RECEIVER DIRECTION DETERMINING APPARATUS
USER LAT/LON TIME, DATE
LAT/LON OF SELECTED DESTINATION
SAT. ALMANAC INFO.
RECEIVED SATELLITE LIST
ANGLE C(DIRECTION SIGNAL)
ANGLE A
ANGLE B
ON
DISPLAY
ANGLE A
ANGLE B
ANGLE C
N
E
S
W
18
19
30
31
29
28
34
54
25
24
36
38
37
40
44
42
45
46
47
43
12
48
49
50
47A
51
52
32
55
53
14

FIG. 2

FIG. 3


51
ANGLE A
47A
SATELLITE ALMANAC DATA
OPTIMAL SATELLITE SELECTOR
57
32
46
RECEIVED SATELLITE LIST
SATELLITE NULL DETECTOR
56
60
43
RECEIVER LOCATION/TIME INFORMATION
59
SATELLITE DIRECTION CALCULATOR
58
53
DISPLAY AND LOCK LIGHT TURN ON DRIVER
61
55

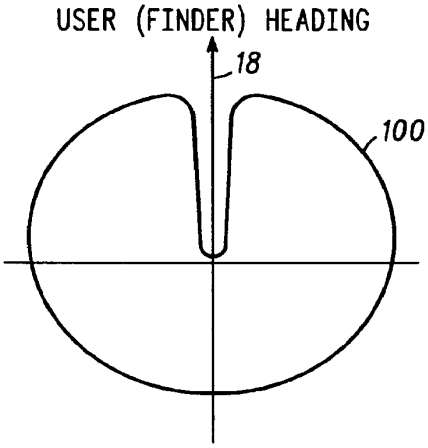

USER (FINDER) HEADING
18
100

FIG. 6

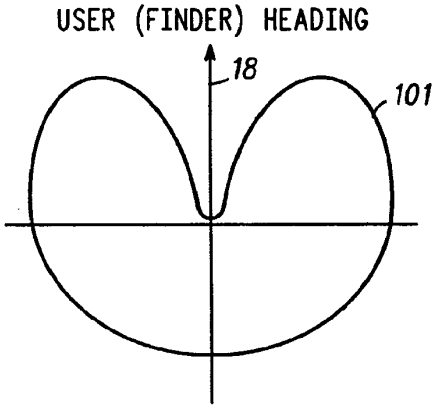

USER (FINDER) HEADING
18
101

FIG.4

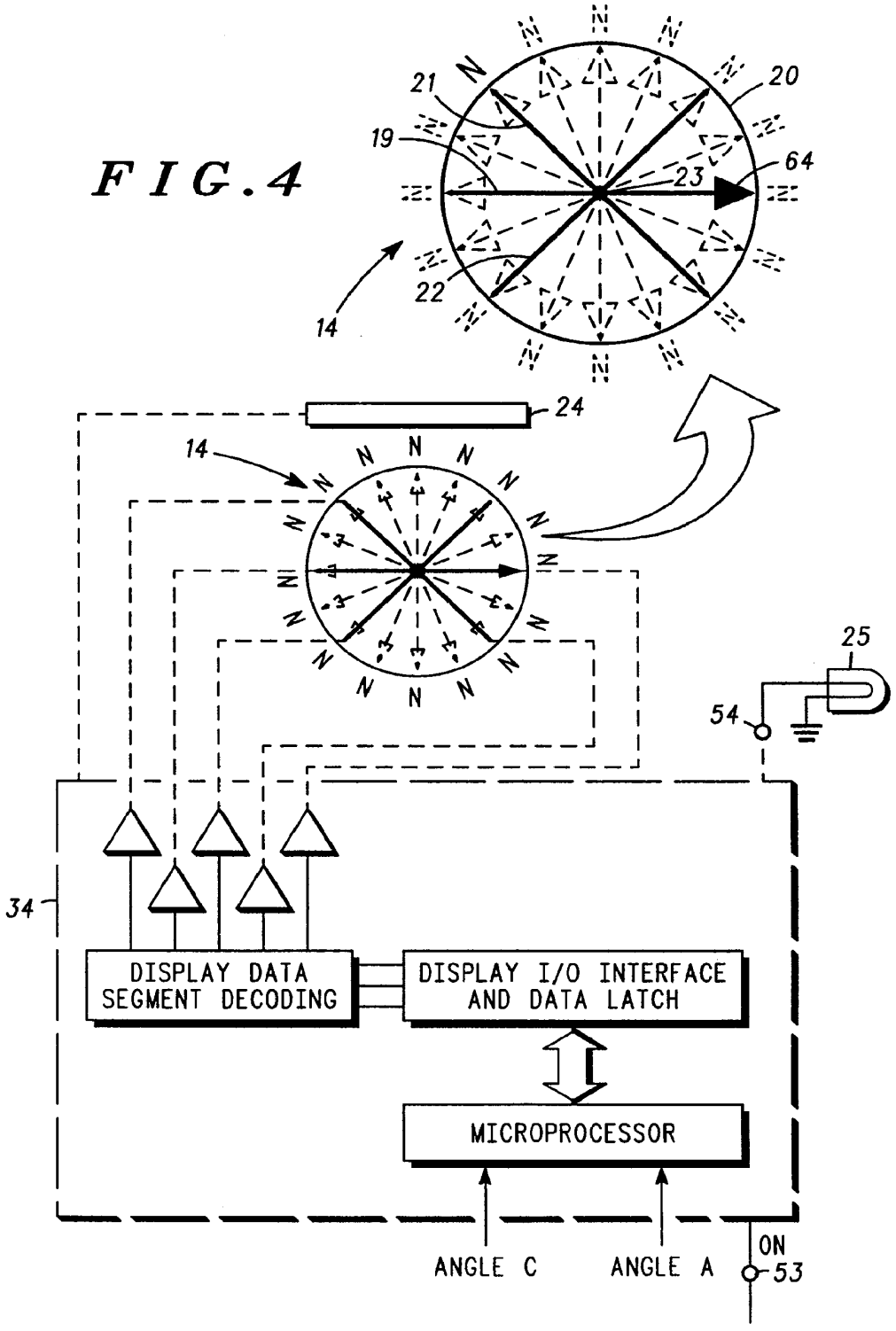
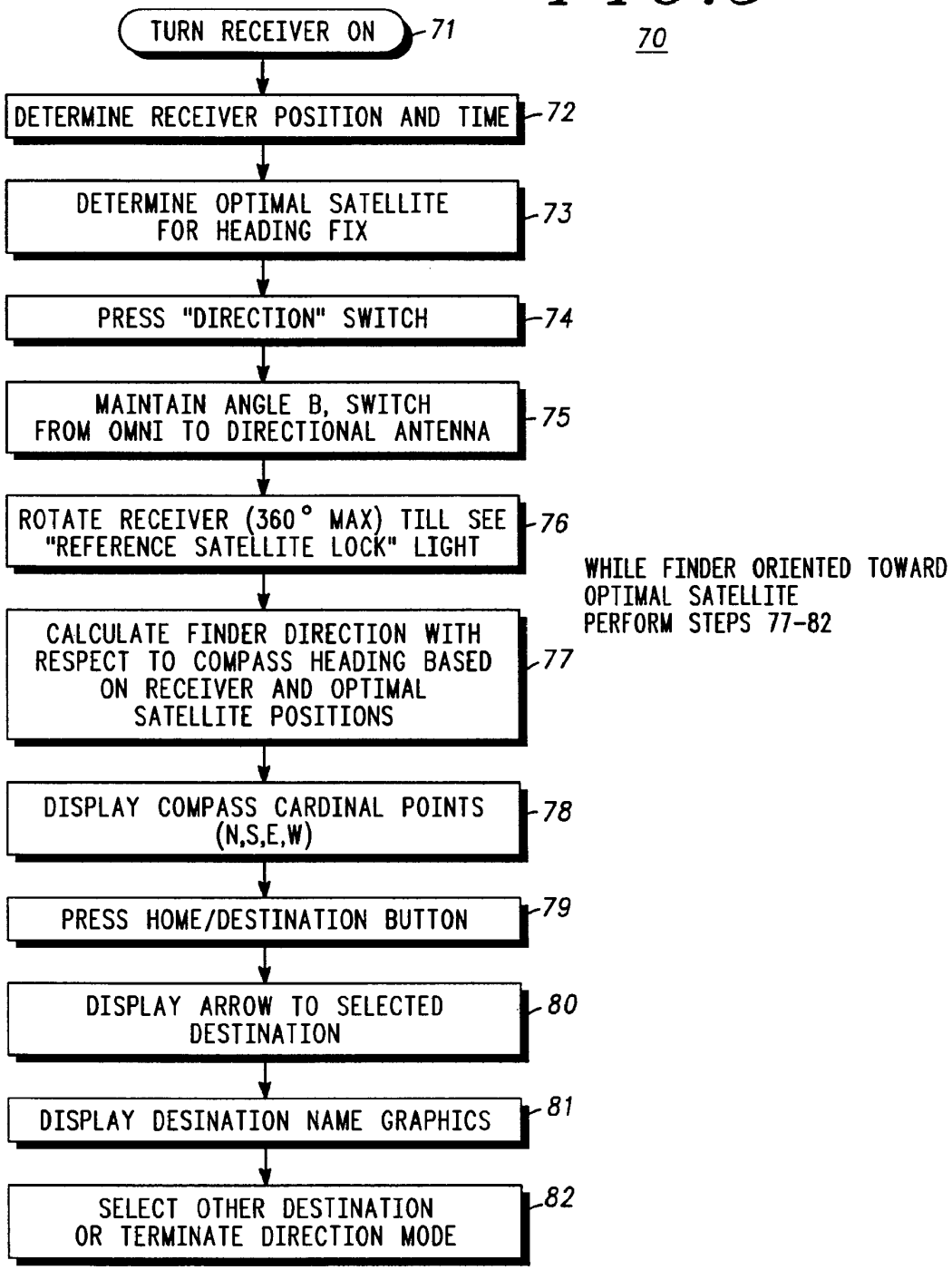

21
20
19
64
23
22
14
24
14
25
54
34
DISPLAY DATA SEGMENT DECODING
DISPLAY I/O INTERFACE AND DATA LATCH
MICROPROCESSOR
ANGLE C
ANGLE A
ON
53

FIG. 5


70
TURN RECEIVER ON
71
DETERMINE RECEIVER POSITION AND TIME
72
DETERMINE OPTIMAL SATELLITE FOR HEADING FIX
73
PRESS "DIRECTION" SWITCH
74
MAINTAIN ANGLE B, SWITCH FROM OMNI TO DIRECTIONAL ANTENNA
75
ROTATE RECEIVER (360° MAX) TILL SEE "REFERENCE SATELLITE LOCK" LIGHT
76
WHILE FINDER ORIENTED TOWARD OPTIMAL SATELLITE PERFORM STEPS 77-82
CALCULATE FINDER DIRECTION WITH RESPECT TO COMPASS HEADING BASED ON RECEIVER AND OPTIMAL SATELLITE POSITIONS
77
DISPLAY COMPASS CARDINAL POINTS (N,S,E,W)
78
PRESS HOME/DESTINATION BUTTON
79
DISPLAY ARROW TO SELECTED DESTINATION
80
DISPLAY DESINATION NAME GRAPHICS
81
SELECT OTHER DESTINATION OR TERMINATE DIRECTION MODE
82

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 92 30 9074

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
P,X	US-A-5 146 231 (GHAEM ET AL) * abstract; figure 2 * ---	1,3,5-9, 11	G01S5/14 G01S3/40 G01S3/14
A	US-A-4 881 080 (JABLONSKI) * abstract; figure 1 * ---	1	
A	US-A-4 384 293 (DEEM ET AL) * abstract; figure 4 * -----	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)
G01S

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 January 1994	HAFFNER, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

Atty. Docket No. ASA-9606-09

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: 15/959,774	Confirmation No.	: 2614
Applicant	: Maxell, Ltd.	TC/GAU	: 2663
Filed	: April 23, 2018	Examiner	: NGUYEN, L. T.
Title	: ELECTRIC CAMERA		

Customer No.: 24956

NOTICE OF RELATED PATENTS INVOLVED IN *INTER PARTES* REVIEW

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

September 7, 2018

Sir:

Applicant notifies the Office that three related patents, from which the above-identified application claims priority under 35 U.S.C. 120, are involved in the following *Inter Partes* Review proceedings:

1. 8,339,493 which matured from application 10/660,710
2. 9,100,604 which matured from application 13/681,495 and
3. 8,059,177 which matured from application 09/520,836.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 8,339,493, *Inter Partes* Review No. IPR2018-00904.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 9,100,604, *Inter Partes* Review No. IPR2018-00908.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 9,100,604, *Inter Partes* Review No. IPR2018-00909.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 8,059,177, *Inter Partes* Review No. IPR2018-00910.

Respectfully submitted,

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Electronic Acknowledgement Receipt

EFS ID:	33652814
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	07-SEP-2018
Filing Date:	23-APR-2018
Time Stamp:	11:51:56
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	NPL58-SonyDSCF55ServiceManual.pdf	15895251 432092c5db4c03b07a415a4b001006f9d840a440	no	115

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Information:					
2	Non Patent Literature	NPL59-SonyMavicaMVC-FD91ServiceManual.pdf	23516952 b53433d67348cbe1020d69dc648d54f9e123ff29	no	20
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7	Non Patent Literature	NPL43-ThumbsPlusManual-SupportedFileTypes.pdf	6727386 c907574e2b64ade33dafa5fa5abf897941007637	no	15
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21	Non Patent Literature	NPL35-XILProgrammers-8.pdf	15307775 92c9cc526711166747aa9d71c724fd4fe3b0fff8	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
22	Non Patent Literature	NPL35-XILProgrammers-9.pdf	14774917 b3bef17ed1d0ed68acb117ed9083f999c2cfd071	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
23	Non Patent Literature	NPL35-XILProgrammers-10.pdf	15227058 ed7876a96974db8a4dc7a16914366c3783215779	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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24	Non Patent Literature	NPL35-XILProgrammers-11.pdf	14342624 643b0e1ac011ddc9fa6ee98cb18287efa59048c7	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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25	Non Patent Literature	NPL35-XILProgrammers-12.pdf	13085972 af75966acd32c49b6119101a6f2f69d9fb4b9cc8	no	50
Warnings:					

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26	Non Patent Literature	NPL35-XILProgrammers-13.pdf	16383951 294139ebcae6e3b0743c32da934c4cc2754b067c	no	56
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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27	Non Patent Literature	NPL62-ANewApproachtoDynamicRangeEnhancementbyFu-ShengCheng-1.pdf	17225568 2b61859ea273e5a1f5a3b14e27e458d4fe1c7e2d	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
28	Non Patent Literature	NPL62-ANewApproachtoDynamicRangeEnhancementbyFu-ShengCheng-2.pdf	18043544 ed03d57af8e0ed6d52eda86a3b9a736c587b3ac3	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
29	Non Patent Literature	NPL62-ANewApproachtoDynamicRangeEnhancementbyFu-ShengCheng-3.pdf	25568900 e559c75cfa8895c09d6e9601d42defaf554e6db0	no	68
Warnings:					
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30	Non Patent Literature	NPL51-TIA-EIA-IS-95-A.pdf	17562220 f28e801d18ed17508ab710447631fd3eb21937e0	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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31	Non Patent Literature	NPL51-TIA-EIA-IS-95-B.pdf	19476383 9d164a05a17606915edbd3c23213b9e4bba481a6	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
32	Non Patent Literature	NPL51-TIA-EIA-IS-95-C.pdf	17071291 f33b06963641e46aeeda9985c914620f28678090	no	42
Warnings:					
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33	Non Patent Literature	NPL51-TIA-EIA-IS-95-D.pdf	16558267 6ea23ad7154f83610f43a279cdb3cb19ead099e4	no	50
Warnings:					
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Information:					
34	Non Patent Literature	NPL51-TIA-EIA-IS-95-E.pdf	14795060 85fb26335f29724079efdd978e23171bd712e324	no	50
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Information:					
35	Non Patent Literature	NPL51-TIA-EIA-IS-95-F.pdf	13373136 b9fd3a6b6091890b72762cec8dbe90c8a9d7e04e	no	44
Warnings:					
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36	Non Patent Literature	NPL51-TIA-EIA-IS-95-G.pdf	17315495 3a660c9aaa7c72b410725a30c0938230c1847b07	no	50
Warnings:					

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37	Non Patent Literature	NPL51-TIA-EIA-IS-95-H.pdf	21779818 4af317fffac77d6be0f23b72bd0f33f159fb950e	no	50
Warnings:					
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Information:					
38	Non Patent Literature	NPL51-TIA-EIA-IS-95-I.pdf	20820325 ab067e9437021f3bea036d223bf6692d577d88d1	no	46
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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39	Non Patent Literature	NPL51-TIA-EIA-IS-95-J.pdf	19201467 33752ece210cf0e10c1412278834 5d2ce5d489ea	no	50
Warnings:					
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40	Non Patent Literature	NPL51-TIA-EIA-IS-95-K.pdf	14935720 167a780308e39ba11ab9cdfa40a405c9852d705e	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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41	Non Patent Literature	NPL51-TIA-EIA-IS-95-L.pdf	20839386 804a1e71846740c03f6dea260276a6c6dc31a10e	no	70
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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42	Non Patent Literature	NPL51-TIA-EIA-IS-95-M.pdf	16239651 d02eeac8fff05e4e41c9e3ac33a815a2adbbef79	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
43	Non Patent Literature	NPL51-TIA-EIA-IS-95-N.pdf	22376603 af2ca4b41777c7e0a88956fd55b7e53b300f30e9	no	60
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
44	Non Patent Literature	NPL51-TIA-EIA-IS-95-O.pdf	16934969 b3112a6490ef1a3322ea922c3a378e357698dcd0	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
45	Non Patent Literature	NPL51-TIA-EIA-IS-95-P.pdf	15784541 cf3dd437f3bee64b7ebf367e172e17cbfd8bdee3	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
46	Non Patent Literature	NPL51-TIA-EIA-IS-95-Q.pdf	8934699 266130957e4c38131198d84b3b5fa58429dca9fc	no	30
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
47	Non Patent Literature	NPL51-TIA-EIA-IS-95-R.pdf	14717082 561d065336720fd5911b3b68457ec120ab6c6230	no	50
Warnings:					

The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
48	Non Patent Literature	NPL51-TIA-EIA-IS-95-S.pdf	9750471 2baeb97ec3276bcb912ca167b7c163c0522a62f0	no	32
Warnings:					
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Total Files Size (in bytes):			780732438		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

ASA-9606-09

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	MAXELL, LTD.	Confirmation No. 2614
Serial No.	:	15/959,774	
Filed	:	April 23, 2018	
For	:	ELECTRIC CAMERA	
Group	:	2663	
Examiner	:	Luong Trung NGUYEN	

RESPONSE TO RESTRICTION REQUIREMENT AND AMENDMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

September 7, 2018

Sir:

In response to the Restriction Requirement mailed July 9, 2018, please amend the above-identified application as follows.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks are included following the amendments.

Amendments to the Claims:

This listing of claims will replace all prior versions and listing of claims in the application.

Listing of Claims:

1. (Currently amended) A camera comprising:

an image sensor having an array of pixels arranged vertically and horizontally in a grid pattern;

a processor to form a plurality of image signals ~~with one or more predetermined view angles~~ by using the pixels of the image sensor in a static image mode and a moving video mode, the processor configured to:

form the image signals by using a first set of the pixels of the image sensor corresponding to a predetermined first view angle during recording in the static image mode~~; and~~, and

form the image signals by using a second set of the pixels of the image sensor corresponding to a predetermined second view angle during recording in the moving video mode, wherein the second view angle is different from the first view angle;

an image-instability detector configured to detect an amount of image-instability of the camera and configured to change a position of the second set of pixels to account for image-instability detected by the image-instability detector; and

a display ~~configured to;~~configured to:

display a still image corresponding to the image signals formed based on the first set of pixels~~; and~~, and

display a moving image corresponding to the image signals formed based on the second set of pixels.

2. (Original) The camera according to claim 1,

wherein the position of the second set of pixels is changed to perform instability correction caused by vertical movement of the camera.

3. (Original) The camera according to claim 1,

wherein the position of the second set of pixels is changed to perform instability correction caused by horizontal movement of the camera.

4. (Original) The camera according to claim 1,

wherein the position of the second set of pixels is changed to perform instability correction caused by vertical and horizontal movement of the camera.

5. (Original) The camera according to claim 1,

wherein the processor is further configured to perform white balance processing on one or more of the first or second set of pixels.

6. (Original) The camera according to claim 1,

wherein the processor is further configured to perform luminance signal processing on one or more of the first or second set of pixels.

7. (Original) The camera according to claim 1,

wherein the processor is further configured to perform color signal processing on one or more of the first or second set of pixels.

8. (Currently amended) The camera according to claim 1, further comprising:

an interpolator ~~for performing~~configured to perform interpolation operations on one or more of the first or second set of pixels.

9. (Currently amended) The camera according to claim 1, further comprising:

an encoder ~~for encoding~~configured to encode the still image with a first encoding format and for encoding the moving image with a second encoding format, wherein the first encoding format is different from the second encoding format.

10. (Currently amended) The camera according to claim 1, further comprising:

a memory ~~for recording~~configured to record the still image after the still image ~~after it~~ is encoded by a first encoding method and for recording the moving image after the moving image ~~after it~~ is encoded by a second encoding method that is different from the first encoding method.

11. (Currently amended) An operating method for a camera comprising:

receiving light with an image sensor having an array of pixels arranged vertically and horizontally in a grid pattern;

forming a plurality of image signals ~~with one or more predetermined view angles~~ by using the pixels of the image sensor in a static image mode and a moving video mode, including:

forming the image signals by using a first set of the pixels of the image sensor corresponding to a predetermined first view angle during recording in the static image mode; and

forming the image signals by using a second set of the pixels of the image sensor corresponding to a predetermined second view angle during recording in the moving video mode, wherein the second view angle is different from the first view angle;

detecting an amount of image-instability of the camera and changing a position of the second set of pixels to account for image-instability that is detected;

displaying a still image corresponding to the image signals formed based on the first set of pixels; and

displaying a moving image corresponding to the image signals formed based on the second set of pixels.

12. (Currently amended) The method according to claim 11,

wherein ~~in the changing a position of the second set of pixels,~~ the position of the second set of pixels is changed to perform instability correction caused by vertical movement of the camera.

13. (Currently amended) The method according to claim 1<u>1</u>,

wherein ~~in the changing a position of the second set of pixels,~~ the position of the second set of pixels is changed to perform instability correction caused by horizontal movement of the camera.

14. (Currently amended) The method according to claim 1<u>1</u>,

wherein ~~in the changing a position of the second set of pixels,~~ the position of the second set of pixels is changed to perform instability correction caused by vertical and horizontal movement of the camera.

15. (Currently amended) The method according to claim 1<u>1</u>, further <u>comprising:</u>~~including~~

performing white balance processing on one or more of the first or second set of pixels.

16. (Currently amended) The method according to claim 1<u>1</u>,further <u>comprising:</u>~~including~~

performing luminance signal processing on one or more of the first or second set of pixels.

17. (Currently amended) The method according to claim 1~~1~~, further comprising:~~including~~

performing color signal processing on one or more of the first or second set of pixels.

18. (Currently amended) The method according to claim 1~~1~~, further comprising:~~including~~

performing interpolation operations on one or more of the first or second set of pixels.

19. (Currently amended) The method according to claim 1~~1~~, further comprising:~~including~~

~~an encoder for~~ encoding the still image with a first encoding format and ~~for~~ encoding the moving image with a second encoding format, wherein the first encoding format is different from the second encoding format.

20. (Currently amended) The method according to claim 1~~1~~, further comprising:~~including~~

recording the still image ~~after it~~ after the still image is encoded by a first encoding step and recording the moving image ~~after it~~ after the moving image is encoded by a second encoding step that is different from the first encoding step.

REMARKS

Claims 1-20 are pending. Claims 1 and 8-20 have been amended to correct minor grammatical informalities therein. No new matter has been added.

Election in Response to Restriction Requirement

In response to the Restriction Requirement mailed July 9, 2018, Applicants elect to prosecute Species I represented by claims 1-20 which are readable upon the elected invention. This election is made without traverse.

The Commissioner is hereby authorized to charge any additional payment due to Deposit Account No. 50-1417.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Reg. No. 30,293
(703) 684-1120

Electronic Acknowledgement Receipt

EFS ID:	33655083
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Krista Hargrove
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	07-SEP-2018
Filing Date:	23-APR-2018
Time Stamp:	12:06:16
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		9606-09-ResptoRestriction.pdf	33191 b0f99d1de23a7ed982e8d00fc0912c47868b5e60	yes	8

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Response to Election / Restriction Filed	1	1
	Claims	2	7
	Applicant Arguments/Remarks Made in an Amendment	8	8
Warnings:			
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	Total Files Size (in bytes):	33191	

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/959,774	Filing Date 04/23/2018	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $460 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	09/07/2018	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $460 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	SLIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	shanda E ross
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

24956 7590 12/12/2018

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
NGUYEN, LUONG TRUNG	

ART UNIT	PAPER NUMBER
2663	

NOTIFICATION DATE	DELIVERY MODE
12/12/2018	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application is being examined under the pre-AIA first to invent provisions.

2. The reply filed on 09/07/2018 is not fully responsive to the prior Office action because of the following matter(s):

The Applicant amended independent claim 1 with limitation "the processor configured to: form the image signals by using a first set of the pixels of the image sensor corresponding to a predetermined first view angle during recording in the static image mode; and form the image signals by using a second set of the pixels of the image sensor corresponding to a predetermined second view angle during recording in the moving video mode, wherein the second view angle is different from the first view angle."

The specification, Figure 7, page 24, line 21 to page 25, line 16, page 27, lines 11-26, page 28 discloses "the view angle switch 18 which changes the angle of view during the moving video mode and the static mode," which reads on "the processor configured to: form the image signals by using a first set of the pixels of the image sensor corresponding to a predetermined first view angle during recording in the static image mode; and form the image signals by using a second set of the pixels of the image sensor corresponding to a predetermined second view angle during recording in the moving video mode, wherein the second view angle is different from the first view angle." Figure 7 is a non-elected Species.

Therefore, the amended independent claim 1 is not read on elected Species I (Figure 1) as Applicants elected on 09/07/2018. Note that elected Species I (Figure 1), page 9, only discloses "a mode selector switch 14 to change over the operation mode between the moving video taking and the still

image taking;" the elected Species I (Figure 1) does not disclose "a predetermined first view angle during recording in the static image mode, a predetermined second view angle during recording in the moving video mode, wherein the second view angle is different from the first view angle" as amended in claim 1.

The Applicant amended independent claim 11 with limitation "forming the image signals by using a first set of the pixels of the image sensor corresponding to a predetermined first view angle during recording in the static image mode; and forming the image signals by using a second set of the pixels of the image sensor corresponding to a predetermined second view angle during recording in the moving video mode, wherein the second view angle is different from the first view angle."

The specification, Figure 7, page 24, line 21 to page 25, line 16, page 27, lines 11-26, page 28 discloses "the view angle switch 18 which changes the angle of view during the moving video mode and the static mode," which reads on "forming the image signals by using a first set of the pixels of the image sensor corresponding to a predetermined first view angle during recording in the static image mode; and forming the image signals by using a second set of the pixels of the image sensor corresponding to a predetermined second view angle during recording in the moving video mode, wherein the second view angle is different from the first view angle." Figure 7 is a non-elected Species.

Therefore, the amended independent claim 11 is not read on elected Species I (Figure 1) as Applicants elected on 09/07/2018. Note that elected Species I (Figure 1), page 9, only discloses "a mode selector switch 14 to change over the operation mode between the moving video taking and the still image taking;" the elected Species I (Figure 1) does not disclose "a predetermined first view angle during recording in the static image mode, a predetermined second view angle during recording in the moving video mode, wherein the second view angle is different from the first view angle" as amended in claim 11. See 37 CFR 1.111.

Since the above-mentioned reply appears to be bona fide, applicant is given a TIME PERIOD of **TWO (2) MONTHS** from the mailing date of this notice within which to supply the omission or correction in order to avoid abandonment. EXTENSIONS OF THIS TIME PERIOD MAY BE GRANTED UNDER 37 CFR 1.136(a).

Conclusion

3. Any inquiry concerning this communication or earlier communications from the examiner should be directed to LUONG TRUNG NGUYEN whose telephone number is (571)272-7315. The examiner can normally be reached on 7:30AM-5:00PM, MONDAY - THURSDAY.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, TWYLER HASKINS can be reached on 571-272-7406. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer

Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2663
12/07/2018

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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	1							

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	1	Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 7,403,226, Inter Partes Review No. IPR2019-00068 dated October 16, 2018	
	2	Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,544,517, Inter Partes Review No. IPR2019-00069 dated October 16, 2018	
	3	BlackBerry Corporation v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 6,765,616, Inter Partes Review No. IPR2019-00087 dated October 15, 2018	
	4	BlackBerry Corporation v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2019-00097 dated October 16, 2018	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-02-12
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	35121641
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	12-FEB-2019
Filing Date:	23-APR-2018
Time Stamp:	13:59:24
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	9606-09-NoticeofIPR-2.pdf	20232 e54c6b9eb00d303c849cf6599c8194ed92ee1c41	no	2

Warnings:

Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-IPR-2.pdf	1034502 c582c22948055e12e22c57b773e2aaba01cd6d37	no	4
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
3	Non Patent Literature	IPR2019-00068.pdf	2325100 17bbc4eb34732e91239a18751770f7bcd92d2087	no	91
Warnings:					
Information:					
4	Non Patent Literature	IPR2019-00069.pdf	2431814 cf0e75e4d12949f872b02a16ab4b83a9943e44c5	no	97
Warnings:					
Information:					
5	Non Patent Literature	IPR2019-00087.pdf	2733171 b3ec65a1b73da323b0fe595d8664e61e656631c9	no	63
Warnings:					
Information:					
6	Non Patent Literature	IPR2019-00097.pdf	732443 4666c9ceab0ffbbdd5939f23408ccfd864ea1fe7	no	73
Warnings:					
Information:					
		Total Files Size (in bytes):	9277262		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Atty. Docket No. ASA-9606-09

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: 15/959,774	Confirmation No.	: 2614
Applicant	: Maxell, Ltd.	TC/GAU	: 2698
Filed	: April 23, 2018	Examiner	: NGUYEN, L. T.
Title	: ELECTRIC CAMERA		

Customer No.: 24956

NOTICE OF RELATED PATENTS INVOLVED IN *INTER PARTES* REVIEW

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

February 12, 2019

Sir:

Applicant notifies the Office of four related U.S. Patent Nos. which claim priority under 35 U.S.C. 120 and are involved in the following *Inter Partes* Review proceedings:

1. 7,403,226 which matured from application 09/520,836
2. 9,544,517 which matured from application 14/264,243
3. 6,765,616 which is the parent of patent nos. 7,403,226 and 9,100,604 and
4. 9,100,604 which matured from application 09/446,338.

Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 7,403,226, *Inter Partes* Review No. IPR2019-00068.

Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 9,544,517, *Inter Partes* Review No. IPR2019-00069.

BlackBerry Corporation v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 6,765,616, *Inter Partes* Review No. IPR2019-00087.

BlackBerry Corporation v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 9,100,604, *Inter Partes* Review No. IPR2019-00097.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly, Reg. No. 30,293
(703) 684-1120

Electronic Acknowledgement Receipt

EFS ID:	35126449
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Krista Hargrove
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	12-FEB-2019
Filing Date:	23-APR-2018
Time Stamp:	14:19:35
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Response to Election / Restriction Filed	9606-09-ResptoNonCompliant.pdf	21037 92ed581c015410a30a3fa797c7fdd671f6ff9ae8	no	2

Warnings:

Information:	
Total Files Size (in bytes):	21037

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

ASA-9606-09

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	MAXELL, LTD.	Confirmation No. 2614
Serial No.	:	15/959,774	
Filed	:	April 23, 2018	
For	:	ELECTRIC CAMERA	
Group	:	2698	
Examiner	:	Luong Trung NGUYEN	

RESPONSE TO NOTICE OF NON-COMPLIANT REPLY

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

February 12, 2019

Sir:

This is in reply to the Notice of Non-Compliant Reply mailed December 12, 2018 in response to Applicant's Response to Restriction Requirement submitted September 7, 2018.

Remarks begin on page 2 of this paper.

REMARKS

Applicant submitted a *Response to Restriction Requirement* on September 7, 2018 with an election of Species I, Fig. 1. However, the Examiner mailed a *Notice of Non-Compliant Reply* on December 12, 2018. In order to comply with the Notice,

Applicant hereby elects Species II, Fig. 7.

According to MPEP § 819, "the general policy of the Office is that applicants are not permitted to shift to claim another invention after an election is made and an Office action on the merits is made on the elected invention." However, there has not been an Office Action on the merits in the present application. Therefore, while "applicant, as a matter of right, may not shift from claiming one invention to claiming another, the examiner is not precluded from permitting a shift." *Id.* Accordingly, Applicant respectfully requests that the Examiner permit a shift in the election from Species I to Species II.

The Commissioner is hereby authorized to charge any additional payment due to Deposit Account No. 50-1417.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Reg. No. 30,293
(703) 684-1120

Doc Code: DIST.E.FILE **Document Description: Electronic Terminal Disclaimer - Filed**	PTO/SB/26 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT**
Application Number	15959774
Filing Date	23-Apr-2018
First Named Inventor	Takahiro NAKANO
Attorney Docket Number	ASA-9606-09
Title of Invention	ELECTRIC CAMERA

☒ Filing of terminal disclaimer does not obviate requirement for response under 37 CFR 1.111 to outstanding Office Action

☒ This electronic Terminal Disclaimer is not being used for a Joint Research Agreement.

Owner	Percent Interest
MAXELL, LTD.	100%

The owner(s) with percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of prior patent number(s)

8736729

as the term of said prior patent is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the prior patent, "as the term of said prior patent is presently shortened by any terminal disclaimer," in the event that said prior patent later:
- expires for failure to pay a maintenance fee;
- is held unenforceable;
- is found invalid by a court of competent jurisdiction;
- is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
- has all claims canceled by a reexamination certificate;
- is reissued; or
- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

◉ Terminal disclaimer fee under 37 CFR 1.20(d) is included with Electronic Terminal Disclaimer request.

○	I certify, in accordance with 37 CFR 1.4(d)(4), that the terminal disclaimer fee under 37 CFR 1.20(d) required for this terminal disclaimer has already been paid in the above-identified application.

Applicant claims the following fee status:

○ Small Entity

○ Micro Entity

◉ Regular Undiscounted

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES

I certify, in accordance with 37 CFR 1.4(d)(4) that I am:

◉ An attorney or agent registered to practice before the Patent and Trademark Office who is of record in this application

Registration Number 30293

○ A sole inventor

○ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application

○ A joint inventor; all of whom are signing this request

Signature	/John R. Mattingly/
Name	John R. Mattingly

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

Electronic Patent Application Fee Transmittal

Application Number:	15959774
Filing Date:	23-Apr-2018
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
STATUTORY OR TERMINAL DISCLAIMER	1814	1	160	160
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**160**

Doc Code: DISQ.E.FILE
Document Description: Electronic Terminal Disclaimer – Approved

Application No.: 15959774

Filing Date: 23-Apr-2018

Applicant/Patent under Reexamination: NAKANO

Electronic Terminal Disclaimer filed on March 6, 2019

☒ APPROVED

This patent is subject to a terminal disclaimer

☐ DISAPPROVED

Approved/Disapproved by: Electronic Terminal Disclaimer automatically approved by EFS-Web

U.S. Patent and Trademark Office

Electronic Acknowledgement Receipt	
EFS ID:	35335822
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly
Filer Authorized By:	
Attorney Docket Number:	ASA-9606-09
Receipt Date:	06-MAR-2019
Filing Date:	23-APR-2018
Time Stamp:	11:23:00
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$160
RAM confirmation Number	030619INTEFSW11225800
Deposit Account	501417
Authorized User	John Mattingly
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Terminal Disclaimer-Filed (Electronic)	eTerminal-Disclaimer.pdf	33451 e1be04d444ce7fba1c14ba79e452a3a6e612264b	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30194 19856a9c264db7cc002752b68e947486ba8944be	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	63645		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

ASA-9606-09

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	MAXELL, LTD.	Confirmation No. 2614
Serial No.	:	15/959,774	
Filed	:	April 23, 2018	
For	:	ELECTRIC CAMERA	
Group	:	2663	
Examiner	:	Luong Trung NGUYEN	

PRELIMINARY AMENDMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

March 6, 2019

Sir:

Following the Response to Restriction Requirement, please amend the above-identified application as follows.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks are included following the amendments.

Amendments to the Claims:

This listing of claims will replace all prior versions and listing of claims in the application.

Listing of Claims:

1. (Currently amended) A camera comprising:

an image sensor having an array of pixels arranged vertically and horizontally in a grid pattern;

a processor to form a plurality of image signals by using the pixels of the image sensor in a static image mode and a moving video mode, the processor configured to:

form the image signals by using a first set of the pixels of the image sensor corresponding to a predetermined first view angle during recording in the static image mode, and

form the image signals by using a second set of the pixels of the image sensor corresponding to a predetermined second view angle during recording in the moving video mode, wherein the predetermined second view angle is different from the predetermined first view angle;

an image-instability detector configured to detect an amount of image-instability of the camera and configured to change a position of the second set of the pixels according to the amount of image-instability detected by the image-instability detector, in order to correct the image-instability~~to account for image-instability detected by the image-instability detector~~; and

a display configured to:

display a still image corresponding to the image signals formed based on the first set of the pixels, and

display a moving image corresponding to the image signals formed based on the second set of the pixels.

2. (Currently amended) The camera according to claim 1,

wherein the position of the second set ~~of pixels~~of the pixels is changed to perform instability correction caused by vertical movement of the camera.

3. (Currently amended) The camera according to claim 1,

wherein the position of the second set ~~of pixels~~of the pixels is changed to perform instability correction caused by horizontal movement of the camera.

4. (Currently amended) The camera according to claim 1,

wherein the position of the second set ~~of pixels~~of the pixels is changed to perform instability correction caused by vertical and horizontal movement of the camera.

5. (Currently amended) The camera according to claim 1,

wherein the processor is further configured to perform white balance processing on one or more of the first or second set ~~of pixels~~of the pixels.

6. (Currently amended) The camera according to claim 1,

wherein the processor is further configured to perform luminance signal processing on one or more of the first or second set ~~of pixels~~of the pixels.

7. (Currently amended) The camera according to claim 1,

wherein the processor is further configured to perform color signal processing on one or more of the first or second set ~~of pixels~~of the pixels.

8. (Currently amended) The camera according to claim 1, further comprising:

an interpolator configured to perform interpolation operations on one or more of the first or second set ~~of pixels~~of the pixels.

9. (Previously presented) The camera according to claim 1, further comprising:

an encoder configured to encode the still image with a first encoding format and for encoding the moving image with a second encoding format, wherein the first encoding format is different from the second encoding format.

10. (Previously presented) The camera according to claim 1, further comprising:

a memory configured to record the still image after the still image is encoded by a first encoding method and for recording the moving image after the moving image is encoded by a second encoding method that is different from the first encoding method.

11. (Currently amended) An operating method for a camera comprising:

receiving light with an image sensor having an array of pixels arranged vertically and horizontally in a grid pattern;

forming a plurality of image signals by using the pixels of the image sensor in a static image mode and a moving video mode, including:

forming the image signals by using a first set of the pixels of the image sensor corresponding to a predetermined first view angle during recording in the static image mode; and

forming the image signals by using a second set of the pixels of the image sensor corresponding to a predetermined second view angle during recording in the moving video mode, wherein the predetermined second view angle is different from the predetermined first view angle;

detecting an amount of image-instability of the camera and changing a position of the second set of the pixels according to the amount of detected image-instability, in order to correct the image-instability ~~to account for image-instability that is detected~~;

displaying a still image corresponding to the image signals formed based on the first set of the pixels; and

displaying a moving image corresponding to the image signals formed based on the second set of the pixels.

12. (Currently amended) The method according to claim 11,

wherein the position of the second set ~~of pixels~~of the pixels is changed to perform instability correction caused by vertical movement of the camera.

13. (Currently amended) The method according to claim 11,

wherein the position of the second set ~~of pixels~~of the pixels is changed to perform instability correction caused by horizontal movement of the camera.

14. (Currently amended) The method according to claim 11,

wherein the position of the second set ~~of pixels~~of the pixels is changed to perform instability correction caused by vertical and horizontal movement of the camera.

15. (Currently amended) The method according to claim 11, further comprising:

performing white balance processing on one or more of the first or second set ~~of pixels~~of the pixels.

16. (Currently amended) The method according to claim 11 ,further comprising:

performing luminance signal processing on one or more of the first or second set ~~of pixels~~of the pixels.

17. (Currently amended) The method according to claim 11, further comprising:

performing color signal processing on one or more of the first or second set ~~of pixels~~of the pixels.

18. (Currently amended) The method according to claim 11, further comprising:

performing interpolation operations on one or more of the first or second set ~~of~~ ~~pixels~~of the pixels.

19. (Previously presented) The method according to claim 11, further comprising:

encoding the still image with a first encoding format and encoding the moving image with a second encoding format, wherein the first encoding format is different from the second encoding format.

20. (Previously presented) The method according to claim 11, further comprising:

recording the still image after the still image is encoded by a first encoding step and recording the moving image after the moving image is encoded by a second encoding step that is different from the first encoding step.

REMARKS

Claims 1-20 are pending. Claims 1-8 and 11-18 have been amended. No new matter has been added.

Claim Amendments

Claims 1 and 11 have been amended for clarification. Claims 2-8 and 12-18 have been amended to ensure correct antecedent basis.

Interview Summary

Applicant has amended claims 1-8 and 11-18 and submitted a Terminal Disclaimer with respect to U.S. Patent No. 8,736,729 following an Examiner initiated telephone interview with the undersigned on February 28, 2019.

Conclusion

In view of the foregoing, Applicant respectfully requests that a timely Notice of Allowance be issued in this case. The Commissioner is hereby authorized to charge any additional payment due to Deposit Account No. 50-1417.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Reg. No. 30,293
(703) 684-1120

Electronic Acknowledgement Receipt

EFS ID:	35335777
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly
Filer Authorized By:	
Attorney Docket Number:	ASA-9606-09
Receipt Date:	06-MAR-2019
Filing Date:	23-APR-2018
Time Stamp:	11:33:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		9606-09-PrelAmendment.pdf	32694 8066ab1586619c8298d49091a1bb893be9c56013	yes	8

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Preliminary Amendment	1	1
	Claims	2	7
	Applicant Arguments/Remarks Made in an Amendment	8	8
Warnings:			
Information:			
	Total Files Size (in bytes):	32694	

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New Applications Under 35 U.S.C. 111
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National Stage of an International Application under 35 U.S.C. 371
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New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/959,774	Filing Date 04/23/2018	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $460 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	03/06/2019	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $460 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/SHAREILL A COLES/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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NOTICE OF ALLOWANCE AND FEE(S) DUE

24956 7590 04/15/2019
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER
NGUYEN, LUONG TRUNG

ART UNIT	PAPER NUMBER
2698	

DATE MAILED: 04/15/2019

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

TITLE OF INVENTION: ELECTRIC CAMERA

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	07/15/2019

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

24956 7590 04/15/2019
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

TITLE OF INVENTION: ELECTRIC CAMERA

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	07/15/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, LUONG TRUNG	2698	348-208600

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required) ❑Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

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EXAMINER	
NGUYEN, LUONG TRUNG	
ART UNIT	**PAPER NUMBER**
2698	

DATE MAILED: 04/15/2019

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	**Application No.** 15/959,774	**Applicant(s)** NAKANO et al.	
	Examiner LUONG T NGUYEN	**Art Unit** 2698	**AIA (FITF) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to Preliminary Amendment and Terminal Disclaimer filed on 03/06/2019.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-20 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☑ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☑ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☑ Certified copies of the priority documents have been received in Application No. 14/661,227 .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file areply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☑ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☑ Interview Summary (PTO-413), Paper No./Mail Date. 02/28/2019.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2698

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application is being examined under the pre-AIA first to invent provisions.

Election/Restrictions

2. Applicant's election without traverse of Species II (Figure 7) readable on claims 1-20 in the reply filed on 02/12/2019 is acknowledged.

Priority

3. Acknowledgment is made of applicant's claim for foreign priority under 35 U.S.C. 119 (a)-(d). The certified copy has been filed in parent Application No. 14/661,227 filed on 03/18/2015.

Information Disclosure Statement

4. The information disclosure statements (IDSs) submitted on 04/23/2018, 09/07/2018, 02/12/2019 are in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner.

Terminal Disclaimer

5. The terminal disclaimer filed on 03/06/2019 disclaiming the terminal portion of any patent granted on this application which would extend beyond the expiration date of prior patent No. US 8,736,729 has been reviewed and is accepted. The terminal disclaimer has been recorded.

Allowable Subject Matter

6. Claims 1-20 are allowed.

The following is an examiner's statement of reasons for allowance:

Claims 1-20 are allowed in view of Terminal Disclaimer filed on 03/06/2019, and the prior art of the record fails to disclose or fairly suggest a camera, as recited in claim 1, comprising:

an image-instability detector configured to detect an amount of image-instability of the camera and configured to change a position of the second set of the pixels according to the amount of image-instability detected by the image-instability detector, in order to correct the image-instability, in combination with other claimed elements.

Claims 2-10 are allowed as being dependent from claim 1.

Claims 11-20 are method claims of apparatus claims 1-10; therefore, claims 11-20 are allowed for the same reasons given in claims 1-10, respectively.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

7. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Nobuoka (US 5,986,698) discloses image sensing apparatus with a moving image mode and a still image mode.

Okada (US 5,502,484) discloses video camera and video signal reproducing apparatus with shake detection and correction.

Nakazato (US 5,592,575) discloses apparatus for recording image signal controllable in two modes of operation.

Vogel et al. (US 4,750,041) discloses apparatus for merged field operation of an image sensor in a still video camera.

Morofuji et al. (US 6,208,377) discloses image-shake correcting device for detecting vibration frequency and characteristics.

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to LUONG TRUNG NGUYEN whose telephone number is (571)272-7315. The examiner can normally be reached on 7:30AM-5:00PM, MONDAY - THURSDAY.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, TWYLER HASKINS can be reached on (571) 272-7406. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer

Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2698
04/10/2019

Examiner-Initiated Interview Summary	**Application No.** 15/959,774	**Applicant(s)** NAKANO et al.	
	Examiner LUONG T NGUYEN	**Art Unit** 2698	**AIA (FITF) Status** No

All participants (applicant, applicant's representative, PTO personnel):

(1) LUONG TRUNG. NGUYEN. (3) _____.

(2) JOHN R. MATTINGLY (Reg. No. 30,293). (4) _____.

Date of Interview: 28 February 2019.

Type: ☑ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☑ No.
If Yes, brief description: _____.

Issues Discussed ☐ 101 ☐ 112 ☐ 102 ☐ 103 ☑ Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: 1 and 11.

Identification of prior art discussed: Nakano et al. (US 8,736,729).

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

See Continuation Sheet.

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/LUONG T NGUYEN/ Primary Examiner, Art Unit 2698	

Continuation of Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments:

The parties discussed the amendment to claims 1 and 11 to make the claims allowable. The Examiner suggested to amend claim 1 with the feature "an image-instability detector configured to change a position of the second set of the pixels according to amount of image-instability detected by the image-instability detector, in order to correct the image-instability," and amend method claim 11 with similar feature. The Examiner suggested the Applicant to file a Terminal Disclaimer to obviate a Double Patenting Rejection over the prior patent No. 8,736,729.

Notice of References Cited	Application/Control No. 15/959,774	Applicant(s)/Patent Under Reexamination NAKANO et al.	
	Examiner LUONG T NGUYEN	Art Unit 2698	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-8736729-B2	05-2014	Nakano; Takahiro	H04N5/23248	348/294
*	B	US-5986698-A	11-1999	Nobuoka; Kousuke	H04N5/23248	348/208.3
*	C	US-5502484-A	03-1996	Okada; Miyuki	H04N5/23248	348/208.6
*	D	US-5592575-A	01-1997	Nakazato; Saburo	G06T1/00	348/231.6
*	E	US-4750041-A	06-1988	Vogel; Richard M.	H04N3/155	348/220.1
*	F	US-6208377-B1	03-2001	Morofuji; Tsuyoshi	G02B27/646	348/208.3
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/959,774	NAKANO et al.
	Examiner	Art Unit
	LUONG T NGUYEN	2698

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04N5/372, H04N9/045, H04N2209/045	04/10/2019	LTN
H04N5/23248, H04N5/23258, H04N5/23274, H04N5/3741	04/10/2019	LTN

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	**Date**	**Examiner**
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history printout	04/10/2019	LTN
Inventorship search	04/10/2019	LTN

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**
	USPAT; USPGPUB; text search, see interference search history printout	04/10/2019	LTN

/L.T.N/ Primary Examiner, Art Unit 2698	

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/959,774	NAKANO et al.
	Examiner	**Art Unit**
	LUONG T NGUYEN	2698

CPC						
Symbol					**Type**	**Version**
H04N	/	5	/	372	F	2013-01-01
H04N	/	5	/	23248	I	2013-01-01
H04N	/	5	/	23258	I	2013-01-01
H04N	/	5	/	23274	I	2013-01-01
H04N	/	9	/	045	I	2013-01-01
H04N	/	5	/	3741	I	2013-01-01
H04N	/	2209	/	045	A	2013-01-01

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	20	
/LUONG T NGUYEN/ Primary Examiner, Art Unit 2698	10 April 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	7

U.S. Patent and Trademark Office — Part of Paper No.: 20190410

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/959,774	NAKANO et al.
	Examiner	**Art Unit**
	LUONG T NGUYEN	2698

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H04N5/372	/	5	/	372
H04N9/04	/	9	/	04
H04N5/232	/	5	/	232
H04N5/374	/	5	/	374

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 20	
/LUONG T NGUYEN/ Primary Examiner, Art Unit 2698 (Primary Examiner)	10 April 2019 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 7

U.S. Patent and Trademark Office — Part of Paper No.: 20190410

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/959,774	NAKANO et al.
	Examiner	**Art Unit**
	LUONG T NGUYEN	2698

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☑ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		10		19										
	2		11		20										
	3		12												
	4		13												
	5		14												
	6		15												
	7		16												
	8		17												
	9		18												

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	20	
/LUONG T NGUYEN/ Primary Examiner, Art Unit 2698	10 April 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	7

U.S. Patent and Trademark Office — Part of Paper No.: 20190410

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/959,774	NAKANO et al.
	Examiner	**Art Unit**
	LUONG T NGUYEN	2698

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☑ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/02/2018	04/10/2019							
	1	÷	=							
	2	÷	=							
	3	÷	=							
	4	÷	=							
	5	÷	=							
	6	÷	=							
	7	÷	=							
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	17	÷	=							
	18	÷	=							
	19	÷	=							
	20	÷	=							

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	1	15/959774	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/03 14:40
S2	1866	(gyro near sensor$1) same detect$3 same (motion or shak$3 or shift$3) same camera	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/03 14:40
S3	19	S2 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/03 14:42
S4	8	("20010014171" | "4734726" | "5155520" | "5309190" | "5649237" | "6035133" | "6130709" | "6486910").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/03 14:44
S5	2	"20080246599".PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/03 15:13
S6	293	((("NAKANO") near3 ("Takahiro"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/03 15:47
S7	13	("20010043276" | "20020118291" | "4434435" | "4910599" | "5264939" | "5450129" | "5657082" | "5668597" | "5986698" | "6122007" | "6181375" | "6529236" | "6580457").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/03 15:50
S8	43	((("NISHIMURA") near3 ("Ryuji"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/03 15:54
S9	43	((("KINUGASA") near3 ("Toshiro"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/03 15:58
S10	4540	(gyro near sensor$1) same detect$3 same (motion or shak$3 or shift$3) and camera	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2019/04/09 18:51

			JPO; DERWENT; IBM_TDB			
S11	31	S10 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 18:52
S12	12	("20020097324" | "4780739" | "5210563" | "5227889" | "5266981" | "5416558" | "5555061" | "5585875" | "5623305" | "5649237" | "6388705" | "6486910").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/09 18:54
S13	47	(gyro near sensor$1) same (motion or shak$3 or shift$3) same (angle near view)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 18:59
S14	94	(gyro near sensor$1) same (angle near view)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 18:59
S15	7970	(motion or shak$3 or shift$3) same (angle near view)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:01
S16	845	S15 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:02
S17	398	S16 and camera	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:02
S18	170	(motion or shak$3 or shift$3) same (angle near view) and (effective near pixel$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:07
S19	16	S18 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2019/04/09 19:08

			JPO; DERWENT; IBM_TDB			
S20	3	"6930708".PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:10
S22	15	(gyro near sensor$1) same (image$unstability) same detect$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:17
S23	15	(gyro near sensor$1) same (image$unstability)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:18
S24	0	(motion or shak$3 or shift$3) same (angle near view) same (image$unstability)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:19
S25	0	(angle near view) same (image$unstability)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:19
S26	15	(angle near view) and (image$unstability)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:19
S27	2172	(angle near view) and (image near stabiliz$5)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:20
S28	129	(angle near view) and (image near stabiliz$5) and (effective near pixel$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:21
S29	0	S28 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT;	OR	ON	2019/04/09 19:21

			USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			
S30	32	(angle near view) and (image near stabiliz$5) and (mov$3 near mode) and ((static or still) near mode)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:22
S31	225	(angle near view) and (mov$3 near mode) and ((static or still) near mode) and pixels	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:25
S32	2	S31 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:25
S33	18	(angle near view) and (image$instability)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:27
S34	766	(angle near view) and ((stability or stabilzation or stable) near image)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:28
S35	68	S34 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:28
S36	10	(angle near view) and ((stability or stabilzation or stable) near image) and (mov$3 near mode) and ((static or still) near mode) and pixels	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:34
S37	10	("20010007469" | "20030063200" | "20030098847" | "20040004667" | "20040051793" | "20040100487" | "20040239792" | "20050206736" | "6137468" | "6819362").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/09 19:34
S38	2	(shoot$3 near range) and ((stability or stabilzation or stable) near image) and	US-PGPUB; USPAT;	OR	ON	2019/04/09 19:36

		(mov$3 near mode) and ((static or still) near mode) and pixels	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			
S39	2	(shoot$3 near range) and ((stability or stabilzation or stable) near image) and (mov$3 near mode) and ((static or still) near mode)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:37
S40	14	(angle near view) and ((stability or stabilzation or stable) near image) and (mov$3 near mode) and ((static or still) near mode)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/09 19:37
S41	802	(gyro near sensor$1) same detect$3 same (motion or shak$3 or shift$3) and ((field near view) or (angle near view))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:34
S42	9	S41 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:35
S43	2397	(gyro or gyroscopic) same detect$3 same (motion or shak$3 or shift$3) and ((field near view) or (angle near view))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:36
S44	33039	(H04N5/372 or H04N9/045 or H04N2209/045).CPC.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:38
S45	33	S43 and S44	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:39
S46	20040	(H04N5/23248 or H04N5/23258 or H04N5/23274 or H04N5/3741).CPC.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:41

S47	256	S43 and S46	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:41
S48	3	S47 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:41
S49	11	("4713697" | "4780739" | "4862277" | "4963981" | "5020890" | "5060074" | "5095198" | "5117246" | "5175580" | "5245378" | "5309250").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/10 12:43
S50	7	(angular$velocity adj sensor) same detect$3 same (motion or shak$3 or shift$3) and ((field near view) or (angle near view))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:49
S51	614	(angular adj velocity adj sensor) same detect$3 same (motion or shak$3 or shift$3) and ((field near view) or (angle near view))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:50
S52	169	S51 and (S44 or S46)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:51
S53	6	S52 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:51
S54	7	(angular$velocity adj sensor) same detect$3 same (motion or shak$3 or shift$3) and ((field near view) or (angle near view))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:51
S55	490	(angular adj velocity adj sensor) same (motion or shak$3 or shift$3) and ((field near view) or (angle near view)) and pixels	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:53
S56	129	S55 and (S44 or S46)	US-PGPUB;	OR	ON	2019/04/10

			USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			12:53
S57	38	(angle near view) and (gyro or gyroscopic) and (mov$3 near mode) and ((static or still) near mode)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:56
S58	12287	(pixel$1) same detect$3 same (motion or shak$3 or shift$3) and ((field near view) or (angle near view))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:58
S59	728	S58 and (S44 or S46)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:58
S60	121	S59 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 12:58
S61	1	(pixel$1) same detect$3 same (motion or shak$3 or shift$3) and ((field near view) or (angle near view)) and ((stability or stabilzation or stable) near image) and (mov$3 near mode) and ((static or still) near mode)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 13:03
S62	12	(pixel$1) and ((field near view) or (angle near view)) and ((stability or stabilzation or stable) near image) and (mov$3 near mode) and ((static or still) near mode)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 13:03
S63	31	(pixel$1) and ((field near view) or (angle near view)) and ((stability or stabilization or stable) near image) and (mov$3 near mode) and ((static or still) near mode)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 13:04
S64	4455	(pixel$1) and ((field near view) or (angle near view)) and ((stability or stabilization or stable) near image)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	2019/04/10 13:05

			IBM_TDB			
S65	601	S64 and (S44 or S46)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 13:06
S66	26	S65 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 13:06
S67	80	("4054915" | "4541010" | "4691253" | "4958915" | "5054052" | "5060074" | "5170249" | "5187569" | "5287192" | "5402173" | "5438365" | "5440343" | "5493335" | "5497191" | "5497192" | "5638132" | "5793923" | "5828406" | "5847758").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 13:09
S68	61	("5986698" | "6195125" | "6512541" | "6519000" | "6661451" | "6734424" | "6765616" | "6781634" | "6798448" | "6906746" | "6970191" | "7154539" | "7352391" | "7403226" | "8059177" | "9100604" | "9544517").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 13:10
S69	12	("4054915" | "4570178" | "4746988" | "4837628" | "4924316" | "4929824" | "5239380" | "5444482" | "5508739" | "5592575" | "5828406" | "5847756").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/10 13:10
S70	6	("4839719" | "5122873" | "5227863" | "5258859" | "5335097" | "5442717").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/10 13:13
S71	5	("4546390" | "4750041" | "4758883" | "5067029" | "5309247").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/10 13:14
S72	296	(mov$3 near mode) and ((static or still) near mode) and pixels and (stability or stabilization or stabiliz$3 or stable)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 13:42
S73	64	S72 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 13:42
S74	9	("4714966" | "4837628" | "4860108" | "4881127" | "4910606" | "5202798" | "5446599" | "5559552" | "5589943").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/10 13:46
S75	367	(mov$3 near mode) and ((static or still) near mode) and (stability or	US-PGPUB; USPAT;	OR	ON	2019/04/10 14:28

		stabilization or stabiliz$3 or stable) and correct$3	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			
S76	86	S75 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 14:29
S77	14	("4939594" | "4982291" | "5001568" | "5130813" | "5130860" | "5361173" | "5459582" | "5613032" | "5706097" | "5760767" | "5786851" | "5815201" | "5850500" | "5911032").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/10 14:29
S78	30	(mov$3 near mode) and ((static or still) near mode) and (stability or stabilization or stabiliz$3 or stable) and (gyro near sensor$1) same detect$3 same (motion or shak$3 or shift$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 14:34
S79	44	(mov$3 near mode) and ((static or still) near mode) and (stability or stabilization or stabiliz$3 or stable) and (gyro near sensor$1) and detect$3 same (motion or shak$3 or shift$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 14:35
S80	47	(mov$3 near mode) and ((static or still) near mode) and (stability or stabilization or stabiliz$3 or stable) and (gyro near sensor$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 14:35
S81	2	09/255549	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 14:38
S82	12	("5060074" | "5249037" | "5386264" | "5497191" | "5502483" | "5502484" | "5526045" | "5717611" | "5926212" | "6122004" | "6211910" | "6625166").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/10 14:39
S83	93	(mov$3 near video) and ((static or still) near image$1) and (stability or stabilization or stabiliz$3 or stable) and (gyro near sensor$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 14:48
S84	286	(mov$3 near video) and ((static or still) near image$1) and (stability or stabilization or stabiliz$3 or stable) and (gyro or gyroscopic)	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2019/04/10 14:49

			JPO; DERWENT; IBM_TDB			
S85	1	S84 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 14:50
S86	1641	(mov$3 near video) and ((static or still) near image$1) and (stability or stabilization or stabiliz$3 or stable) and camera	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 14:51
S87	79	S86 and (S44 or S46)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 14:52
S88	3	("4819075" | "4881127" | "5101276").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/04/10 14:56
S89	650	(mov$3 near video) and ((static or still) near image$1) and (stability or stabilization or stabiliz$3 or stable) and camera and ((field near view) or (angle near view))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 14:58
S90	35	S89 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 14:58
S91	675	(mov$3 near video) and ((static or still) near image$1) and (stability or stabilization or stabiliz$3 or stable) and ((field near view) or (angle near view))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 15:01
S93	37	S91 and (S44 or S46)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 15:06
S94	35	S91 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	2019/04/10 15:07

			IBM_TDB			
S95	232	(mov$3 near video) and ((static or still) near image$1) and (stability or stabilization or stabiliz$3 or stable) and ((set or group) near pixel$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 15:28
S96	10	S95 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 15:31
S97	1395	(mov$3 near video) and ((static or still) near image$1) and (stability or stabilization or stabiliz$3 or stable) and (pixel$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 15:33
S98	65	S97 and (S44 or S46)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/04/10 15:33

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S99	0	((mov$3 near mode) and ((static or still) near mode) and (stability or stabilization or stabiliz$3 or stable) and (gyro near sensor$1) same detect$3 same (motion or shak$3 or shift$3)).clm.	US-PGPUB; USPAT	OR	ON	2019/04/10 16:52
S104	0	((view near angle) and (mov$3 near mode) and ((static or still) near mode) and (image$instability) and detector).clm.	US-PGPUB; USPAT	OR	ON	2019/04/10 16:59
S106	0	((view near angle) and (mov$3 near video) and ((static or still) near mode) and (image$instability) and detector).clm.	US-PGPUB; USPAT	OR	ON	2019/04/10 17:01
S108	2	(pixels and (mov$3 near video) and ((static or still) near mode) and (image$instability) and detector).clm.	US-PGPUB; USPAT	OR	ON	2019/04/10 17:03
S109	2	((mov$3 near video) and ((static or still) near mode) and (image$instability) and detector).clm.	US-PGPUB; USPAT	OR	ON	2019/04/10 17:04
S110	2	((view near angle) and (image$instability) and detector).clm.	US-PGPUB; USPAT	OR	ON	2019/04/10 17:04
S111	0	((view near angle) and (mov$3 near video) and (static near mode) and (image$instability) and detector).clm.	US-PGPUB; USPAT	OR	ON	2019/04/10 17:05
S112	0	((view near angle) and (mov$3 adj video) and (static adj mode) and (image$instability) and	US-PGPUB;	OR	ON	2019/04/10 17:07

		detector).clm.	USPAT			
S113	2	((view near angle) and (image$instability) and detector and mode).clm.	US-PGPUB; USPAT	OR	ON	2019/04/10 17:08
S114	2	((view near angle) and (image$instability) and detector and (image adj mode)).clm.	US-PGPUB; USPAT	OR	ON	2019/04/10 17:08

4/ 10/ 2019 5:11:45 PM
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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	
Examiner Name	NGUYEN, L.
Attorney Docket Number	ASA-9606-09

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4958915	A	1990-09-25	OKADA et al.	
	2	5060074	A	1991-10-22	KINUGASA et al.	
	3	5440343	A	1995-08-08	PARULSKI et al.	
	4	5493335	A	1996-02-20	PARULSKI et al.	
	5	5497191	A	1996-03-05	YOO et al.	
	6	5497192	A	1996-03-05	ISHIZUKA	
	7	5054052	A	1991-10-01	NONAMI	
	8	5793923	A	1998-08-11	SAWANOBORI	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	
	Examiner Name	NGUYEN, L.
	Attorney Docket Number	ASA-9606-09

	9	5828406	A	1998-10-27	PARULSKI et al.	
	10	6512541	B2	2003-01-28	DUNTON et al.	

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	1	ZTE (USA) Inc.'s Provisional Preliminary Invalidity Contentions which were filed in the following litigation: HITACHI MAXELL, LTD. v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-00179 RWS (E.D. Tex.), filed ~~November 18, 2016~~ April 17, 2017	
	2	ZTE (USA) Inc.'s Invalidity Contentions which were filed in the following litigation: HITACHI MAXELL, LTD. v. HUAWEI DEVICE USA INC. and HUAWEI DEVICE CO., LTD., Civil Action No. 5:16-cv-00178 RWS (E.D. Tex.) and v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-00179 RWS (E.D. Tex.), filed ~~November 18, 2016~~ June 30, 2017	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	
	Examiner Name	NGUYEN, L.
	Attorney Docket Number	ASA-9606-09

	3	Asustek Computer Inc. and Asus Computer International's Invalidity Contentions which were filed in the following litigation: MAXELL, LTD. v. ASUSTEK COMPUTER INC. AND ASUS COMPUTER INTERNATIONAL, Civil Action No. 2:17-cv-7528-R-MRW (C.D. CA), filed ~~October 13, 2017~~ March 26, 2018

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EXAMINER SIGNATURE

Examiner Signature	/LUONG T NGUYEN/	Date Considered	04/04/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2018-04-23
Name/Print	John R. Mattingly	Registration Number	30,293

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2018-04-23
First Named Inventor	T. NAKANO
Art Unit	
Examiner Name	NGUYEN, L.
Attorney Docket Number	ASA-9606-09

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6765616	B1	2004-07-20	NAKANO et al.	
	2	7403226	B2	2008-07-22	NAKANO et al.	
	3	6781634	B1	2004-08-24	SHIOZAKI et al.	
	4	5402173		1995-03-28	NOGUCHI et al.	
	5	5438365		1995-08-01	YAMASHITA et al.	
	6	5638132		1997-06-10	HOKARI et al.	
	7	7352391	B1	2008-04-01	HATAKEYAMA	
	8	6661451	B1	2003-12-09	KIJIMA et al.	

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	Attorney Docket Number	ASA-9606-09

	9	7154539	B1	2006-12-26	NISHIMURA et al.	
	10	5828406		1998-10-27	PARULSKI et al.	
	11	4054915		1977-10-18	SUGIHARA	
	12	5170249		1992-12-08	OHTSUBO et al.	
	13	5187569		1993-02-16	TANI	
	14	6195125	B1	2001-02-27	UDAGAWA et al.	
	15	6906746	B2	2005-06-14	HIJISHIRI et al.	
	16	6519000	B1	2003-02-11	UDAGAWA	
	17	5847758		1998-12-08	IIZUKA	
	18	6970191	B1	2005-11-29	SASE et al.	
	19	6734424		1998-03-31	SASAKI	

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	20	6798448	B1	2004-09-28	MOTONO et al.	
	21	5287192		1994-02-15	IIZUKA	
	22	8059177	B2	2011-11-15	NAKANO et al.	
	23	9100604	B2	2015-08-04	NAKANO; Takahiro	
	24	5986698	A	1999-11-16	NOBUOKA; Kousuke	
	25	4691253	A	1987-09-01	Silver; Bruce R.	
	26	4541010	A	1985-09-10	Alston; Lawrence E.	
	27	9544517	B2	2017-01-10	Nakano; Takahiro	
	28	4958915	A	1990-09-25	OKADA et al.	
	29	5060074	A	1991-10-22	KINUGASA et al.	
	30	5440343	A	1995-08-08	PARULSKI et al.	

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	Attorney Docket Number	ASA-9606-09

	31	5493335	A	1996-02-20	PARULSKI et al.	
	32	5497191	A	1996-03-05	YOO et al.	
	33	5497192	A	1996-03-05	ISHIZUKA	
	34	5054052	A	1991-10-01	NONAMI	
	35	5793923	A	1998-08-11	SAWANOBORI	
	36	5828406	A	1998-10-27	PARULSKI et al.	
	37	6512541	A	2003-01-28	DUNTON et al.	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	9-270959	JP		1997-10-14	SONY CORP.		
	2	11-187306	JP		1999-07-09	SHARP CORP.		
	3	04-323973	JP		1992-11-13	HITACHI, LTD.		
	4	11-004456	JP		1999-01-06	FUJI PHOTO FILM CO., LTD.		
	5	11-355665	JP		1999-12-24	FUJI PHOTO FILM CO., LTD.		

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		

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Examiner Signature	/LUONG T NGUYEN/	Date Considered	04/04/2019

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	Attorney Docket Number	ASA-9606-09

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Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2018-04-23
Name/Print	John R. Mattingly	Registration Number	30293

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Receipt date: 02/12/2019

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

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Receipt date: 02/12/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	1	Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 7,403,226, Inter Partes Review No. IPR2019-00068 dated October 16, 2018	
	2	Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,544,517, Inter Partes Review No. IPR2019-00069 dated October 16, 2018	
	3	BlackBerry Corporation v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 6,765,616, Inter Partes Review No. IPR2019-00087 dated October 15, 2018	
	4	BlackBerry Corporation v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2019-00097 dated October 16, 2018	

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EXAMINER SIGNATURE

Examiner Signature	/LUONG T NGUYEN/	Date Considered	04/08/2019

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

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Receipt date: 09/07/2018

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	~~2663~~ 2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

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Receipt date: 09/07/2018

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	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	~~2683~~ 2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	1	No copy submitted. ~~TIA/EIA/IS-95-A - TSB74 (February 27, 1996) ("IS-95")~~	
	2	"Retrieval and Browsing of Images Using Image Thumbnails," by Harvey A. Cohen, published in the Journal of Visual Computing and Image Representation, Vol. 8, No. 2, June 1997, pp. 226-234	
	3	SONY DCS F55/F55E Manual , 1999.	
	4	No copy submitted. ~~SONY DCS-F55 specification sheet~~	
	5	SONY ~~MVC-FD81 Manual~~ Digital Still Camera MVC-FD81, 1998, Manual.	
	6	SONY MVC-~~FD88/FD83 Manual~~ FD83/FD88, 1999, Manual.	
	7	SONY MVC-FD91 Manual , Version 1.0, 1998	
	8	SONY DCS-F55/F55E Service Manual (Ver. 1.1, 7-1999)	
	9	SONY MVC-FD91 Service Manual (Ver. 1.0, 10-1998)	
	10	A. Abidi "Direct-Conversion Radio Transceivers for Digital Communications," IEEE Journal of Solid-State Circuits, Vol. 30, No. 12, Dec. 1995	
	11	F. Adachi et.al. "Wideband DS-CDMA for Next-Generation Mobile Communications Systems," published Sept, 1998 IEEE Communications Magazine	

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	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	12	F. Cheng, "A New Approach to Dynamic Range Enhancement," Oct. 1994
	13	Date not shown on submitted copy S. Manji and W. Zhuang, "Reverse Link Power Control for Packetized DS-CDMA in a Slowly Rayleigh Fading Environment," published in Dept. of Electrical and Computer Engineering, University of Waterlo, Canada
	14	A. Salmasi and K. Gilhousen, "On the System Design Aspects of Code Division Multiple Access (CDMA) Applied to Digital Cellular and Personal Communications Networks" IEEE 1991 (57-62)

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EXAMINER SIGNATURE

Examiner Signature	/LUONG T NGUYEN/	Date Considered	04/08/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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Receipt date: 09/07/2018

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	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

X That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

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See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2018-09-07
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Bibliographic Data

Application No: 15/959,774

Foreign Priority claimed: (•) Yes ( ) No

35 USC 119 (a-d) conditions met: [✓] Yes [ ] No [ ] Met After Allowance

Verified and Acknowledged: /LUONG T NGUYEN/ Examiner's Signature [ ] Initials

Title: ELECTRIC CAMERA

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
04/23/2018	348	2698	ASA-9606-09
RULE			

APPLICANTS

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INVENTORS

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Ryuji NISHIMURA Tokyo, JAPAN

Toshiro KINUGASA Tokyo, JAPAN

CONTINUING DATA

This application is a CON of 15386656 12/21/2016

15386656 is a CON of 14661227 03/18/2015 PAT 9544517

14661227 is a CON of 14264243 04/29/2014 PAT 9100604

14264243 is a CON of 13681495 11/20/2012 PAT 8736729

13681495 is a CON of 12845266 07/28/2010 PAT 8339493

12845266 is a CON of 10660710 09/12/2003 PAT 8059177

10660710 is a DIV of 09520836 03/08/2000 PAT 6765616

FOREIGN APPLICATIONS

JAPAN 2000-006064 01/11/2000

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Art Unit	~~2663~~ 2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6091686		2000-07-18	CAFFARELLI	
	2	5245297		1993-09-14	CLAYDON	
	3	5592382		1997-01-07	COLLEY	
	4	6321158		2001-11-20	DELORME	
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	6	5101173		1992-03-31	DIPIAZZA	
	7	6693667		2004-02-17	DORON	
	8	6559888		2003-05-06	DORON	

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	9	5684532		1997-11-04	ELY	
	10	6005613		1999-12-21	ENDSLEY	
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	17	4766580		1988-08-23	GO	
	18	6728476		2004-04-27	HASENO	
	19	6937277		2005-08-30	HATTORI	

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	31	5283651		1994-02-01	ISHIZUKA	
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	51	6937273		2005-08-30	LOUI	
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	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	~~2663~~
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

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	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	~~2667~~
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20020054218	A1	2002-05-09	KOBAYASHI et al.	
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	1	6-60158 w/abs	JP	A	1994-03-04	HITACHI, LTD.		
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	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	~~2683~~
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

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	First Named Inventor	NAKANO, T.
	Art Unit	~~2669~~
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

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	First Named Inventor	NAKANO, T.
	Art Unit	~~2683~~ 2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

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	First Named Inventor	NAKANO, T.
	Art Unit	~~2685~~ 2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

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	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
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Name/Print	John R. Mattingly	Registration Number	30,293

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	Art Unit	~~2663~~ 2698
	Examiner Name	NGUYEN, L. T.
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	Art Unit	~~2653~~ 2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	1	Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,339,493, Inter Partes Review No. IPR2018-00904 dated June 20, 2018	
	2	Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2018-00908 dated June 20, 2018	
	3	Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2018-00909 dated June 20, 2018	
	4	Olympus Corporation, Olympus Corporation of the Americas and Olympus America Inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,059,177, Inter Partes Review No. IPR2018-00910 dated June 20, 2018	

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	1	TIA/EIA/IS-95-A +TSB74 (February 27, 1996) ("IS 95")	
	2	SONY DCS-F55 specification sheet	
	3	S. Manji and W. Zhuang, "Reverse Link Power Control for Packetized DS-CDMA in a Slowly Rayleigh Fading Environment," June 12, 1997, published in Dept. of Electrical and Computer Engineering, University of Waterloo, Canada	
	4	Asustek Computer Inc. and Asus Computer International's First Amended Invalidity Contentions which were filed in the following litigation: MAXELL, LTD. v. ASUSTEK COMPUTER INC. AND ASUS COMPUTER INTERNATIONAL, Civil Action No. 3:18-cv-01788-VC (N.D. CA), filed June 12, 2018	
	5	"Annex F of ITU-T Recommendation T.84 | ISO/IEC IS 10918-3, DIGITAL COMPRESSION AND CODING OF CONTINUOUS-TONE STILL IMAGES - Extensions", 1997, pp. HUAWEI-HM_0027238-0027259	
	6	"Kodak Professional DCS 300 Series Digital Cameras User's Guide", 1999, pp. 1-1-F-1	
	7	Z_RNE, J., "Versatile Video Camera is Smooth to Use for MPEG Video, JPEG Images and Audio", February 9, 1998, GCN, URL: https://gcn.com/articles/1998/02/09/versatile-video-camera-is-smooth-to-use-for-mpeg-video-jpeg-images-and-audio.aspx	
	8	LEE, H. et al., "User Interface Issues for Browsing Digital Video", 21st BCS IRSG Colloquium on IR, 1999, pp. 1-11, Glasgow	
	9	"XIL Programmer's Guide", 1997, Sun Microsystems, Inc., pp. 1-646	
	10	NIELSEN, K., "A Review and Comparison of Pulse Width Modulation (PWM) Methods for Analog and Digital Input Switching Power Amplifiers", 1997	
	11	"First Looks: The Digital Chameleon at 72", MP-EG1 PC Mag, PC Magazine, July 1997	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

If you wish to add additional non-patent literature document citation information please click the Add button	Add		
EXAMINER SIGNATURE			
Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-06-13
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	36287232
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	13-JUN-2019
Filing Date:	23-APR-2018
Time Stamp:	11:32:15
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	9606-09-Request-Reconsideration-IDS.pdf	37670 f258a9a7ddc9a9891fa4749115ce25f41dd79295	no	6

Warnings:

Information:					
2	Transmittal Letter	CopyofAcknowledgementReceipts.pdf	555034 9aaf71eba7d1ba120b01ac89a6fde11216634531	no	21
Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-Resubmission09-07-2018-IDS.pdf	1035496 db6e7be93ae4464146ce12027c11ac7b67cbd847	no	5
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
4	Non Patent Literature	NPL54-SONYDCS-F55SPECSHEET-000109-000110.pdf	1777910 7e1660de35fc0cd9031b2c2333fb19e7cd4759c6	no	2
Warnings:					
Information:					
5	Non Patent Literature	NPL63-ReverseLinkPowerControlforPacketizedDS.pdf	11572185 e63d88c225b34a882bf3d93c3bcec6af78781ba	no	6
Warnings:					
Information:					
6	Non Patent Literature	NPL1-E52018-06-12-Asus1stAmendedInvalidityContentions.pdf	1267883 7fa52d7435ba02de401b853cff270bd1e3b96fb3	no	101
Warnings:					
Information:					
7	Non Patent Literature	NPL4-AnnexFofITU-TNPL5-RecommendationT84ISO-IECIS10918-3.pdf	4645587 c87e43a6a814021dc7e395938661a13e6fe2c277	no	26
Warnings:					
Information:					

8	Non Patent Literature	NPL33-UserInterfaceIssues.pdf	5491319 049c223c77e53f7f56d2aacd1fbd97bb36d957a5	no	11
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
9	Non Patent Literature	NPL48-AReviewandComparisonofPulseWidthModulation.pdf	24256351 4ddd5be6bd1fc7810cf4ab6963c42e237efee151	no	59
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
10	Non Patent Literature	NPL49-TheDigitalChameleon-July1997PCMagazine.pdf	2836142 696a328d770b90ebe0b2032bce65278b56d936e1	no	1
Warnings:					
Information:					
11	Non Patent Literature	NPL16-KodakProfessionalDCS300SeriesDigitalCamerasUserGuide.pdf	18408429 7b7649e8e560b517641b390a828d7e0943328de4	no	130
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
12	Non Patent Literature	NPL31-VersatileVideoCamera.pdf	796735 547d8acee83ae9d5451aaea45afc0b1477a4741e	no	4
Warnings:					
Information:					
			Total Files Size (in bytes):	72680741	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	Takahiro NAKANO et al.
		Confirmation No.: 2614
Serial No.	:	15/959,774
Filed	:	April 23, 2018
For	:	ELECTRIC CAMERA
Group	:	2698
Examiner	:	L. NGUYEN
Docket No.	:	ASA-9606-09
Customer No.:		24956

REQUEST FOR RECONSIDERATION OF INFORMATION DISCLOSURE STATEMENTS

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

June 13, 2019

Sir:

Applicant requests reconsideration of the Information Disclosure Statements filed September 7, 2018 in the above application. The Examiner has crossed through references submitted with the Information Disclosure Statements, as an indication that these references have not been fully considered. Each of the crossed through documents has been re-listed on a PTO/SB/08a form submitted herewith to assist the Examiner in providing his initials for each of the documents to be reconsidered for the following reasons.

The two Information Disclosure Statements (PTO/SB/08a forms) filed September 7, 2018 are distinguishable in the Image File Wrapper in PAIR by page count, as follows.

(I) IDS form PTO/SB/08a submitted on September 7, 2018 (5 pages)

A. Acknowledgement Receipt (10 pages)

(II) IDS form PTO/SB/08a submitted on September 7, 2018 (19 pages)

B. Acknowledgement Receipt (11 pages)

A "Copy of Acknowledgement Receipts" document, combining Acknowledgement Receipts A and B, noted above, (21 pages total) forms an Appendix to this Request in order to efficiently refer to the electronic filing acknowledgement of the documents submitted on September 7, 2018 by document number and page number, referring to the "Copy of Acknowledgement Receipts" document.

(I) IDS form PTO/SB/08a submitted on September 7, 2018 (5 pages)

For IDS (I), the following references have been crossed through, and the reason Applicant asserts that the references should be initialed as an indication of consideration of the references is set forth as follows.

(i) NPL-1 TIA/EIA/IS-95-A +TSB74 (February 27, 1996) ("IS 95")

A copy of the document was submitted on September 7, 2018. See document numbers 30-48 on page 2 of the Copy of Acknowledgement Receipts. The cited document was submitted in several parts in order to comply with the page count restriction in PAIR. To

assist the Examiner in reconsideration of the document, another copy is submitted with this Request for Reconsideration.

(ii) NPL-4 SONY DCS-F55 specification sheet

A copy of the document was submitted September 7, 2018. See document number 53 on page 9 of the Copy of Acknowledgement Receipts. To assist the Examiner in reconsideration of the document, another copy is submitted with this submission.

(iii) NPL-13 S. Manji and W. Zhuang, "Reverse Link Power Control for Packetized DS-CDMA in a Slowly Rayleigh Fading Environment," published in Dept. of Electrical and Computer Engineering, University of Waterloo, Canada

A copy of the document was submitted on September 7, 2018 without a publication date. See document number 5 on page 13 of the Copy of Acknowledgement Receipts. Applicant resubmits the copy with an abstract page indicating the date of publication, which is also shown on the resubmitted SB/08a.

(II) IDS form PTO/SB/08a submitted on September 7, 2018 (19 pages)

For IDS (II), the following references have been crossed through, and the reason Applicant asserts that the references should have been initialed as an indication of consideration of the references is set forth as follows.

(iv) Asustek Computer Inc. and Asus Computer International's First Amended Invalidity Contentions which were filed in the following litigation: MAXELL, LTD. v. ASUSTEK COMPUTER INC. AND ASUS COMPUTER INTERNATIONAL, Civil Action No. 3:18-cv-01788-VC (N.D. CA), filed June 12, 2018

A copy of the document was submitted on September 7, 2018. See document number 5 on page 2 of the Copy of Acknowledgement Receipts. To assist the Examiner in reconsideration of the document, another copy is submitted with this Request for Reconsideration.

(v) "Annex F of ITU-T Recommendation T.84 | ISO/IEC IS 10918-3, DIGITAL COMPRESSION AND CODING OF CONTINUOUS-TONE STILL IMAGES - Extensions", 1997, pp. HUAWEI-HM_0027238-0027259

A copy of the document was submitted on September 7, 2018 without a publication date. See document number 8 on page 2 of the Copy of Acknowledgement Receipts. Applicant resubmits the copy with Title pages of the document indicating the copyright date, which is also shown on the resubmitted SB/08a.

(vi) "Kodak Professional DCS 300 Series Digital Cameras User's Guide", 1999, pp. 1-1-F-1

A copy of the document was submitted on September 7, 2018 without a publication date. See document number 20 on page 4 of the Copy of Acknowledgement Receipts. Applicant resubmits the copy with a new last page of the document indicating the copyright date, which is also shown on the resubmitted SB/08a.

(vii) Z_RNE, J., "Versatile Video Camera is Smooth to Use for MPEG Video, JPEG Images and Audio", February 9, 1998, GCN, URL: https://gcn.com/articles/1998/02/09/versatile-video-camera-is-smooth-to-use-for-mpeg-video-jpeg-images-and-audio.aspx

A copy of the document was submitted on September 7, 2018. See document number 38 on page 7 of the Copy of Acknowledgement Receipts. To assist the Examiner in reconsideration of the document, another copy is submitted with this Request for Reconsideration.

(viii) LEE, H. et al., "User Interface Issues for Browsing Digital Video", 21st BCS IRSG Colloquium on IR, 1999, pp. 1-11, Glasgow

A copy of the document was submitted on September 7, 2018. See document number 57 on page 10 of the Copy of Acknowledgement Receipts. To assist the Examiner in reconsideration of the document, another copy is submitted with this Request for Reconsideration.

(ix) "XIL Programmer's Guide", 1997, Sun Microsystems, Inc., pp. 1-646

A copy of the document (NPL-35) was submitted on September 7, 2018. See document numbers 14-26 on pages 14-15 of the Copy of Acknowledgement Receipts. The cited document was submitted in several parts in order to comply with the page count restriction in PAIR. To assist the Examiner in reconsideration of the document, another copy of the document is submitted with this Request for Reconsideration.

(x) NIELSEN, K., "A Review and Comparison of Pulse Width Modulation (PWM) Methods for Analog and Digital Input Switching Power Amplifiers", 1997

A copy of the document was submitted on September 7, 2018 without a publication date. See document number 13 on page 14 of the Copy of Acknowledgement Receipts. Applicant resubmits the copy with an abstract page indicating the date of publication, which is also shown on the resubmitted SB/08a.

(xi) "First Looks: The Digital Chameleon at 72", MP-EG1 PC Mag, PC Magazine, July 1997

A copy of the document was submitted on September 7, 2018 with a publication date. See document number 49 on page 8 of the Copy of Acknowledgement Receipts. The publication date of July 1997 is shown on submitted copy. To assist the Examiner in reconsideration of the document, another copy is submitted with this Request for Reconsideration.

Conclusion

In view of the foregoing, Applicant respectfully asserts that all of the documents re-listed on the PTO/SB/08a form submitted herewith, with dates of publication added as required, were previously submitted on September 7, 2018, and therefore the documents should be considered in accordance with this Request for Reconsideration. Accordingly, Applicant requests that the Examiner initial the documents on the

PTO/SB/08a form submitted herewith as an indication that the Examiner has fully considered these references.

The Commissioner is authorized to charge any shortage in the fees due, or credit any overpayment, to Deposit Account No. 50-1417 (referencing Attorney Docket No. ASA-9606-09).

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Registration No. 30,293
703-684-1120

Electronic Acknowledgement Receipt

EFS ID:	33652727
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	07-SEP-2018
Filing Date:	23-APR-2018
Time Stamp:	11:50:14
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	JP6-60158.pdf	217875 484fabfea3491045183070 2b2c80f9e40f48db3c	no	6

Warnings:

Information:					
2	Foreign Reference	WO98-28843.pdf	906765 41a75eb507aca81f4f2d5b4260ee9721c78a5395	no	21
Warnings:					
Information:					
3	Foreign Reference	JP9-275351.pdf	158545 3f9215ec19946d4e78c64e689b8c0ed9d078a7b2	no	4
Warnings:					
Information:					
4	Foreign Reference	EP0587954.pdf	1154257 d2501f66c0ed7cf88a05678ac0e18e9fd1e23e61	no	16
Warnings:					
Information:					
5	Non Patent Literature	NPL1-E52018-06-12-Asus1stAmendedInvalidityContentions.pdf	1267883 7fa52d7435ba02de401b853cff270bd1e3b96fb3	no	101
Warnings:					
Information:					
6	Non Patent Literature	NPL2-DigitalStillCameraImageFileFormatStandardv21.pdf	19256586 80a008dbcd24edc40b1f53183418e62c76c41a22	no	172
Warnings:					
Information:					
7	Non Patent Literature	NPL3-MPEGCAMMP-EG1AInstructionManual.pdf	17899261 6131ac2f0b6dc4baa107aadfb594a265f4be8e2b	no	101
Warnings:					
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8	Non Patent Literature	NPL4-AnnexFofITU-TNPL5-RecommendationT84ISO-IECIS10918-3.pdf	4610029 612e8ae9aa3454fa57608398e39b17c32e9fc983	no	22
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59	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-Litigation.pdf	1040862 f78bb598a6dd5b0f70488a48896abf9bfa9c5bfb	no	19
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60	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-Litigation-2.pdf	1035278 a6444c06293c355049f1b813339954d4512fe1a7	no	5
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EFS ID:	33652814
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	07-SEP-2018
Filing Date:	23-APR-2018
Time Stamp:	11:51:56
Application Type:	Utility under 35 USC 111(a)

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	NPL58-SonyDSCF55ServiceManual.pdf	15895251 432092c5db4c03b07a415a4b001006f9d840a440	no	115

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34	Non Patent Literature	NPL51-TIA-EIA-IS-95-E.pdf	14795060 85fb26335f29724079efdd978e23171bd712e324	no	50
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35	Non Patent Literature	NPL51-TIA-EIA-IS-95-F.pdf	13373136 b9fd3a6b6091890b72762cec8dbe90c8a9d7e04e	no	44
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36	Non Patent Literature	NPL51-TIA-EIA-IS-95-G.pdf	17315495 3a660c9aaa7c72b410725a30c0938230c1847b07	no	50
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37	Non Patent Literature	NPL51-TIA-EIA-IS-95-H.pdf	21779818 4af317fffac77d6be0f23b72bd0f33f159fb950e	no	50
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38	Non Patent Literature	NPL51-TIA-EIA-IS-95-I.pdf	20820325 ab067e9437021f3bea036d223bf6692d577d88d1	no	46
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39	Non Patent Literature	NPL51-TIA-EIA-IS-95-J.pdf	19201467 33752ece210cf0e10c1412278834 5d2ce5d489ea	no	50
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42	Non Patent Literature	NPL51-TIA-EIA-IS-95-M.pdf	16239651 d02eeac8fff05e4e41c9e3ac33a815a2adbbef79	no	50
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45	Non Patent Literature	NPL51-TIA-EIA-IS-95-P.pdf	15784541 cf3dd437f3bee64b7ebf367e172e17cbfd8bdee3	no	50
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47	Non Patent Literature	NPL51-TIA-EIA-IS-95-R.pdf	14717082 561d065336720fd5911b3b68457ec120ab6c6230	no	50
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48	Non Patent Literature	NPL51-TIA-EIA-IS-95-S.pdf	9750471 2baeb97ec3276bcb912ca167b7c163c0522a62f0	no	32
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Electronic Acknowledgement Receipt

EFS ID:	36287517
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	13-JUN-2019
Filing Date:	23-APR-2018
Time Stamp:	11:32:58
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	NPL35-XILProgrammers-1.pdf	13767881 96abf1f34c6ebbad4142d425ad41fe586481dfd9	no	50

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2	Non Patent Literature	NPL35-XILProgrammers-2.pdf	14827137 008bb981a6287e4cc607610be02f62a34db579a2	no	50
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3	Non Patent Literature	NPL35-XILProgrammers-3.pdf	14502543 6d276fd50134902cf175741f80ca84838ac63fd3	no	50
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4	Non Patent Literature	NPL35-XILProgrammers-4.pdf	15126478 28346be9d40fdca49890e1a9ddc3d34dfefc4e22	no	50
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5	Non Patent Literature	NPL35-XILProgrammers-5.pdf	11867398 7d8a0cabe194d6c6432dfacf3b1b9216eb035c3b	no	40
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6	Non Patent Literature	NPL35-XILProgrammers-6.pdf	15146075 127c718a0a92aae94384d53956bd2387ac3779cf	no	50
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7	Non Patent Literature	NPL35-XILProgrammers-7.pdf	15252095 45328239ee64626c5527264fc168b78dc1a276cb	no	50
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9	Non Patent Literature	NPL35-XILProgrammers-9.pdf	14774917 b3bef17ed1d0ed68acb117ed9083f999c2cfd071	no	50
Warnings:					
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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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11	Non Patent Literature	NPL35-XILProgrammers-11.pdf	14342624 643b0e1ac011ddc9fa6ee98cb18287efa59048c7	no	50
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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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12	Non Patent Literature	NPL35-XILProgrammers-12.pdf	13085972 af75966acd32c49b6119101a6f2f69d9fb4b9cc8	no	50
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13	Non Patent Literature	NPL35-XILProgrammers-13.pdf	16383951 294139ebcae6e3b0743c32da934c4cc2754b067c	no	56
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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

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Electronic Acknowledgement Receipt

EFS ID:	36287717
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	13-JUN-2019
Filing Date:	23-APR-2018
Time Stamp:	11:31:24
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	NPL51-TIA-EIA-IS-95-A.pdf	17562220 f28e801d18ed17508ab710447631fd3eb21937e0	no	50

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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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3	Non Patent Literature	NPL51-TIA-EIA-IS-95-C.pdf	17071291 f33b06963641e46aeeda9985c914620f28678090	no	42
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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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4	Non Patent Literature	NPL51-TIA-EIA-IS-95-D.pdf	16558267 6ea23ad7154f83610f43a279cdb3cb19ead099e4	no	50
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5	Non Patent Literature	NPL51-TIA-EIA-IS-95-E.pdf	14795060 85fb26335f29724079efdd978e23171bd712e324	no	50
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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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6	Non Patent Literature	NPL51-TIA-EIA-IS-95-F.pdf	13373136 b9fd3a6b6091890b72762cec8dbe90c8a9d7e04e	no	44
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7	Non Patent Literature	NPL51-TIA-EIA-IS-95-G.pdf	17315495 3a660c9aaa7c72b410725a30c0938230c1847b07	no	50
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9	Non Patent Literature	NPL51-TIA-EIA-IS-95-I.pdf	20820325 ab067e9437021f3bea036d223bf6692d577d88d1	no	46
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10	Non Patent Literature	NPL51-TIA-EIA-IS-95-J.pdf	19201467 33752ece210cf0e10c1412278834 5d2ce5d489ea	no	50
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11	Non Patent Literature	NPL51-TIA-EIA-IS-95-K.pdf	14935720 167a780308e39ba11ab9cdfa40a405c9852d705e	no	50
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Information:					
12	Non Patent Literature	NPL51-TIA-EIA-IS-95-L.pdf	20839386 804a1e71846740c03f6dea260276a6c6dc31a10e	no	70
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13	Non Patent Literature	NPL51-TIA-EIA-IS-95-M.pdf	16239651 d02eeac8fff05e4e41c9e3ac33a815a2adbbef79	no	50
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14	Non Patent Literature	NPL51-TIA-EIA-IS-95-N.pdf	22376603 af2ca4b41777c7e0a88956fd55b7e53b300f30e9	no	60
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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
15	Non Patent Literature	NPL51-TIA-EIA-IS-95-O.pdf	16934969 b3112a6490ef1a3322ea922c3a378e357698dcd0	no	50
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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
16	Non Patent Literature	NPL51-TIA-EIA-IS-95-P.pdf	15784541 cf3dd437f3bee64b7ebf367e172e17cbfd8bdee3	no	50
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
17	Non Patent Literature	NPL51-TIA-EIA-IS-95-Q.pdf	8934699 266130957e4c38131198d84b3b5fa58429dca9fc	no	30
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18	Non Patent Literature	NPL51-TIA-EIA-IS-95-R.pdf	14717082 561d065336720fd5911b3b68457ec120ab6c6230	no	50
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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
19	Non Patent Literature	NPL51-TIA-EIA-IS-95-S.pdf	9750471 2baeb97ec3276bcb912ca167b7c163c0522a62f0	no	32
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

24956 7590 07/09/2019

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1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
NGUYEN, LUONG TRUNG	

ART UNIT	PAPER NUMBER
2698	

NOTIFICATION DATE	DELIVERY MODE
07/09/2019	ELECTRONIC

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Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

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Alexandria, Virginia 22313-1450

APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR/ PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
15/959,774	04/23/2018	NAKANO et al.	ASA-9606-09

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Commissioner for Patents

The Information Disclosure Statement (IDS) filed on 06/13/2019 was filed after the mailing date of the Notice of Allowance on 04/15/2019. The submission is in compliance with the provisions of 37 CFR 1.97. Accordingly, the Information Disclosure Statement is being considered by the Examiner.

Attachment: Initialed Information Disclosure Statement PTO/SB/08a filed on 06/13/2019.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2698

PTO-90C (Rev.04-03)

Receipt date: 06/13/2019

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

EFS Web 2.1.18

Receipt date: 06/13/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	1	TIA/EIA/IS-95-A +TSB74 (February 27, 1996) ("IS 95")	
	2	SONY DCS-F55 specification sheet , 1999.	
	3	S. Manji and W. Zhuang, "Reverse Link Power Control for Packetized DS-CDMA in a Slowly Rayleigh Fading Environment," June 12, 1997, published in Dept. of Electrical and Computer Engineering, University of Waterloo, Canada	
	4	Asustek Computer Inc. and Asus Computer International's First Amended Invalidity Contentions which were filed in the following litigation: MAXELL, LTD. v. ASUSTEK COMPUTER INC. AND ASUS COMPUTER INTERNATIONAL, Civil Action No. 3:18-cv-01788-VC (N.D. CA), filed June 12, 2018	
	5	"Annex F of ITU-T Recommendation T.84 | ISO/IEC IS 10918-3, DIGITAL COMPRESSION AND CODING OF CONTINUOUS-TONE STILL IMAGES - Extensions", 1997, pp. HUAWEI-HM_0027238-0027259	
	6	"Kodak Professional DCS 300 Series Digital Cameras User's Guide", 1999, pp. 1-1-F-1	
	7	Z_RNE, J., "Versatile Video Camera is Smooth to Use for MPEG Video, JPEG Images and Audio", February 9, 1998, GCN, URL: https://gcn.com/articles/1998/02/09/versatile-video-camera-is-smooth-to-use-for-mpeg-video-jpeg-images-and-audio.aspx	
	8	LEE, H. et al., "User Interface Issues for Browsing Digital Video", 21st BCS IRSG Colloquium on IR, 1999, pp. 1-11, Glasgow	
	9	"XIL Programmer's Guide", 1997, Sun Microsystems, Inc., pp. 1-646	
	10	NIELSEN, K., "A Review and Comparison of Pulse Width Modulation (PWM) Methods for Analog and Digital Input Switching Power Amplifiers", 1997	
	11	"First Looks: The Digital Chameleon at 72", MP-EG1 PC Mag, PC Magazine, July 1997	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

EFS Web 2.1.18

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/LUONG T NGUYEN/	Date Considered	07/03/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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Receipt date: 06/13/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
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	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-06-13
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

24956 7590 04/15/2019
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

TITLE OF INVENTION: ELECTRIC CAMERA

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	07/15/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, LUONG TRUNG	2698	348-208600

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Mattingly & Malur, PC
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Maxell, Ltd.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Kyoto, Japan

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ☒ Corporation or other private group entity ❑ Government

4a. Fees submitted: ☒ Issue Fee ❑ Publication Fee (if required) ❑ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

☒ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 50-1417

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /John R. Mattingly/ Date July 15, 2019

Typed or printed name John R. Mattingly Registration No. 30,293

Electronic Patent Application Fee Transmittal

Application Number:	15959774
Filing Date:	23-Apr-2018
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly/Jasmyn Martinez
Attorney Docket Number:	ASA-9606-09

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	1501	1	1000	1000

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**1000**

Electronic Acknowledgement Receipt

EFS ID:	36577257
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Jasmyn Martinez
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	15-JUL-2019
Filing Date:	23-APR-2018
Time Stamp:	12:29:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1000
RAM confirmation Number	071519INTEFSW12301600
Deposit Account	501417
Authorized User	Jasmyn Martinez
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	9606-09-Issue_Fee_Transmittal.pdf	86336 68a39bf2cdf735204a0193a08e87f66f34dbc8a4	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30279 fc4734951fb262d4458a598e56235106fb738ebe	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	116615		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2018-04-23
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	NGUYEN, L.
	Attorney Docket Number	ASA-9606-09

	9	7154539	B1	2006-12-26	NISHIMURA et al.	
	10	5828406		1998-10-27	PARULSKI et al.	
	11	4054915		1977-10-18	SUGIHARA	
	12	5170249		1992-12-08	OHTSUBO et al.	
	13	5187569		1993-02-16	TANI	
	14	6195125	B1	2001-02-27	UDAGAWA et al.	
	15	6906746	B2	2005-06-14	HIJISHIRI et al.	
	16	6519000	B1	2003-02-11	UDAGAWA	
	17	5847758		1998-12-08	IIZUKA	
	18	6970191	B1	2005-11-29	SASE et al.	
Change(s) applied to document /J.K.W./ 6/6/2019	19	6734424		~~1998-03-31~~ 05/2004	~~SASAKI~~ Lennon et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

EFS Web 2.1.17

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	08/27/2019	10397507	ASA-9606-09	2614

24956 7590 08/07/2019

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Takahiro NAKANO, Tokyo, JAPAN;
Maxell, Ltd., Kyoto, JAPAN;
Ryuji NISHIMURA, Tokyo, JAPAN;
Toshiro KINUGASA, Tokyo, JAPAN;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

PTO/SB/30EFS (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	15959774	Filing Date	2018-04-23	Docket Number (if applicable)	ASA-9606-09	Art Unit	2698
First Named Inventor	NAKANO, T.			Examiner Name	NGUYEN, L. T.		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☐ Amendment/Reply
- ☒ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____
(Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 501417

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

Applicant Signature

PTO/SB/30EFS (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Signature of Registered U.S. Patent Practitioner			
Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-08-26
Name	John R. Mattingly	Registration Number	30293

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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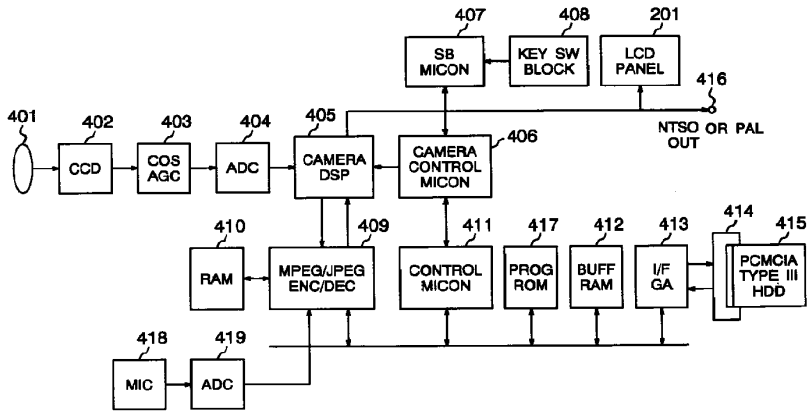
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(54) Apparatus for recording and reproducing digital image and speech

(57) A digital image and speech recording and reproducing apparatus is arranged to quickly and simply retrieve, classify, and erase a great deal of data for improving the operativity in small-sized equipment. The apparatus includes a recording and reproducing unit (401, 402, 403, 404, 405, 409, 412, 415) for a moving image signal, a recording and reproducing unit (401, 402, 403, 404, 405, 409, 412, 415) for a still image signal, a recording and reproducing unit (418, 419, 409, 415) for a digital speech signal operated in synchronous to the image, a display (201) for displaying the image for said moving image signal or said still image signal, a recording condition recording unit for recording recording conditions containing data information about recorded data for distinguishing said moving image from said still image and recording time information for recording an image or a speech. The recording conditions consisting of at least the data information and the recording time information about the recorded data are graphically and literarily displayed on the display, so that the recorded data item may be selected on the display screen.

FIG. 4



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Description

BACKGROUND OF THE INVENTION

The present invention relates to operativity of a portable digital camcorder.

The prior art relevant to the portable digital camcorder has been published as an electronic photograph system, that is, the so-called electronic still camera that is arranged to record a still image signal as a video signal in a memory composed of a semiconductor (termed as a semiconductor memory or simply a memory) as disclosed in JP-A-2-292974. With recent prevail of personal computers, recording mediums such as semiconductor memories and harddisks are progressively made lower in cost, smaller in size, and greater in capacity. At a time, the advance of signal compressing technology such as JPEG or MPEG allows even the small-sized equipment to record greater number of still images and moving ones. Taking a harddisk drive as an example, the resulting harddisk drive is kept as small as a card and has as great a capacity as about 300 Mbytes.

This type of harddisk drive enables to record about 3000 still images through the use of the JPEG compression and about 20-minutes moving picture through the use of the MPEG compression. It is thus necessary to improve the operativity of the portable equipment for retrieving, grouping, and deleting a great deal of recording data. The technique disclosed in JP-A-2-292974, however, does not provide means for retrieving a great deal of recording data quickly and easily. In actual, therefore, the technique does not have any means except the method of retrieving the great deal of recorded data as checking all images reproduced on screen from the recorded data.

In case that 3000 JPEG still images are recorded on a feasible media such as the aforementioned harddisk drive and then are retrieved as expanding those images on the screen one by one, about one second for expanding one JPEG still image is required. It means that the expansion of 3000 images needs about one hour. This method lacks in practicability. In order to retrieve a great deal of data, therefore, it is necessary to enhance the operating speed of the system.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an apparatus which is arranged to overcome the foregoing shortcoming and enhance the operativity even if the apparatus is small-sized.

In carrying out the object, for improving the operativity of a small-sized apparatus, the present invention is achieved by an apparatus which comprises recording means for recording both imaging time information and imaging mode information for distinguishing moving images from still images at a time when taking the still image or moving image, display means for displaying as a list the informations as well as expanded images on a liquid crystal display screen built in the main body of the apparatus itself, and keying means for retrieving, classifying, and erasing the recorded data.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing a state transition of a program used in an apparatus according to the present invention;

Fig. 2 is a view showing an outer appearance of a portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 3 is an expanded view showing an operating switch portion provided in the portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 4 is a circuit diagram showing an arrangement of a portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 5 is a view showing a display screen provided in the portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 6 is a view showing a display screen on which the recorded data is classified;

Fig. 7 is a view showing a display screen on which the recorded data is selected;

Fig. 8 is a view showing a display screen with expanded images in which the recorded data is selected;

Fig. 9 is a view showing a display screen on which the function details of the recorded data are selected;

Fig. 10 is a flowchart showing a method for selecting the function details;

Fig. 11 is a view showing a display screen on which the classifications of the recorded data are changed;

Fig. 12 is a view showing a display screen on which the displaying sequence of the recorded data is changed;

Fig. 13 is a view showing a display screen on which each date of the recorded data is changed;

Fig. 14 is a view showing a display screen on which each erasing attribute of the recorded data is changed;

Fig. 15 is a view showing a display screen on which a remaining state of the recording medium is displayed;

Fig. 16 is a flowchart showing a method for reading recorded data from a harddisk driver and reproducing it;

Fig. 17 is a view showing an imaged screen appearing if a still image recording mode is selected when recording an image;

Fig. 18 is a view showing an imaged screen appearing if a moving image recording mode is selected when recording an image; and

Fig. 19 is a view showing marks for modes;

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Later, the description will be oriented to the embodiments of the present invention with reference to Figs. 1 to 19.

Fig. 1 shows a flow of a software program according to an embodiment of the present invention.

The software program shown in Fig. 1 flows through the process of selecting a classification containing data to be played back or handled (101) and reaches the process of playing back the data (103) or flows to a function selecting items (105) in which a temporary discard (106), a complete abandon (107), a state display (112) of a storage unit, setting of protection from erasion (111), change of a display list (109), or change of a record date and hour (110) is selected. Moreover, when selecting a classification (101), the flow goes to the function selecting items (105) in which a temporary discard (106), a complete abandon (107), a state display of a storage unit (112), or automatic playback is selected. In the playback (103), a move to next data (115), a move to previous data (116), a fast playback (117), a rewind playback (118), or a temporary stop (121) is selected. In the temporary stop (121), a forward frame advance (119) or reverse frame advance (120) is selected.

Fig. 2 shows an example of an outer appearance of a portable digital comcorder 200 in which the software program shown in Fig. 1 is executed. This comcorder 200 provides a capability of recording and reproducing an NTSC or PAL TV system signal.

Fig. 3 is an expanded view showing an operating switch portion of the portable digital camcorder shown in Fig. 2. In the portable digital camcorder 200 shown in Fig. 2, with the operating switches, a digital moving signal obtained from the camera system is compressed to one MPEG (Moving Picture Expert Group) format and then is recorded on a harddisk storage medium sized to a memory card. In the playback, with the operating switches, the MPEG1 format signal recorded in a memory card is expanded and then displayed on a display unit 201 built in the camcorder itself. The display unit may be connected to the outside of the comcorder 201. The portable digital camcorder 200 shown in Fig. 2 may recorded the MPEG moving image data as well as the JPEG data for the still images and the MPEG speech format for the speech data.

Fig. 4 schematically shows a circuit arrangement of the portable digital comcorder 200. At first, the description will be oriented to the procedure of recording the moving image through the portable digital comcorder 200. When a user presses a recording switch 301, an image of an object obtained through a lens 401 is converted into the corresponding electric signal through the effect of a CCD sensor 402. The signal read out of a sensor is electrically processed through a CDS (Correlated Double Sampling) circuit for suppressing the low-frequency noises of the signal and a circuit 403 integrated with a AGC circuit for controlling an automatic gain of the signal for stabilizing the signal level. Then, the processed signal is converted into a digital signal through an ADC 404 and then is applied to a camera signal processing circuit 405.

A camera signal processing circuit (camera DSP) 405 is configured of a function of converting a digital pixel signal from the sensor into a luminance signal Y and color difference signals U and V, a function of adding a synchronous signal, a function of controlling relation between an iris and a shutter speed, a function of adjusting a white balance, and a function of digitally zooming in or out the signal. Though not illustrated in detail in Fig. 4, the camera DSP 405 is operated to feed a horizontal and a vertical driving signal pulses to the CCD sensor 402 and read the signal from the CCD sensor 402 as adjusting the timing between the synchronous signal and the pulses. Moreover, a camera control microcomputer 406 is operated to feed operating parameters for the DSP 405 to the camera DSP 405 in order to control the overall camera system.

On the other hand, the digital luminance signal Y and the digital color difference signals U and V obtained by the camera DSP 405 are sent to an MPEG1 encoder 409 through a digital bus line. The MPEG1 is a standard compression format for the digital signal for a moving image. The encoder 409 operates to compress the data according to the MPEG1 format and then convert it into the digital data. A numeral 410 denotes a working memory used in encoding the data according to the MPEG1 format. The data converted into the MPEG1 format is sent to a microcomputer 411 for controlling a transmission rate of the digital output data. The MPEG1 encoder 409, the working memory 410 and the microcomputer 411 compose the overall system for compressing the moving image.

The microcomputer 411 for controlling the transmission rate stores a constant amount of MPEG1-formatted data in a buffer memory 412. The formatted data is passed through an interface circuit 413 and a card connector 414 and reaches a harddisk drive 415. The card connector 414 is configured on the PCMCIA standards and thus contains 68 pins. The harddisk drive 415 is sized to a memory card and subject to the PC card standards defined by the PCMCIA (Personal Computer Memory Card International Association).

The foregoing description has concerned with the method for recording the moving image. In case the still image recording mode is selected by the user, the MPEG encoder 409 is switched to a JPEG compressing circuit. Then, a still image data is generated at the encoder 409 and then transferred to the microcomputer 411 for doing the same operation as described above. The MPEG compression data process and the JPEG compression data process have the same common points, so that the use of both the data formats may effectively save the circuit scale. This is a well-known method for saving the circuitry.

Further, the speech signal is converted into an analog electric signal through a microphone 418. The ana-

log electric signal is sent to a speech ADC 419 for converting the analog electric signal into the corresponding digital data. The digital speech data is applied into the data bus through the effect of the MPEG encoder 409. Then, the microcomputer 411 performs the MPEG-format-based compression through the program run therein so that the digital speech data is added to the moving image data or the still image data in precise time sequences.

According to this embodiment, the portable digital comcorder 200 is arranged to record the MPEG1-formatted data, the JPEG-formatted data, and the MPEG1-formatted speed data.

In recording the data, the microcomputer 411 also enables to record a data, a time, and a symbol for representing any one of the MPEG1-formatted data, the JPEG-formatted data, and the MPEG1-formatted data on a time when the recording switch 301 is pressed. At a time, the microcomputer 411 enables to record a symbol for representing a classification for retrieving the recorded data and a symbol for representing whether or not the operation of erasing the recorded data is prohibited. In recording the data, the classification symbol is recorded as "not classified" and the deletion symbol is recorded as "erasable".

In the general disk operating system, the symbol for indicating the imaging mode is discriminated using a code for a data type. The symbol for representing the classification and the symbol for representing if the data is erased are recorded in the corresponding files.

On the other hand, when recording the data, a digital signal applied to the camera DSP 405 as a monitoring signal is converted into an analog TV signal through the effect of an NTSC or PAL encoder built in the circuit 405 and then is fed at an output terminal 416 and the built-in display unit 201. The foregoing description has concerned with the MPEG1-formatted moving image data with the speech. In actual, the JPEG-formatted data or the MPEG1-formatted speech data may be solely processed in the similar manner to the above operation.

When the system stays at the playback mode, the signal flows in an opposite manner to the flow at the recording mode. Fig. 16 is a flowchart showing the reproduction of the signal. Text data indicating information of data is read from the harddisk drive 415 (step 1601). Next, the user retrieves data from a list of data displayed on the built-in display unit 201 and specifies the data to be played back with the operating switch 408 (step 1604). The list of the recorded data displayed on the display unit 201 is a feature of the invention. With the specification, a file system is started (step 1605) so that the data is read out of the harddisk drive 415 and then sent to the microcomputer 411 (step 1606).

Then, the data type is discriminated (steps 1607 and 1608). If the recorded data is the moving image, the MPEG-formatted moving image data and the MPEG-formatted speech data are both decoded (step 1609). If the recorded data is the still image, the JPEG-formatted still image data is decoded (step 1610). If the recorded data is the still image with the speech, the JPEG-formatted still image data and the MPEG-formatted speech data are both decoded (step 1611). Then, the decoded image and the decoded speech if any are displayed on the screen (step 1612).

An indication signal issued by the operating switch 408 is read by a sub-microcomputer 407 and then is sent to the microcomputer 411 through a camera-controlling microcomputer 406. The software program according to this embodiment is read out of a ROM 417 (Read-only Memory) for storing a program and then is executed. In this embodiment, the program is stored in the ROM 417. In place of the ROM 417, another storage unit such as a flash RAM or a harddisk drive may be used for the purpose.

Next, the data is transferred to the buffer memory 412 through the PCMCIA connector 414 and the interface circuit 413. The timing of the data stored in the buffer memory 412 is controlled by the microcomputer 411. Then, the data whose timing is adjusted is sent to the MPEG1 decoder 409. The decoder 409 switches the MPEG1 coding to the MPEG1 decoding or vice versa.

The data decoded by the MPEG1 decoder 409 is sent to the camera DSP circuit 405 through the digital path line. The decoded data is converted into an analog video signal through the effect of an NTSC or PAL encoder and a DAC built in the circuit 405 and then is led at an output terminal 416 and from the built-in display unit 201 to the outside of the apparatus. The foregoing description has concerned with the MPEG1-formatted moving picture data with the speech. The JPEG-formatted still image data or the MPEG1-formatted speech data may be solely processed in the same manner as described above.

The portable comcorder of this embodiment is arranged to use a harddisk unit of 260 MB for the harddisk drive 415. In case that only the JPEG-formatted still image data is recorded, about 3000 still images may be recorded. In actual, the portable comcorder of this invention enables to retrieve 3000 items of data quickly and easily using the classifying function.

Fig. 4 shows a circuit arrangement about the moving image. The corresponding circuit arrangement to that of Fig. 4 is required for the still images and the speech. That is, the portable comcorder of this embodiment is arranged to have a general-purpose means for imaging a moving object / a still object, a microphone, means for digitally converting a moving image / a still image, means for digitally converting speech, and means for digitally recording a moving image, a still image, and a speech signal.

Fig. 5 shows the screen of the built-in display unit 201 used in the embodiment of the invention, in which the diagonal length is 1.8 inch (45.7 mm), the horizontal length is 36.6 mm, and the vertical length is 27 mm. The illustrated screen arrangement uses a liquid crystal consisting of 352 pixels and 240 pixels. In order to reduce

the power consumption and the size of the portable digital camcorder 200, the 1.8-inch liquid crystal is used for the built-in display unit 201. This built-in display unit 201 shows an imaging screen formed by a monitoring signal when recording the signal, a retrieval screen formed by the program when retrieving the data, and a playback screen formed by the decoded data when playing back the data.

In recording the data, the moving image recording mode (MPEG compression recording mode) or the still image recording mode (JPEG compression recording mode) may be switched each time the mode selecting button is pressed. As the user can select the recording mode with this button, as shown in Figs. 17 and 18, the mark for each mode located in the upper left portion of the imaging screen is switched each time the mode is switched.

Fig. 17 shows the imaging screen appearing when the still image recording mode is selected when recording data. In Fig. 17, a numeral 1701 denotes a mark representing a still image mode. Fig. 18 shows the imaging screen appearing when the moving image recording mode is selected when recording data. In Fig. 18, a numeral 1801 denotes a mark representing the moving image mode. The mark for each mode appears on the screen so that the user can visually recognize the current imaging mode as he or she is pushing the mode selecting button. This mark allows the user to handle the comcorder without having to keep his eyes out of the imaging screen. It means that the digital comcorder offers convenient operativity to the user.

The mark for each mode is displayed on the retrieving screen through the effect of the program sent from a data containing unit. The retrieving screen will be discussed in detail together with the display of the mode mark. Fig. 19 shows the concrete mark for each mode. In actual, however, the marks are not limited to the illustrative ones. Any mark may be used if it can distinguish the modes from each other.

In Fig. 5, the display screen 500 consists of 20 x 9 characters at maximum, each character consisting of 16 and 24 pixels. The character size consisting of 16 x 24 pixels keeps the maximum recognizable size compatible with efficient digitizing of the character data. The blanks of a left side 501, a right side 502, an upper side 503, and a lower side 504 of the screen are secured because the display unit or the built-in display unit 201 connected to an output terminal 416 disables to display the overall area of the main screen.

A numeral 505 denotes an operating state display area where the operating state of the program of this embodiment is displayed. A numeral 506 denotes an area where the information of the recorded data and the functions to be operated for specifying the data details of the data by pressing a function switch 304 are displayed as individual items in partitioned sub-screens. A numeral 507 denotes an area where an operating procedure suggests the operating method to the user.

Fig. 6 shows a display screen 600 appearing when a program starting switch 303 is pressed by the user for starting the program of this embodiment. The display screen 600 corresponds to a classifying selection 101 of Fig. 1 for indicating the state transition of the operation. As mentioned earlier, the data recorded by the user is unconditionally recorded "unclassified" when recording the data. The figure (number of files) displayed on the "unclassified" row stands for the number of MPEG1-formatted moving image data items with the speech 602, the number of JPEG-formatted still image data pieces 603, and the number of MPEG1-formatted speech 604.

Likewise, the figure displayed on each row of a mark 605 for indicating the first classification, a mark 606 for indicating the second classification, and a mark 607 for indicating the third classification indicate the numbers of data items arbitrarily classified by the user, respectively. A mark 608 for indicating all data items at a batch indicates the total number of the data items on the "unclassified" row 601, the "first classified" row 605, the "second classified" row 606, and the "third classified" row 607.

A mark 609 for indicating the "temporary discard" means a classification for temporarily discarding the data items so that the user cannot erroneously erase the data items. With the mark 609, the user can temporarily move the "unclassified", "first classified", "second classified", and "third classified" data items to the "temporary discard" row. The figure represented on the row of the mark 609 does not contain a figure represented on the row of the mark 608 for indicating all data items at a batch.

In Fig. 6, the row of the mark 601 for indicating the unclassification is reversed to the rows of the other marks. It indicates that the mark 601 for indicating the unclassification is the selected item. In place of the reversing, another kind of way may be used such as change of a color. The software program is executed by the user so that the recorded data items whose classifying destinations are not changed are contained in the row of the mark 601 for indicating the unclassification.

When the upper arrow switch 305a of Fig. 3 is pressed by the user, the selected item is shifted upward by one row, while the lower arrow switch 305c is pressed, the selected item is shifted downward by one row.

In case that the selected item is an item on the first row of the display area 506, that is, on the mark 601 for indicating the unclassification, when the user presses the upper arrow switch 305a, the selected item is shifted to the item on the sixth row of the display area 506, that is, on the mark 609 for indicating the temporary discard. In case that the selected item is an item on the sixth row of the display area 506, that is, on the mark 609 for indicating the temporary discard, when the user presses the lower arrow arrow 503c, the selected item is shifted to the item on the first row of the display area 506, that is, on the mark 601 for indicating the unclassification.

When the user presses the right arrow switch 305b, the display screen is shifted into the screen on which

the content of the classification of the selected row is represented.

Moreover, the guide indication 610 for the operating procedure is displayed so as to remind the user of the operation.

As an example, Fig. 7 shows a display screen 700 on which the mark 605 for indicating the first classification is selected so that the data items on the row of the mark 605 appear as ones to be selected if the right arrow switch 305b is pressed by the user. This function corresponds to the data selection 102 shown in Fig. 1.

The display screen 700 is a screen on which a data item is to be retrieved from a data list and played back. The data list is a feature of the present invention. On the screen 700, the data items recorded by the portable digital comcorder 200 may be listed using a mark 703 for representing a sort of data content of a recording start time 702, a moving image, a still image, and a speech, a classifying mark 704, and a mark 705 for protecting data from being erased by the erroneous operation.

The data items displayed on the screen 700 are ranged from the top to the down in the sequence of the recording year/month/day 701 and the recording start time 702. Hence, the latest recorded data is listed on the topmost row, so that the user can effectively retrieve the data. The number of the pages of the displayed lists is checked, so that the lists are displayed as pages as indicated by a numeral 707. In the page display 707, a denominator indicates all the list pages, while a numerator indicates the current one of the list pages.

The imaging status of the user such as the recording date and time and the data type are automatically recorded as the aforementioned information, so that the user can manually record these pieces of information. Since the user may optionally change the classifying destination according to his or her purpose, the user's retrieval work for the destination data is made simpler and more efficient.

These pieces of information are all composed of a list represented in characters. This does not need a time consumed in expanding the compressed image data recorded on the media. Further, if the user selects a data item using the operating button, the screen can be rewound quickly, so that the quick retrieval is made possible.

This list retrieving operation may offer comfortable operativity without having to impose stress on the user who wants to quickly select the recorded image.

The selecting classification 706 indicates a classification selected by a display screen 600. This embodiment has concerned with the user's selection of the first classification 605 on the display screen 600.

The display list of the data items on the display screens 700 and 800 is arranged in the sequence of recording the data on the harddisk drive 415, that is, in the sequence that the latest data item comes to the topmost row. Since the user may change the sequence of recording the data items on the harddisk driver 415, he or she may change the display sequence. The data immediately after imaging is recorded on the topmost row (701 of Figs. 7 and 8) of the display area 506 on the unclassified data selecting screen. If the user makes sure of the just imaged data, he or she only reproduces the data and makes sure of the topmost row of the display area 506 on the unclassified data selecting screen.

Like the display screen 600, when the user presses the upper arrow switch 305a, the selected data item is shifted upward by one row. When the user presses the lower arrow switch 305c, the selected data item is shifted downward by one row. In this embodiment, the six rows of the data items are displayed on one screen. In case the user selects the sixth data item, if the lower arrow switch 305c is pressed, the seventh data item is displayed on the first row of the display area 506. It means that the seventh data item is the selected item. The eighth, the ninth and the following data items are displayed on the second, the third, and the following rows, respectively.

On the other hand, for example, in case the seventh data item is selected, if the upper arrow switch 305a is pressed, the seventh data item is displayed on the first row of the display area 506. The second, the third, the fourth, the fifth, and the sixth data items are respectively displayed on the rows after the first one, so the selected data item is changed to the sixth data item.

That is, the n-th data item is displayed on a remainder-th row on the display area 506, in which the remainder is obtained by dividing n by 6.

In case the head data item or the tail one is selected, if the upper arrow switch 305a or the lower arrow switch 305c is pressed, like the display screen 600, the data items containing the head and the tail items are displayed as a list so that the head or the tail data item is selected. Though Fig. 6 shows the one-page screen on which the number of folders is fixed, Figs. 7 and 8 show the screen on which the pages are increased or decreased in number according to the number of data items.

If the user selects the upper arrow switch 305a and the lower arrow switch 305c shown in Fig. 3 and depresses the right arrow switch 305, the selected data is fed out of the output terminal 416 and is played back on the built-in display unit 201.

While the data is being played back, the upper arrow switch 305a, the lower arrow with 305c, and the left arrow switch 30, as shown in Fig. 3, are served as fast feed, rewind, and stop, respectively. While the data is being played back, if the left arrow switch 305d served as a stop switch is pressed by the user, the playback is stopped, and the display screen 700 is displayed again. The state transition during the data playback is denoted by a numeral 103 of Fig. 1.

Next, the description will be oriented to the display content on which reduced images are added to the recording date and time so that the content of the data may be easily recognized. In the state of the display screen 700, if the user presses the reduced image display switch 302, a reduced image 801 of the first frame

of the data listed on the subject row is displayed on the display screen 800 shown in Fig. 8. This makes it possible to surprisingly enhance the retrieval of the data. The state transition in the reduced image display function is denoted by a numeral 104 of Fig. 1.

For example, in case that the viewable area of the 1.8-inch built-in LCD display unit 201 consists of 379 dots in horizontal and 220 dots in vertical, the reduced image 801 is adjusted to consist of 64 dots in horizontal and 48 dots in vertical. (if the LCD panel consists of 352 and 240 dots, the reduced image 801 consists of 240/48 = 5 dots in vertical and 352/5 = 70.4 in horizontal. From a vertical viewpoint, the reduced image is one-fifth and from a horizontal viewpoint, the reduced image is one-fifth with a slight margin.) In this reduction, three reduced images, the recording starting year month day 701, the recording starting time 702, the mark 703 representing the content type of the data indicating the moving image, the still image, and the speech, the classification mark 704, and the mark 705 for protecting the data from being erroneously erased can be all displayed on one screen. This screen arrangement makes it possible to secure more visible reduced images on the display. Like the display screen 700, on this display screen 800, the data may be played back by pressing the operating button 305 and the like.

In this state, if the reduced image display switch 302 is pressed again, the display screen is returned to the display screen 600 for displaying the data classification. The reduced image is depicted in the RAM 410 shown in the circuit block of Fig. 4 through the effect of the control microcomputer 411 and the MPEG encoder 409.

In turn, the description will be oriented to a function selecting display screen 900 for easily changing the display state from the data selecting display screen 700. The function selecting display screen 900 includes the reduced number of operation switches and function items displayed thereon so that the ease of use in operation may be improved as viewing the screen. The operating switches 304, 305a, 305b, 305c, and 305d shown in Fig. 3 implement the operating system for selectively operating the function. The state transition on the display screen 900 is denoted by a numeral 105 of Fig. 1.

On the reduced image display screen 800, the function selecting display screen 900 is displayed by the same procedure. On the display screen 600, the display screen having the necessary functions such as "empty a garbage", "move to a garbage", "display a state", and "auto play" shown in Fig. 1 is displayed by the same procedure. In this case, the function items on the display screen 900 are not required to be identical with the function items on the data classifying display screen 600.

The flow of operation on the display screen 900 is shown in Fig. 10. The display screen 900 is displayed when the user pressed the function switch 304 on the display screen 700 (step 1001). The selective movement of each item is indicated by the upper arrow switch 305a and the switch lower arrow switch 305c. If the user pressed the upper arrow switch 305a, the selected data item is moved upward by one row. If the lower arrow switch 305c is pressed, the selected data item is moved downward by one row (step 1002). If the user presses the right arrow switch 305b (step 1003), the function of the selected data item is executed (step 1004). If the left arrow function switch 305d is pressed, the display screen 900 is returned to the data selecting display screen 700 (step 1005).

As mentioned earlier, in this embodiment, the erasion of the data is realized by moving the data to the temporary discard location and then erase the data contained in the temporary discard location. The state transition of this function is denoted by a numeral 106 of Fig. 1.

The procedure of erasing the data will be described below.

If the data is erased, the data is moved to the temporary discard location. In this case, the procedure for selectively executing "move the data to a garbage" will be described with reference to Fig. 9.

At first, on the display screen 700, the user selects the data item to be temporarily discarded with the upper arrow switch 305a and the lower arrow operating switch 305c and then depresses the function switch 304. Then, the display screen 700 is changed to the display screen 900. The user selects the "move data to a garbage" 901 with the upper arrow operation switch 305a and the lower arrow function switch 305c and then depresses the right arrow switch 305b. Then, the selected data item is moved to the garbage that is the temporary discard location. If the user presses the switch 306, the similarly selected data is moved to the garbage.

When the user selects the "empty a garbage" 902 on the display screen 900, all the data items left in the garbage are erased. The state transition of this function is denoted by a numeral 107 of Fig. 1.

In the operating system, the user is required to do two operations for erasing the data. The two operations protect the data from the user's erroneous erasion.

As mentioned earlier, when recording the data, the classifying symbol to be allocated to each data item is an unclassified one. When playing back the data, the classification may be changed by the user's operation. This classifying function is used for classifying the data item. Hence, since the user classifies the data item for each destination, the ease of use of the retrieval may be surprisingly enhanced. The state transition of this function is denoted by a numeral 108 of Fig. 1.

Later, the description will be oriented to the procedure for changing the data classification. On the display screen 700, the user selects the data item whose classification is to be changed with the upper arrow switch 305a or the lower arrow operation switch 305c and then presses the function switch 304. Then, the display screen is changed to the display screen 900. The user selects the "change a group" 905 that is a function of changing the classification with the upper arrow operation switch 305a and the lower arrow operation switch

305c and then presses the right arrow switch 305b. Then, a display screen 1100 is displayed on which the classification of the selected data shown in Fig. 11 is changed.

If the right arrow switch 305b is pressed on the display screen 1100, the classification is cyclically changed from "unclassification" to 1 to 2 to 3 to "unclassification". In this embodiment, the update of the symbol for the classification according to the display screen is executed by the control microcomputer 411 at a time when the user presses the left arrow switch 305d and the display screen 600 appears. This is intended for enhancing the processing speed and retrying the user's operation.

As described earlier, unless the user does the following operation, the list indicated on the display screen 700 is arranged in the recording sequence of the recorded data. When playing back the data, the sequence may be changed so as to implement a simple editing function. The state transition of this function is denoted by a numeral 109 of Fig. 1.

The procedure of changing the data displaying sequence will be described below. At first, on the display screen 700, the user selects the data item whose displaying sequence is to be changed with the upper arrow switch 305a and the lower arrow switch 305c. Then, if the function switch 304 is pressed, the display screen 900 is displayed.

The user selects the "change a data display sequence" 906 that is a function of changing the display sequence with the lower arrow switch 305c and depresses the right arrow switch 305b. Then, the display screen 1200 shown in Fig. 12 is displayed, so that the display sequence of the selected data item may be changed. Next, the user specifies the location where the selected data is to be inserted with the upper arrow switch 305a and the lower arrow switch 305c. Then, if the right arrow switch 305b is pressed, the selected data item is inserted to the specified location. In this case, the sequence of the data item located after the specified location is shifted lower by one.

The portable digital camcorder 200 of this embodiment incorporates an internal clock for displaying on the display screen 700 the date and the time when the data is recorded. However, if failure such as rundown of a battery takes place while imaging an object, the recorded data and time may not be correctly displayed on the display screen 700. In this embodiment, the user may operate to optionally change the date and time when the data is recorded. The state transition of this function is denoted by a numeral 110 of Fig. 1.

Later, the description will be oriented to the procedure for changing the date and time. The user selects the data whose recording date and time are to be changed using the upper arrow switch 305a and the lower arrow switch 305c. Then, if the function switch 304 is pressed, the display screen 900 is displayed. The user selects the "change a recording date and time" 907 that is a function of changing the displaying sequence with the upper arrow switch 305a and the lower arrow switch 305c. Next, if the right arrow switch 305b is pressed, the display screen 1300 shown in Fig. 13 is displayed where the recording date and time of the selected data are to be changed.

In this state, when the user pressed the upper arrow switch 305a, the year figure 1301 is increased by 1, while the lower arrow switch 305c is pressed, the year figure 1301 is decreased by 1. When the right arrow switch 305b is pressed, the year figure 1301 is determined as a numeric value represented at the time point. Next, the user may specify the increment or decrement of the numeric value of a month figure 1302.

Likewise, if the upper arrow switch 305a is pressed, the month figure 1302 is increased by 1, while if the lower arrow switch 305c is pressed, the month figure 1302 is decreased by 1. If the right arrow switch 305b is pressed, the month figure 1302 is determined as a numerical value displayed at the time point. Next, the user may specify the increment or decrement of a numerical value of a day figure 1303.

Further, when the left arrow switch 305d is pressed, the year figure 1301 may be retried. The similar operation may be executed to set the day figure 1303, an a.m or p.m. indication 1304, a time figure 1305, and a minute figure 1306. After adjusting a value of the minute figure 1306, if the right arrow switch 305b is pressed, the change of the recording date and time is terminated and the date and time of the data is changed to a new numeric value.

In the case of specifying an numeric value that does not exist in the calendar such as February 30, the numeric value is changed to the nearest date (that is, March 1) to the value.

In this embodiment, though the user can freely erase the data, the user may provide the data with an attribute of prohibiting the erasion for preventing the data from being erased. The state transition of this function is denoted by a numeral 111 of Fig. 1.

Later, the description will be oriented to the procedure for adding the attribute of protecting the data from the erasion to the data. At first, on the display screen 700, the user selects the data whose erasing attribute is to be changed with the upper arrow switch 305a or the lower arrow switch 305c. Then, the function switch 304 is pressed, so that the display screen 700 is changed to the display screen 900. The user selects the "change a lock" 904 that is a function of changing the erasing attribute with the upper arrow switch 305a or the lower arrow switch 305c. Then, if the right arrow switch 305b is pressed, the display screen 1400 is displayed where the erasing attribute of the selected data shown in Fig. 14 is changed.

When the user pressed the right arrow switch 305b, the erasing attribute is cyclically changed from "disabled" to "enabled" to "disabled". The protecting mark 705 is displayed or not displayed according to the erasing attribute.

In this embodiment, the user can know the remain-

ing volume of the harddisk drive 415. The state transition of this function is denoted by a numeral 112 of Fig. 1.

Hereafter, the description will be oriented to the procedure for checking the remaining volume of the harddisk drive 415. On the display screen 700, if the user presses the function switch 304, the display screen 700 is changed to the display screen 900. The user selects the "display a state" 903 that is a function of changing the displaying sequence with the upper arrow switch 305a or the lower arrow switch 305c. Then, if the right arrow switch 305b is pressed, the display screen 1500 is displayed where the remaining volume of the harddisk drive 415 shown in Fig. 15 is shown.

On the display screen 1500, a remaining time 1501 left if only the MPEG1-formatted moving image data with the speech is recorded on the harddisk drive 415, a remaining pages left if only the JPEG-formatted still image data is recorded, a remaining time 1503 left if only the MPEG1-formatted speech data is recorded, and a remaining volume 1504 represented in bytes are all displayed as a list. Since the remaining volume of the harddisk drive is listed with respect to each recordable data type, the user can more easily grasp the remaining volume of the harddisk drive 415.

In this embodiment, when playing back the data, the user needs to use only the switches 305a, 305d, 305c and 305d for playing back the data. It is epoch-making that the minimum number of operating switches are just required for playing back the data.

Another epoch-making point is the increase of the functions without increasing the operating buttons by using the functional selecting screen 900.

In this embodiment, as shown in Fig. 6, the classified number of data items is four including "unclassified". The classified number of data may take any value. On the data selecting display screen 700, the data items may be displayed as a list independently of the types of the moving image, the still image, and the speech. This embodiment may apply to the function of automatically classifying the data according to the data type with the user's specification.

Moreover, the control microcomputer 411 is operated to automatically select the data according to the imaging modes such as the moving image and the still image. For example, the user can select only the imaging mode for the still image, pick up only the image type of the still image, and reproduce it.

The foregoing description has been concerned with the specific embodiments of the invention. The present invention may apply to the following arrangement.

For example, the present invention may be achieved by an image recording apparatus which includes converting means for converting a video signal into a digital signal, a codec unit for selectively performing a MPEG system or a JPEG system compression about the digital signal, for generating the compressed data, a recording unit for recording the compressed data, and a selective indicating means for a compression mode, for selectively indicating the MPEG system compression or the JPEG system compression.

This image recording apparatus may be applicably arranged to switch the compressing system of the codec unit according to the indication given by the selective indicating means.

Further, the image recording apparatus may be applicably arranged to add a code for indicating the compression system to the compressed data according to the indication given by the selective indicating means.

Further, the image recording apparatus may be applicably arranged so that the codec unit may be a circuit for performing the MPEG system and the JPEG system processing at one process.

Moreover, the image recording apparatus may be applicably arranged so that the video signal is obtained from an imaging element and the recording unit is a harddisk drive.

The present invention may be also achieved by the image reproducing apparatus which includes a recording unit for receiving compressed data generated according to the MPEG system or the JPEG system and recording the compressed data, specifying means for specifying a data item to be reproduced of the compressed data recorded in the recording unit, readout means for retrieving and reading out the compressed data specified by the specifying means from the recording unit, a codec unit for selectively performing the MPEG system or the JPEG system expansion about the compressed data and generating the digital signal, and converting means for converting the digital signal generated by the codec unit into a video signal.

Moreover, the image reproducing apparatus may be applicably arranged so that the expanding system of the codec unit may be switched according to the compressed data read out of the readout means.

Further, the image reproducing apparatus may be applicably arranged so that the compressed data of the recording unit pre-contains the code indicating the compressing system and the expanding system of the codec unit may be switched according to the code for indicating the compressing system added to the compressed data read out of the readout means.

Further, the image reproducing apparatus may be applicably arranged so that the codec unit may be a circuit for performing the MPEG system and the JPEG system expansion at one process, the video signal is output to the built-in display unit, and the recording unit may be a harddisk drive.

The present invention may be achieved by the image recording and reproducing apparatus for converting a video signal into a digital signal, recording the digital signal, converting the digital signal into the video signal, and reproducing the video signal, which includes a codec unit for selectively performing the MPEG system or the JPEG system compression about the digital signal for generating the compressed data in recording the data and selectively performing the MPEG system or the JPEG system expansion about the compressed

data for generating the digital signal in reproducing the data, a recording unit for recording the compressed data, selective indicating means for the compressing mode for selectively indicating the MPEG system compression or the JPEG system compression, specifying means for specifying the data to be reproduced of the compressed data recorded in the recording unit, and readout means for retrieving and reading the compressed data specified by the specifying means from the recording unit.

Moreover, the image recording and reproducing apparatus may be applicably arranged so that the codec unit may switch the compressing system according to the indication given by the selective indicating means in recording the data or the expanding system according to the compressed data read out of the readout means in reproducing the data.

Further, the image recording and reproducing apparatus may be applicably arranged so that in recording the data, the recording unit adds the code for indicating the compressing system to the compressed data according to the indication given by the selective indicating means and records the compressed data and in reproducing the data, the codec unit switches the expanding system according to the code for indicating the compressing system added to the compressed data read out of the readout means.

Moreover, the image recording and reproducing apparatus may be applicably arranged so that the codec unit may be a circuit for performing the MPEG system and the JPEG system processing at one process, the video signal to be recorded is obtained from an imaging element, the video signal to be reproduced is output to the built-in display unit, and the recording unit is a hard-disk drive.

As described above, as keeping the capacity of the recording medium larger and advancing the compressing technology, the data items to be recorded on one recording medium are increased in number. This embodiment, however, makes it possible to do the recording and the reproducing operations with quite few keys. Hence, this embodiment offers the below-indicated effects, so that it may improve the operativity even if it is applied to the small-sized apparatus with a limited space prepared for the operation buttons or switches.

This embodiment may display the recording date and time information and the marks for modes such as the moving image, the still image, and the still image with the speech as a list. Hence, the user can efficiently and quickly retrieve the data as grasping the content of the data. In recording the data, the marks are switchably displayed on the imaging screen each time the mode is switched so that the user can grasp the current imaging mode. Hence, the user can focus his or her attention onto the imaging screen at any mode when recording the data.

The display list is composed of a date and a time. The apparatus of this embodiment may automatically create the overall list and at once output the reduced images, so that the user can more easily grasp the content of the data.

The imaged data may be classified to the predetermined locations. Hence, the imaged data may be classified on the mode information and the date and time information according to the imaging statue and the object. This classification makes it easier for the user to retrieve the data.

Further, the displaying sequence of the list and the generating sequence of the data are allowed to be replaced depending on the mode information and the date and time information. Hence, the optimal reproducing effect can be obtained without having to depend on the recording sequence.

Then, the classification of "temporary discard" is provided for preventing the erasion of the data resulting from the user's erroneous operation and reusing the unnecessary data if it is made necessary after being deleted.

As described above, if the operation on the relatively simple graphic screen is executed to record a great deal of data, the function of this embodiment enables to offer quicker retrieval than the conventional function of reproducing the data as expanding all image screens.

Claims

1. A digital image and speech recording and reproducing apparatus comprising:

   means (401, 402, 403, 404, 405, 409, 412, 415) for recording and reproducing a digital video signal of a moving image;
   means (418, 419, 409, 415) for recording and reproducing a digital speech signal in synchronous to said moving image;
   means (401, 402, 403, 404, 405, 409, 412, 415) for recording and reproducing a digital still image;
   display means (201) for displaying said moving image signal and said still image signal;
   means (411) for recording recording conditions containing data information about said recorded data for distinguishing said moving image signal from said still image signal and recording time information for indicating when said image or speech is recorded; and
   wherein the recording condition composed of at least said data information and said recording time information is graphically or literarily displayed on a screen of said display means and said displayed recorded data is selected on said screen.

2. A digital image and speech recording and reproducing apparatus comprising:

   means (401, 402, 403, 404, 405, 409, 412,

415) for recording and reproducing a digital moving image signal;
means (418, 419, 409, 415) for recording and reproducing a digital speech signal in synchronous to said moving image signal;
means (401, 402, 403, 404, 405, 409, 412, 415) for recording and reproducing a digital still image signal;
means (418, 419, 409, 415) for recording and reproducing a digital speech signal in synchronous to said still image signal;
display means (201) for displaying said moving image signal and said still image signal;
means (411) for recording recording conditions containing data information about said recorded data for distinguishing said moving image signal from said still image signal and recording time information for indicating when said image or speech is recorded;
wherein the recording condition composed of at least said data information and said recording time information is graphically or literarily displayed on a screen of said display means and said displayed recorded data is selected on said screen.

3. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein the recording condition of said recorded data displayed on said display screen contains information about the reduced image of said recorded data.

4. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, comprising:

means (401, 402) for imaging a moving image;
means (401, 402) for imaging a still image; a microphone (418) for recording speech data;
means (404) for converting said imaged moving image signal into a digital moving image signal;
means (404) for converting said still image signal into a digital still image signal;
means (419) for converting said recorded speech signal into a digital speech signal; and
means (415) for recording said digitized moving image signal, said digitized still image, and said digitized speech signal.

5. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein said display means for displaying said recording condition is composed of a liquid crystal display panel having a horizontal side of 36.6 mm, a vertical side of 27 mm, and a diagonal of 45.7 mm.

6. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein on the display screen of said recording condition, a recording start date (1302, 1303) and a recording start time (1304, 1305, 1306) are displayed as said recording time information.

7. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein on the display screen of said display means, a number of recorded data items are displayed for two or more classifications for retrieval, a storage area for data is secured for each classification, and said recorded data item is saved in said storage area.

8. A digital image and speech recording and reproducing apparatus as claimed in claim 7, wherein on the display screen for said retrieving classification, one of said classifications is selectively operated so that the display screen may be changed into the display screen for indicating the recording condition displayed graphically or literarily.

9. A digital image and speech recording and reproducing apparatus as claimed in claim 7, wherein when reproducing the recorded data, if the classification is not specified, the recorded data contained in the predetermined classification of the topmost row on the display screen is displayed.

10. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein the recording condition of said recorded data displayed on said display screen contains information about the function of preventing erasion to be optionally specified by a user.

11. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein a button for changing the display screen for displaying the number of said recorded data items in each retrieval classification into the display screen for displaying the recording condition composed of said data information and said recording time information, a button for selecting each recording data item from a list of the recording data on the display screen for displaying said recording condition, a button for indicating a function of playing back, stopping, fast-feeding, and rewinding the image, and a button for returning said display screen for indicating the functions into the display screen for indicating said recording condition are composed as the same button (304).

12. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein on the display screen for graphically or literarily displaying the recording condition of said

recorded data, the data items recorded later are displayed on higher locations of the display screen.

13. A digital image and speech recording and reproducing apparatus as claimed in claim 3, wherein a reduced image of said recorded data is formed by thinning out the pixels obtained in actual recording in the horizontal and the vertical directions by one-fifth and is displayed on the same row as the graphic and the literary notation.

14. A digital image and speech recording and reproducing apparatus as claimed in claim 7, wherein one of said storage areas is a temporary discard area where said recorded data is reproducible, and the overall data in said discard area may be erased by the user's specification.

15. A digital image and speech recording and reproducing apparatus as claimed in claim 12, wherein the display sequence of the recording condition for said recorded data may be changed by the user's specification, so that a specific recording condition may be moved from one to another row on said display screen.

16. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein on said display screen for graphically and literarily displaying the recording condition of said recorded data, a function of moving said recorded data to a temporary discard area, a function of erasing all data from said temporary discard area, a function of changing a retrieving classification of said recorded data, a function of changing the displaying sequence of the recorded condition of said recorded data, a function of changing an erasing attribute of said recorded data, a function of displaying a remaining volume of the stored volume of said recorded data are all displayed, and any one of said displayed functions may be specified.

17. A image recording apparatus for converting a video signal into a digital signal and recording an image to be displayed on a screen, comprising:

a compressing unit (409) for selectively compressing said digital signal of a moving image or a still image, for generating compressed data;
a recording unit (415) for recording said compressed data;
a recording mode selection indicating unit (408) for selectively indicating if the image to be compressed is said moving image or still image; and

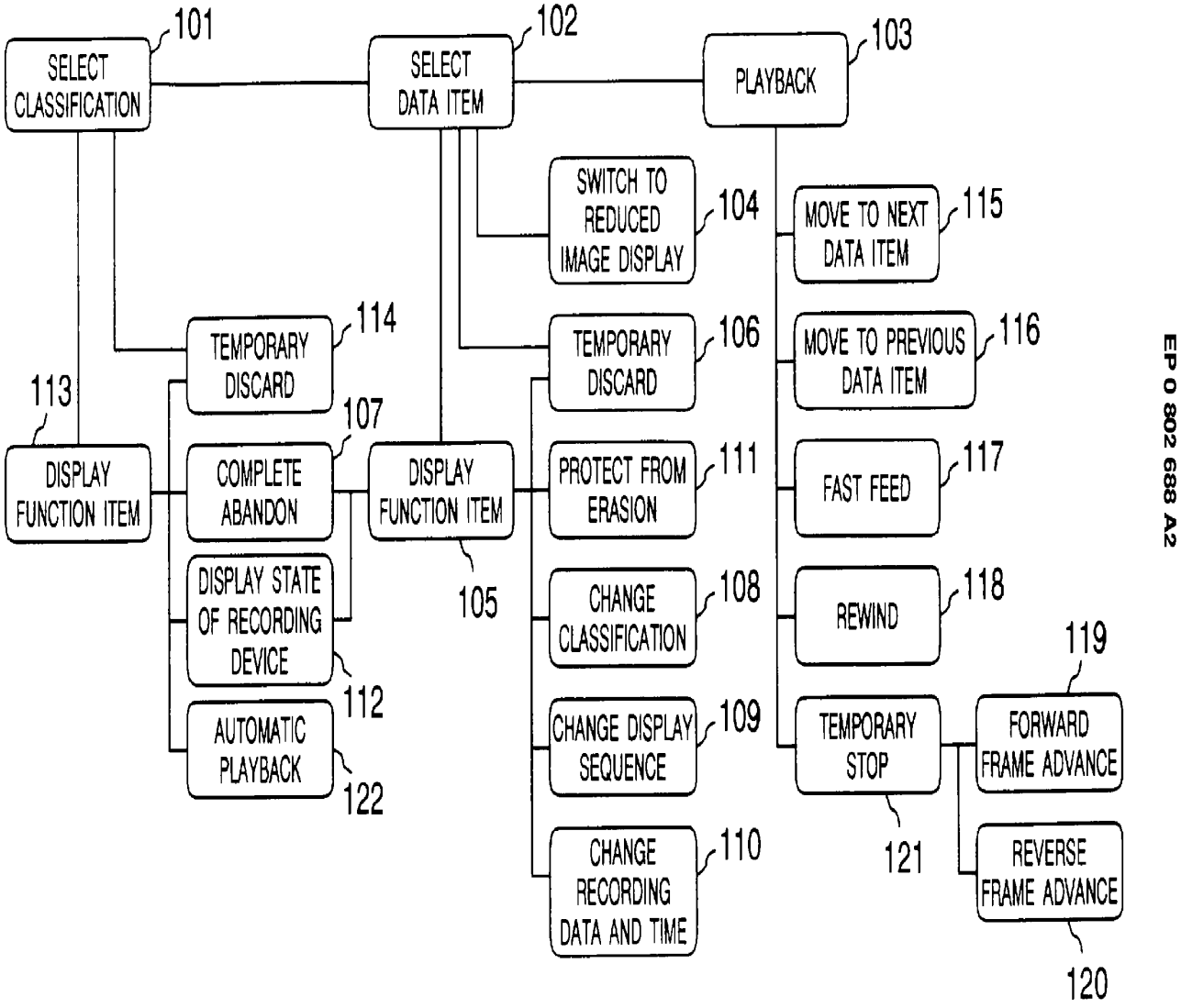
wherein on said screen, the type of said moving image or still image is displayed in association with the selection of said recording mode selection indicating unit (411), and said compressing unit (409) operates to selectively compress said moving image or still image in accordance with the indication given on the types of said moving image and said still image appearing said screen by said recording mode selection indicating unit.

18. A digital image reproducing apparatus comprising:

a storage unit (412) for storing compressed data generated by compressing a moving image or a still image;
an expanding unit (409) for generating a digital signal by selectively expanding said compressed moving image or still image;
said digital signal generated in said expanding unit being converted into the corresponding video signal so that an image for said video signal may appear on a display screen;
means (408) for specifying a data item to be reproduced of said compressed data stored in said storage unit;
means (411) for retrieving and reading out said compressed data item specified by said specifying means from said storage unit; and

wherein the data information indicating the types of said moving image and still image is displayed on said screen in association with said compressed data stored in said storage unit, and said expanding unit operates to selectively expand the compressed data of said moving image or still image if the compressed data is specified according to the data information for indicating the types of said moving image and still image.

FIG. 1



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FIG. 2

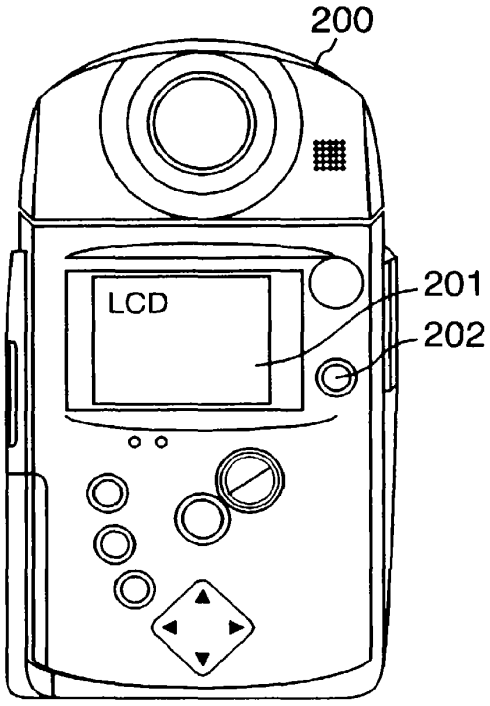

200
LCD
201
202

FIG. 3

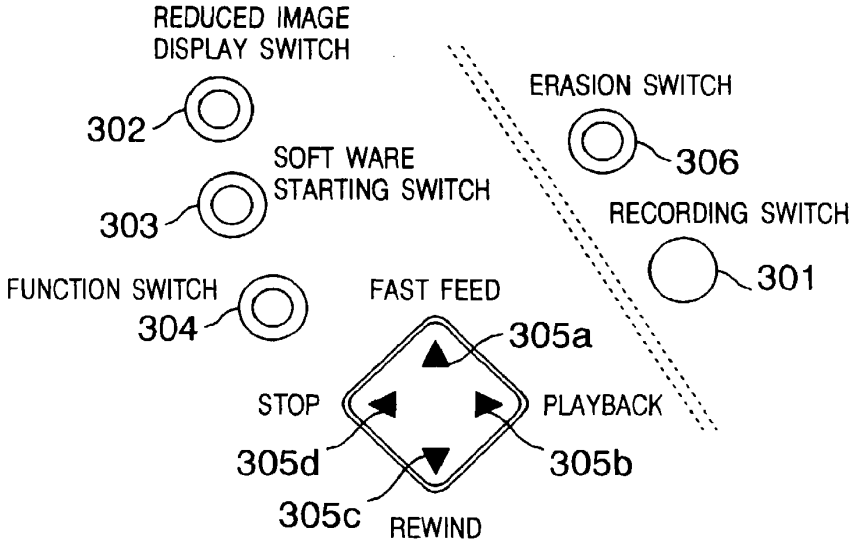
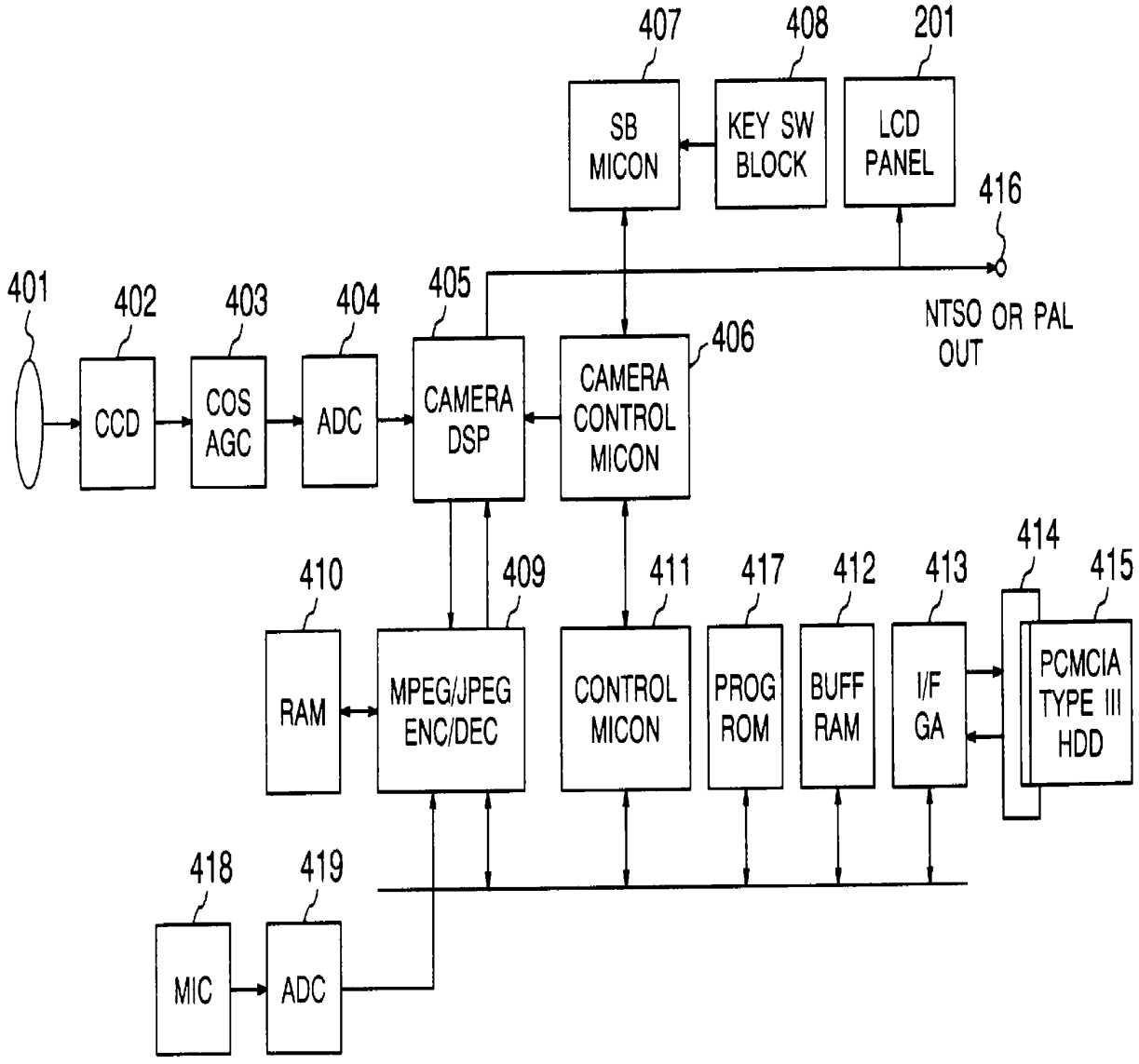

REDUCED IMAGE
DISPLAY SWITCH
302
SOFT WARE
STARTING SWITCH
303
FUNCTION SWITCH
304
ERASION SWITCH
306
RECORDING SWITCH
301
FAST FEED
305a
STOP
PLAYBACK
305d
305b
305c
REWIND

FIG. 4



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FIG. 5

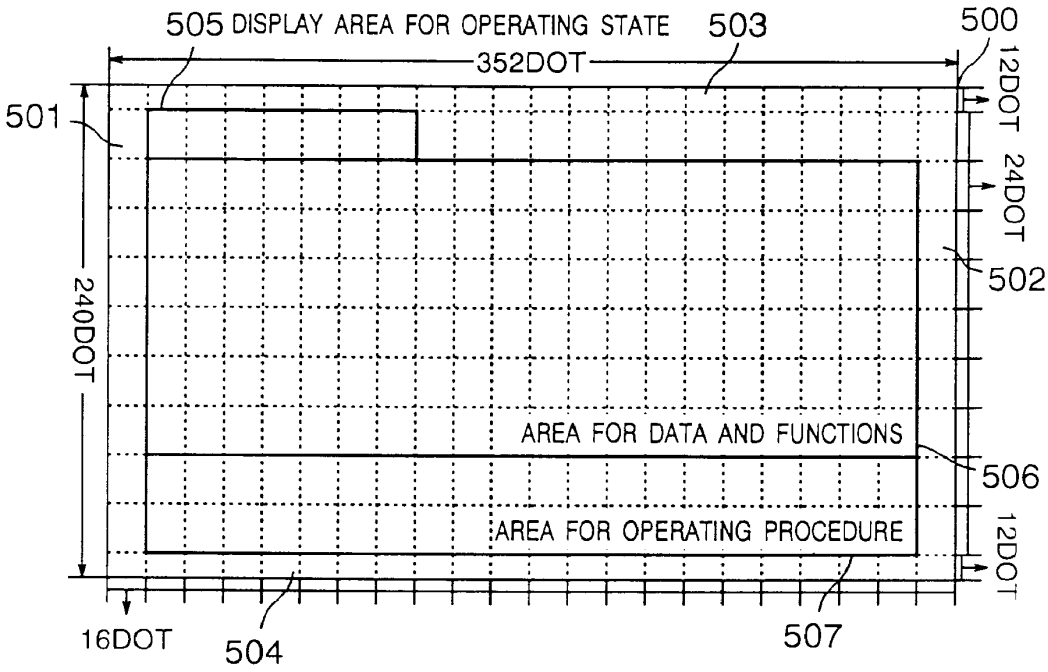

505 DISPLAY AREA FOR OPERATING STATE
503
500
352DOT
12DOT
24DOT
501
240DOT
502
AREA FOR DATA AND FUNCTIONS
506
AREA FOR OPERATING PROCEDURE
12DOT
16DOT
504
507

FIG. 6

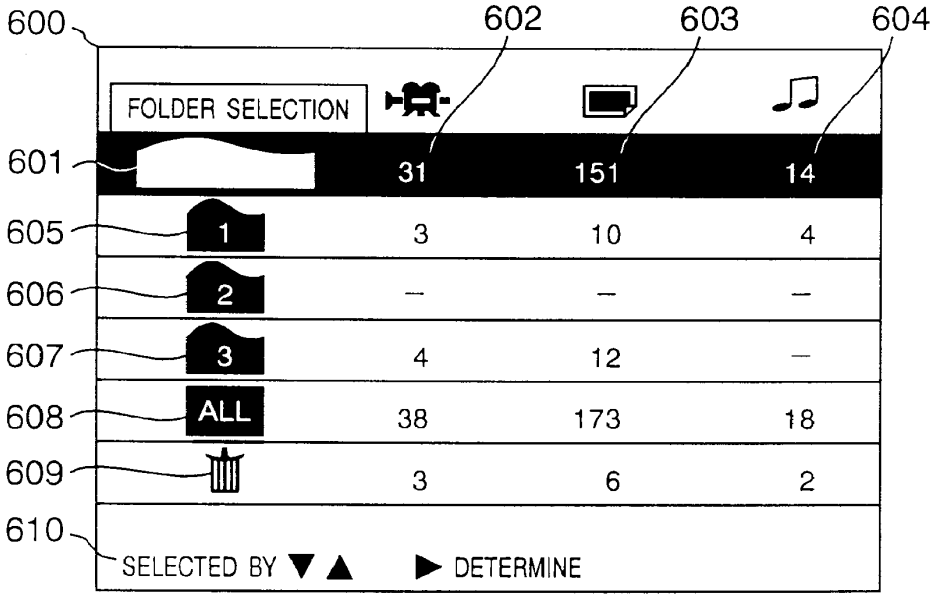

600
602
603
604
FOLDER SELECTION
601
31
151
14
605
1
3
10
4
606
2
–
–
–
607
3
4
12
–
608
ALL
38
173
18
609
3
6
2
610
SELECTED BY ▼ ▲
▶ DETERMINE

FIG. 7

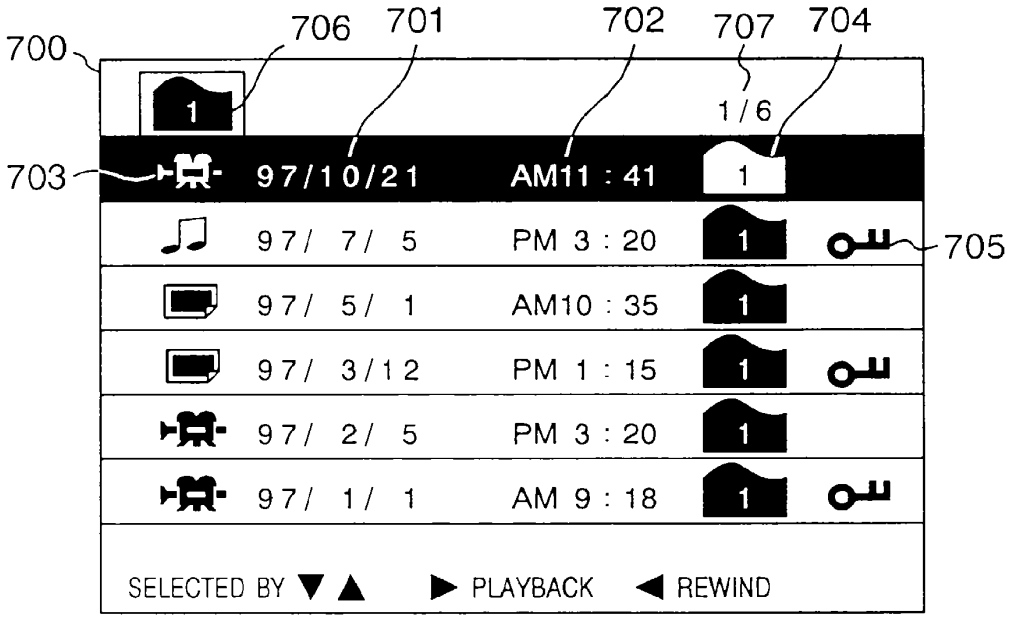

700
706
701
702
707
704
1
1/6
703
97/10/21
AM11 : 41
1
97/ 7/ 5
PM 3 : 20
1
705
97/ 5/ 1
AM10 : 35
1
97/ 3/12
PM 1 : 15
1
97/ 2/ 5
PM 3 : 20
1
97/ 1/ 1
AM 9 : 18
1
SELECTED BY ▼ ▲
▶ PLAYBACK
◀ REWIND

FIG. 8

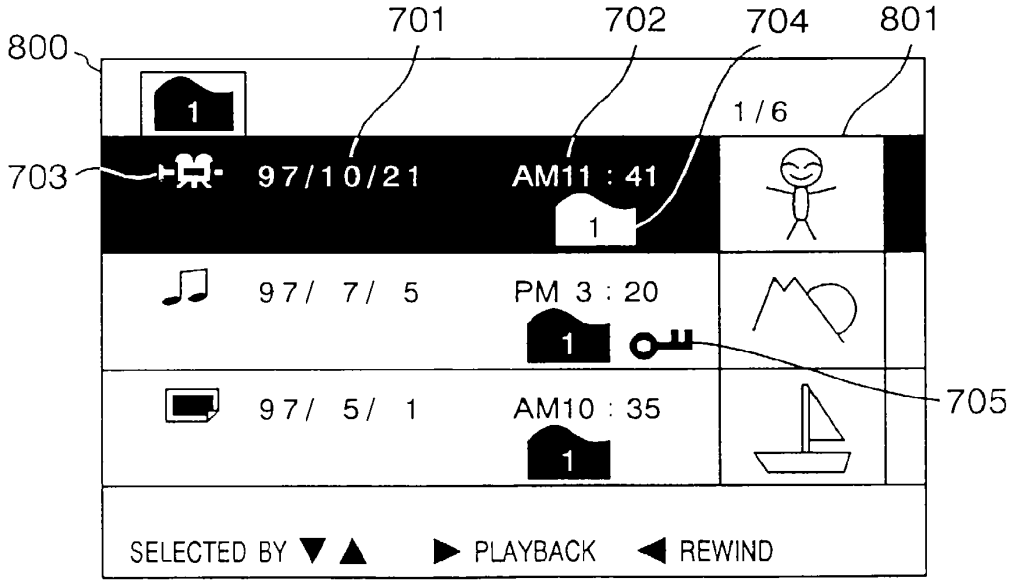

800
701
702
704
801
1
1/6
703
97/10/21
AM11 : 41
1
97/ 7/ 5
PM 3 : 20
1
705
97/ 5/ 1
AM10 : 35
1
SELECTED BY ▼ ▲
▶ PLAYBACK
◀ REWIND

FIG. 9

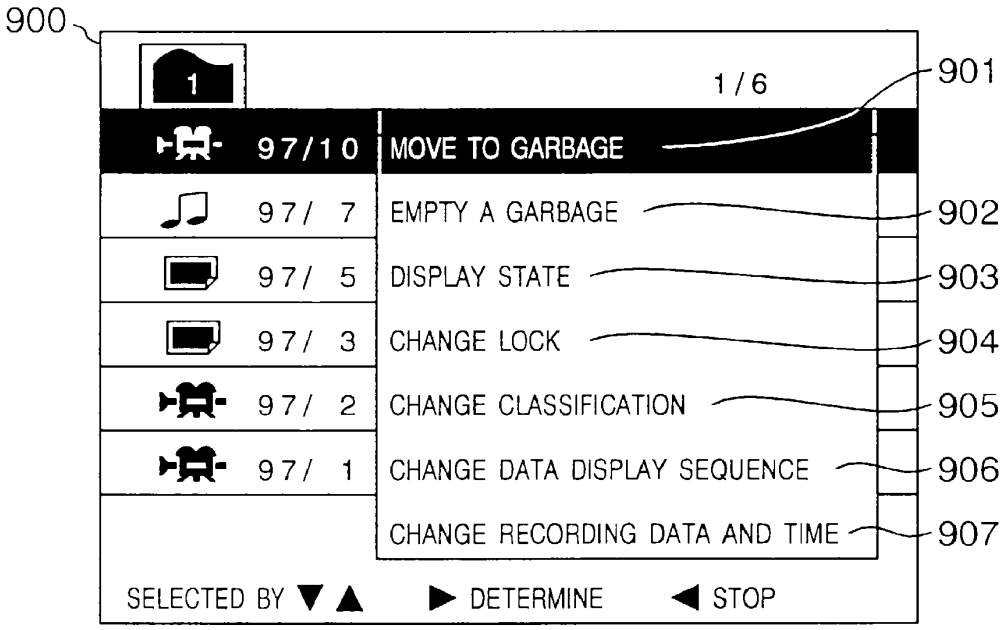

900
1
1/6
901
97/10
MOVE TO GARBAGE
97/ 7
EMPTY A GARBAGE
902
97/ 5
DISPLAY STATE
903
97/ 3
CHANGE LOCK
904
97/ 2
CHANGE CLASSIFICATION
905
97/ 1
CHANGE DATA DISPLAY SEQUENCE
906
CHANGE RECORDING DATA AND TIME
907
SELECTED BY ▼ ▲
▶ DETERMINE
◀ STOP

FIG. 10

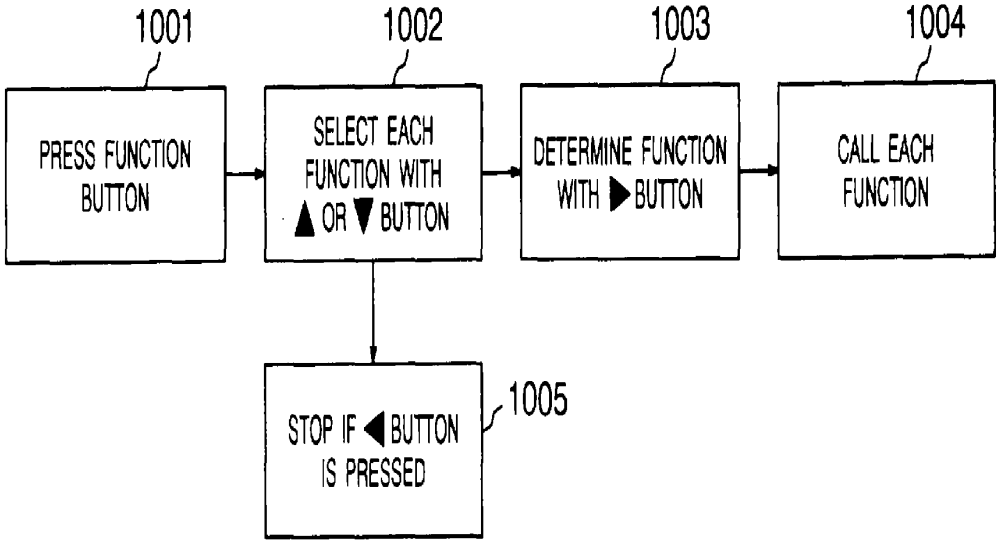

1001
1002
1003
1004
PRESS FUNCTION BUTTON
SELECT EACH FUNCTION WITH ▲ OR ▼ BUTTON
DETERMINE FUNCTION WITH ▶ BUTTON
CALL EACH FUNCTION
STOP IF ◀ BUTTON IS PRESSED
1005

FIG. 11

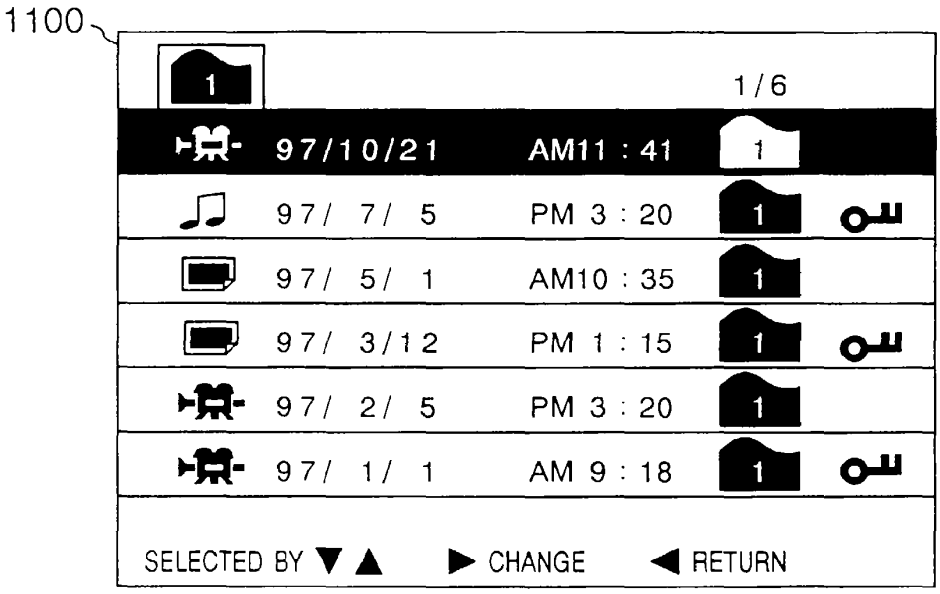

1100
1
1/6
97/10/21 AM11 : 41 1
97/ 7/ 5 PM 3 : 20 1
97/ 5/ 1 AM10 : 35 1
97/ 3/12 PM 1 : 15 1
97/ 2/ 5 PM 3 : 20 1
97/ 1/ 1 AM 9 : 18 1
SELECTED BY ▼ ▲ ▶ CHANGE ◀ RETURN

FIG. 12

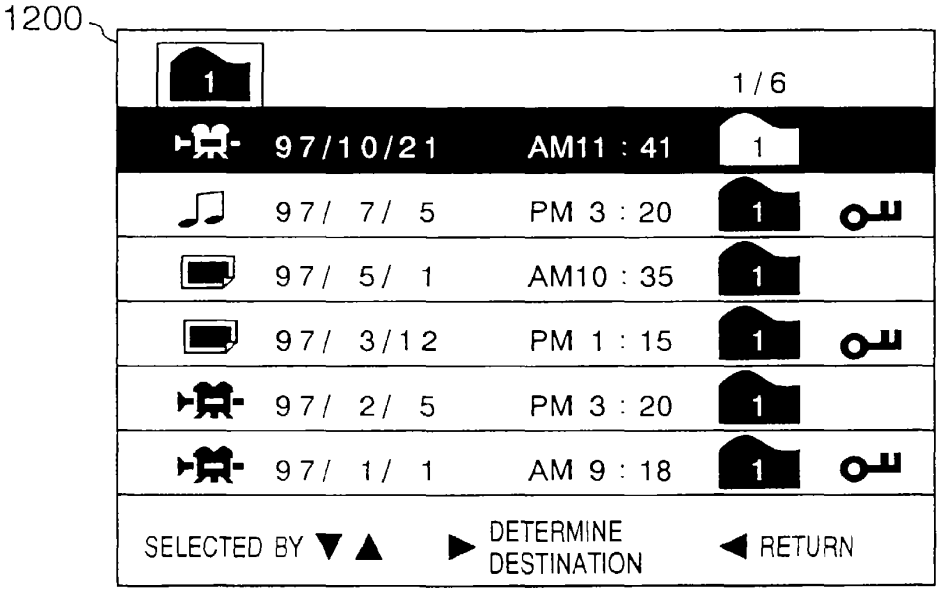

1200
1
1/6
97/10/21 AM11 : 41 1
97/ 7/ 5 PM 3 : 20 1
97/ 5/ 1 AM10 : 35 1
97/ 3/12 PM 1 : 15 1
97/ 2/ 5 PM 3 : 20 1
97/ 1/ 1 AM 9 : 18 1
SELECTED BY ▼ ▲ ▶ DETERMINE DESTINATION ◀ RETURN

FIG. 13

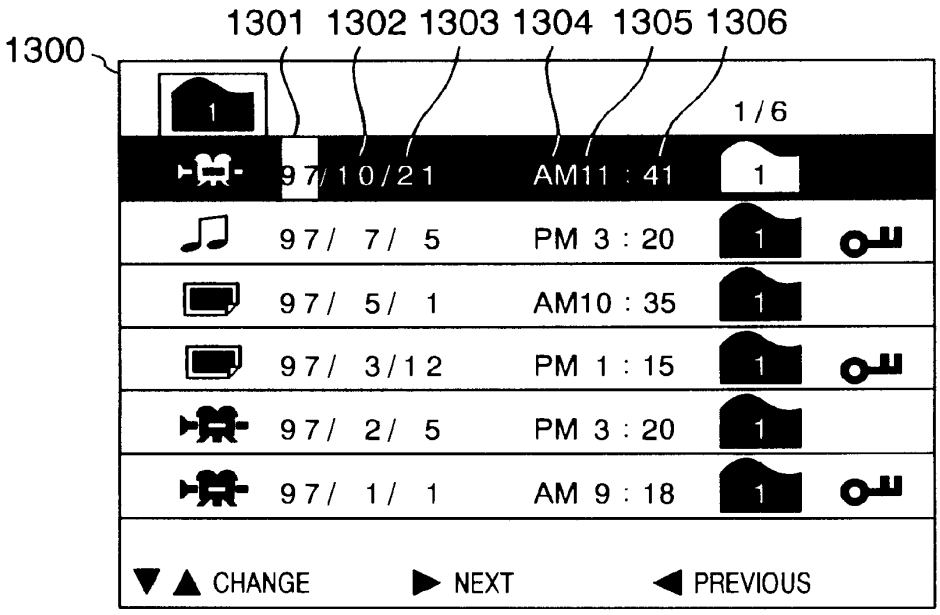

1300
1301
1302
1303
1304
1305
1306
1
1/6
97/10/21
AM11 : 41
1
97/ 7/ 5
PM 3 : 20
1
97/ 5/ 1
AM10 : 35
1
97/ 3/12
PM 1 : 15
1
97/ 2/ 5
PM 3 : 20
1
97/ 1/ 1
AM 9 : 18
1
▼ ▲ CHANGE
▶ NEXT
◀ PREVIOUS

FIG. 14

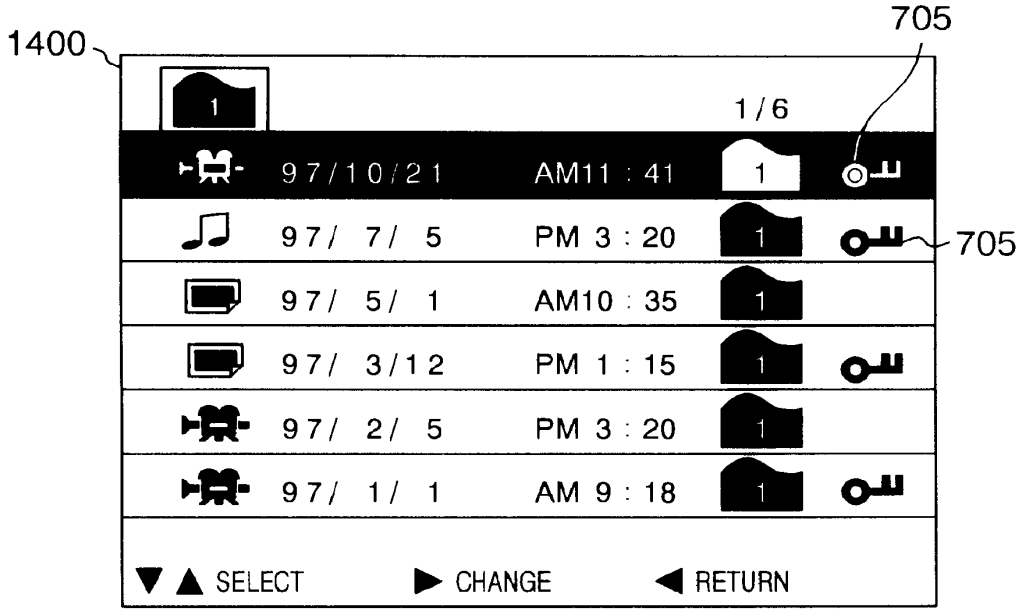

1400
705
1
1/6
97/10/21
AM11 : 41
1
97/ 7/ 5
PM 3 : 20
1
705
97/ 5/ 1
AM10 : 35
1
97/ 3/12
PM 1 : 15
1
97/ 2/ 5
PM 3 : 20
1
97/ 1/ 1
AM 9 : 18
1
▼ ▲ SELECT
▶ CHANGE
◀ RETURN

FIG. 15

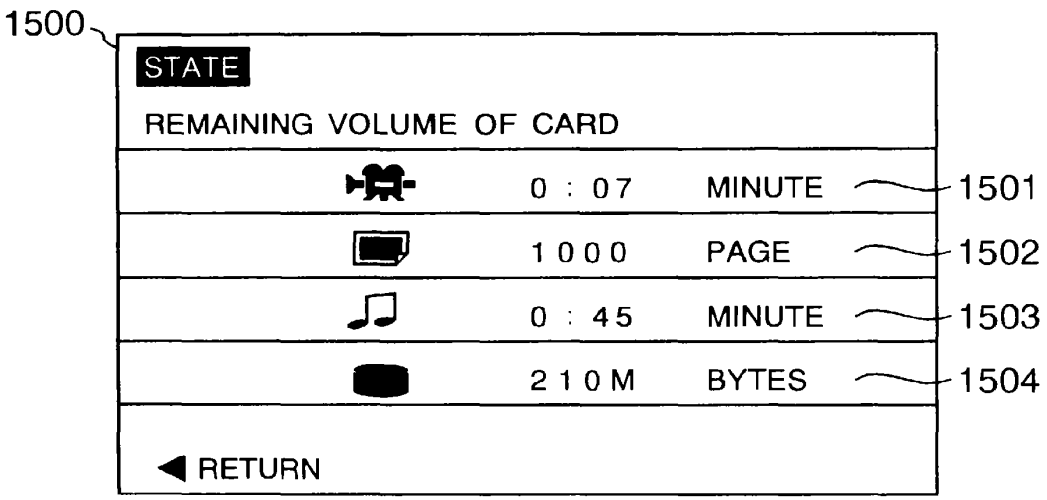

1500
STATE
REMAINING VOLUME OF CARD
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MINUTE
1501
1000
PAGE
1502
0 : 45
MINUTE
1503
210M
BYTES
1504
RETURN

FIG. 16

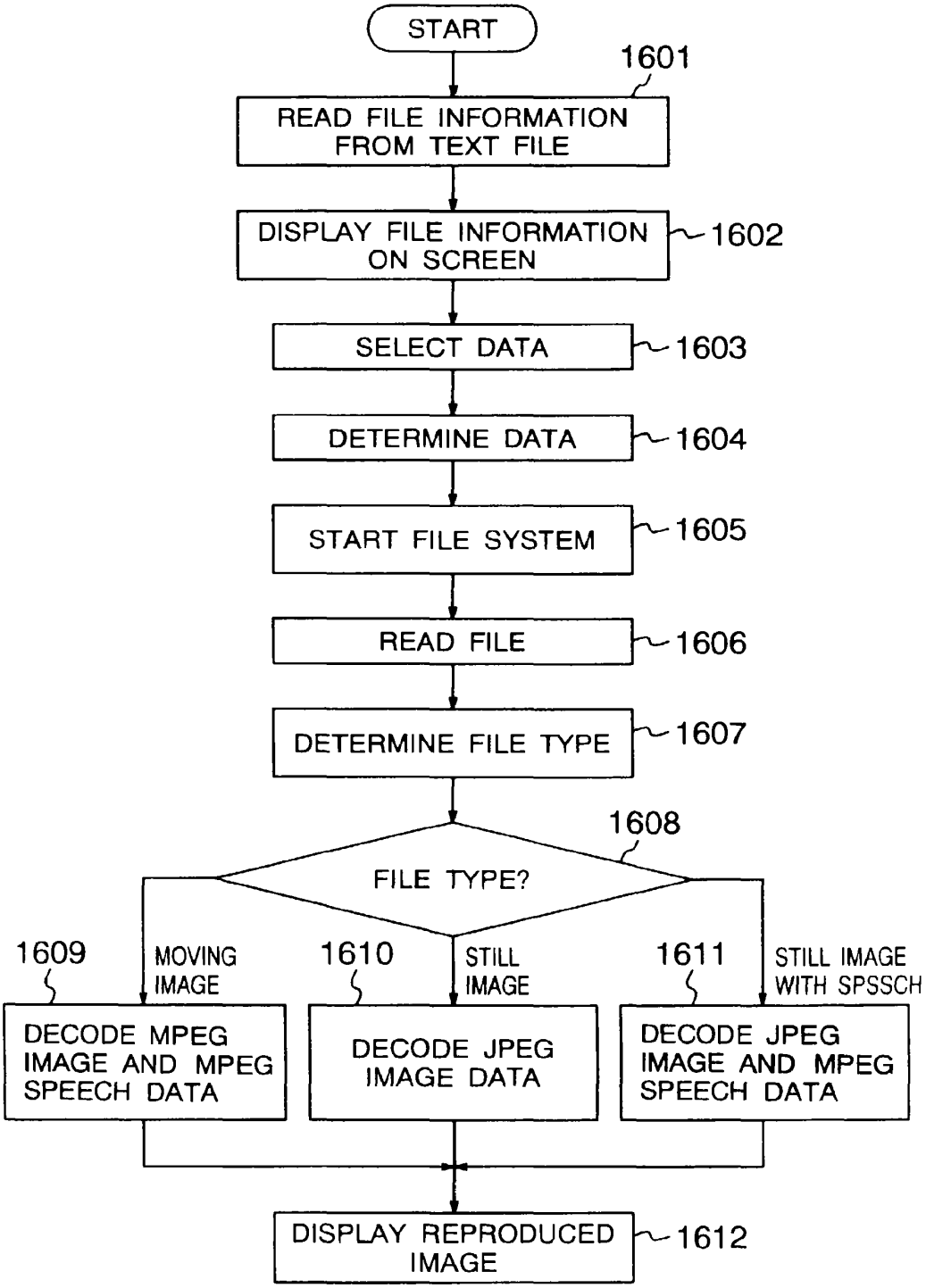

START
1601
READ FILE INFORMATION FROM TEXT FILE
DISPLAY FILE INFORMATION ON SCREEN
1602
SELECT DATA
1603
DETERMINE DATA
1604
START FILE SYSTEM
1605
READ FILE
1606
DETERMINE FILE TYPE
1607
1608
FILE TYPE?
1609
MOVING IMAGE
1610
STILL IMAGE
1611
STILL IMAGE WITH SPSSCH
DECODE MPEG IMAGE AND MPEG SPEECH DATA
DECODE JPEG IMAGE DATA
DECODE JPEG IMAGE AND MPEG SPEECH DATA
DISPLAY REPRODUCED IMAGE
1612

FIG. 17

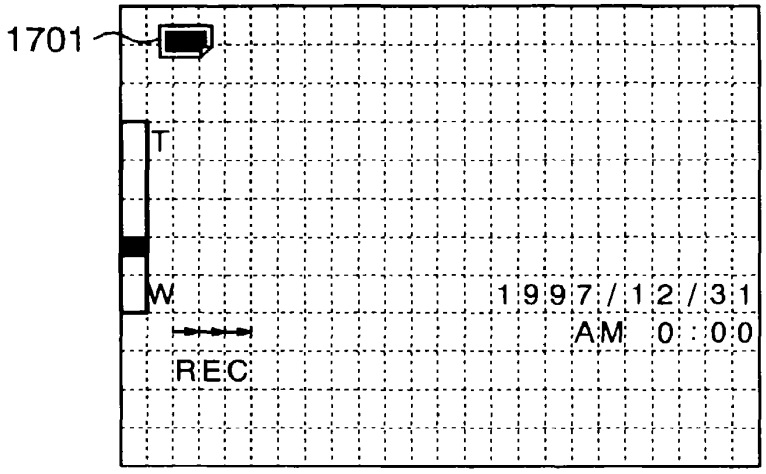


FIG. 18

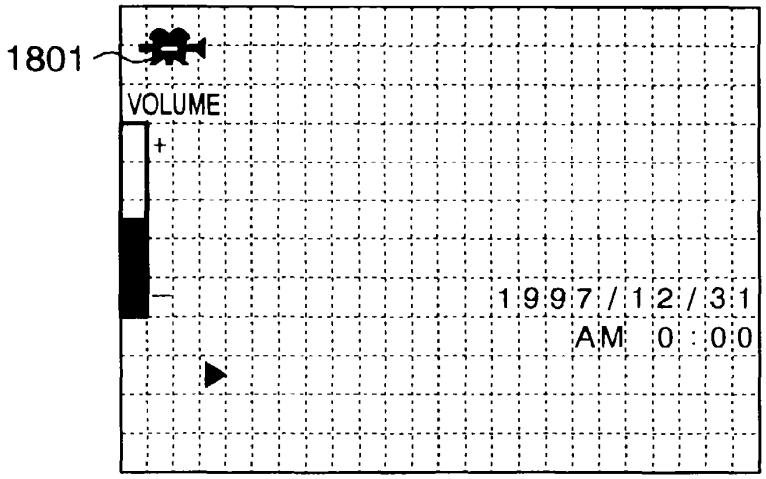


FIG. 19

RECORDING MODE	MODE SYMBOL
MOVING IMAGE	
STILL IMAGE	
SERIAL STILL IMAGE	
STILL IMAGE WITH SPEECH	

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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	2	6018363	A	2000-01-25	HORII	
	3	7903162	B2	2011-03-08	JUEN	
	4	4740828	A	1988-04-26	KINOSHITA	
	5	6563535	B1	2003-05-13	ANDERSON	
	6	6529236	B1	2003-03-04	WATANABE	
	7	6661451	B1	2003-12-09	KIJIMA et al.	
	8	5502483	A	1996-03-26	TAKASE et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	9	4612575	A	1986-09-16	ISHMAN et al.	

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	1	0 802 688	EP	A1	1997-10-22	HITACHI, LTD.		

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Apple Inc.'s Invalidity Contentions which were filed in the following litigation: MAXELL, LTD. v. APPLE INC., Civil Action No. 5:19-cv-00036-RWS (E.D. TX), filed August 14, 2019	
	2	The Sony Digital Video Recorder (DCR-TRV900) User Manual ("DCR-TRV900 Manual"), published by Sony Corporation in 1998	
	3	Sony Consumer Electronics Guide: DCR-TRV900 - More Specifications, webpage published by Sony Corporation, April 24, 1999, URL: https://web.archive.org/web/19990424085854/http://www.sel.sony.com/SEL/consumer/ss5/office/camcorder/digitalvideoproducts/dcr-trv900_specs.shtml	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	4	Sony Consumer Electronics Guide: DCR-TRV900 - More Specifications, webpage published by Sony Corporation, January 28, 1999, URL: https://web.archive.org/web/19990128112515/http://www.sel.sony.com:80/SEL/consumer/ss5/office/camcorder/digitalvideoproducts/dcr-trv900.shtml	
	5	Getting Started With the QuickTake 200 Camera, "QuickTake 200 User's Manual", published by Apple Inc. in 1997	
	6	Using the QuickTake 200 AC Adapter, published by Apple Inc. in 1997	
	7	Published advertisement from The Indianapolis News (Indianapolis, Indiana) dated September 4, 1998	
	8	Published advertisement from The Indianapolis News (Indianapolis, Indiana) dated September 12, 1998	
	9	J. Ozer, "Digital Video Cameras," PC Magazine, Vol. 18, No. 7, April 6, 1999	
	10	Published advertisement from Popular Photography magazine dated October 1999	
	11	Published advertisement from The Daily Sentinel (Grand Junction, Colorado) newspaper dated Sunday, June 13, 1999	
	12	JVC GR-DVL9600 GR-DVL9500 User's Manual, "JVCVRDVL9500 Manual", published by the Victor Company of Japan, Ltd. in 1999	
	13	Excerpts from the JVC America Website published around January 1999 (from https://web.archive.orgweb/19990117003015/http://jvc-america.com:80/digital_camcorders/digital_camcorders.html)	
	14	Published review from the Iowa City Press (Iowa City, Iowa) newspaper dated January 12, 1999	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	15	Published advertisement from The Courier-News (Bridgewater, New Jersey) newspaper dated February 17, 1999	

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

X That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-08-26
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc Code: PET.AUTO Document Description: Petition automatically granted by EFS-Web	PTO/SB/140 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**PETITION TO WITHDRAW AN APPLICATION FROM ISSUE AFTER PAYMENT OF THE ISSUE FEE UNDER 37 CFR 1.313(c)**
Application Number	15959774
Filing Date	23-Apr-2018
First Named Inventor	Takahiro NAKANO
Art Unit	2698
Examiner Name	LUONG NGUYEN
Attorney Docket Number	ASA-9606-09
Title	ELECTRIC CAMERA

An application may be withdrawn from issue for further action upon petition by the applicant. To request that the Office withdraw an application from issue, applicant must file a petition under this section including the fee set forth in § 1.17(h) and a showing of good and sufficient reasons why withdrawal of the application from issue is necessary.

APPLICANT HEREBY PETITIONS TO WITHDRAW THIS APPLICATION FROM ISSUE UNDER 37 CFR 1.313(c).

A grantable petition requires the following items:
(1) Petition fee; and
(2) One of the following reasons:
(a) Unpatentability of one or more claims, which must be accompanied by an unequivocal statement that one or more claims are unpatentable, an amendment to such claim or claims, and an explanation as to how the amendment causes such claim or claims to be patentable;
(b) Consideration of a request for continued examination in compliance with § 1.114 (for a utility or plant application only); or
(c) Express abandonment of the application. Such express abandonment may be in favor of a continuing application, but not a CPA under 37 CFR 1.53(d).

Petition Fee

- ○ Small Entity
- ○ Micro Entity
- ◉ Regular Undiscounted

Reason for withdrawal from issue

○ One or more claims are unpatentable ◉ Consideration of a request for continued examination (RCE) (List of Required Documents and Fees) ○ Applicant hereby expressly abandons the instant application (any attorney/agent signing for this reason must have power of attorney pursuant to 37 CFR 1.32(b)).	
RCE request,submission, and fee. ☐ I certify, in accordance with 37 CFR 1.4(d)(4) that : The RCE request ,submission, and fee have already been filed in the above-identified application on ☒ Are attached.	
THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES I certify, in accordance with 37 CFR 1.4(d)(4) that I am: ◉ An attorney or agent registered to practice before the Patent and Trademark Office who has been given power of attorney in this application. ○ An attorney or agent registered to practice before the Patent and Trademark Office, acting in a representative capacity. ○ A sole inventor ○ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application ○ A joint inventor; all of whom are signing this e-petition	
Signature	/John R. Mattingly/
Name	John R. Mattingly
Registration Number	30293

Electronic Patent Application Fee Transmittal

Application Number:	15959774
Filing Date:	23-Apr-2018
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly/Emily Scotti
Attorney Docket Number:	ASA-9606-09

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
PETITION FEE- 37 CFR 1.17(H) (GROUP III)	1464	1	140	140
RCE- 1ST REQUEST	1801	1	1300	1300
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1440**

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

Decision Date : August 26, 2019

In re Application of :

Takahiro NAKANO

DECISION ON PETITION
UNDER CFR 1.313(c)(2)

Application No : 15959774

Filed : 23-Apr-2018

Attorney Docket No : ASA-9606-09

This is an electronic decision on the petition under 37 CFR 1.313(c)(2), filed August 26, 2019 , to withdraw the above-identified application from issue after payment of the issue fee.

The petition is **GRANTED.**

The above-identified application is withdrawn from issue for consideration of a submission under 37 CFR 1.114 (request for continued examination). See 37 CFR 1.313(c)(2).

Petitioner is advised that the issue fee paid in this application cannot be refunded. If, however, this application is again allowed, petitioner may request that it be applied towards the issue fee required by the new Notice of Allowance.

Telephone inquiries concerning this decision should be directed to the Patent Electronic Business Center (EBC) at 866-217-9197.

This application file is being referred to Technology Center AU 2698 for processing of the request for continuing examination under 37 CFR 1.114 .

Office of Petitions

Electronic Acknowledgement Receipt	
EFS ID:	36972329
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	26-AUG-2019
Filing Date:	23-APR-2018
Time Stamp:	13:56:43
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1440
RAM confirmation Number	E20198PD56143029
Deposit Account	501417
Authorized User	Emily Scotti
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

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1	Transmittal Letter	9606-09-NoticeOfPatentinLitigation-2.pdf	15977 dee30ea0a603157ac2fc0e97a1308f499a00e097	no	1
Warnings:					
Information:					
2	Request for Continued Examination (RCE)	9606-09-RCE.pdf	1349901 56b3368bba9bc562cf038ca9104d4878d79f2205	no	3
Warnings:					
Information:					
3	Quick Path Information Disclosure Statement	9606-09-QPIDS.pdf	178504 2da72412a2e6bcb21820ad17ab6a4b37ad353042	no	2
Warnings:					
Information:					
4	Non Patent Literature	NPL1-E5037-09EU_AppleslnvalidityContentions.pdf	867028 6b42c90ce96d05055e65dc9bee5c434df7b572f3	no	135
Warnings:					
Information:					
5	Non Patent Literature	NPL3-19-SonyConsumerElectronicsGuide-1999.pdf	280050 b51553c9b2857817f50fc867467dd182f7b4c0d3	no	4
Warnings:					
Information:					
6	Non Patent Literature	NPL4-20-SonyConsumerElectronicsGuide-1999.pdf	204803 d9b89abd1e7e78be43396d2c8baca0d7618a5269	no	2
Warnings:					
Information:					

7	Foreign Reference	EP0802688.pdf	1283490 756cb7c14bb3f95e03f170870dfde00babc5eb20	no	25
Warnings:					
Information:					
8	Non Patent Literature	NPL2-16-DigitalVideoRecorder-1998-A.pdf	16183592 e8cdc809187bafaad2e54fa9bcd38edd5e720591	no	40
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Information:					
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Information:					
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Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
11	Non Patent Literature	NPL2-16-DigitalVideoRecorder-1998-D.pdf	14226016 de0c04597789fda2c09c1bc3bef33ae0a94377b9	no	37
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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
12	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-Litigation-3.pdf	1035781 51a184f9791caf8004953c6659eb6ff20f6c7e9b	no	6
Warnings:					
Information:					

13	Non Patent Literature	NPL5-QuickTake200UsersManual.pdf	1149829 71272070a7b08c79dcba1ae759decd5450eb03dc	no	98
Warnings:					
Information:					
14	Non Patent Literature	NPL7-ADfromIN.pdf	407117 6e76c5490e7ef7615d4bd731533bd0afda066389	no	1
Warnings:					
Information:					
15	Non Patent Literature	NPL8-AdfromIN.pdf	238370 53fc1ad5324331a4ece526d8deeb57a73d2eb54f	no	1
Warnings:					
Information:					
16	Non Patent Literature	NPL9-DigitalVideoCameras.pdf	9989167 5ebf7c04ecdd6657fa2e4f71e36277583746b0c7	no	9
Warnings:					
Information:					
17	Non Patent Literature	NPL10-PopularPhotographyAd.pdf	1190584 ba8d10dab4c5802d8bbee4f13016edc8339c7586	no	2
Warnings:					
Information:					
18	Non Patent Literature	NPL11-AdfromCO.pdf	455770 4464b95fba1fa8fc48b531ccfbe4bd2485beeef4	no	1
Warnings:					
Information:					
19	Non Patent Literature	NPL12-JVCVRDVL9500Manual.pdf	2669207 92857076f2ebb31569e705c11975cd1f1ac8a66d	no	80
Warnings:					
Information:					

20	Non Patent Literature	NPL14-AdfromIA.pdf	287636 885cb6252e25a1d709688fdd9d5b9d1e02c7a8e7	no	1
Warnings:					
Information:					
21	Non Patent Literature	NPL15-ADfromNJ.pdf	289529 c9f30a7f96701a20f00a1549875b6f2ac7f99c4b	no	1
Warnings:					
Information:					
22	Non Patent Literature	NPL13-JVCSite.pdf	287402 676516b2bb12d358faaee6a3e1a53383df8fcf1d	no	8
Warnings:					
Information:					
23	Non Patent Literature	NPL6-AppleQuickTake.pdf	89174 4ff5cd27eb45e15c66b79f6ac349fc97f98d5201	no	1
Warnings:					
Information:					
24	Petition automatically granted by EFS	petition-request.pdf	31540 a57c082388331e565bdfc167a49d17d312384d5e	no	2
Warnings:					
Information:					
25	Fee Worksheet (SB06)	fee-info.pdf	32137 04eca78c903b4e26045b3bc11917ef0c5fe72450	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	80450454		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Atty. Docket No. ASA-9606-09

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: 15/959,774	Confirmation No.	: 2614
Applicant	: Maxell, Ltd.	TC/GAU	: 2698
Filed	: April 23, 2018	Examiner	: NGUYEN, L.T.
Title	: ELECTRIC CAMERA		

Customer No.: 24956

NOTICE OF RELATED PATENTS INVOLVED IN LITIGATION

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

August 26, 2019

Sir:

Applicant notifies the Office that one related patent, U.S. Patent No. 8,339,493 which matured from application 10/660,710, and from which the above-identified application claims priority under 35 U.S.C. 120, is involved in the following litigation:

Maxell, Ltd. v. Apple Inc., Civil Action No. 5:19-cv-00036-RWS (E.D. TX), filed March 15, 2019.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly, Reg. No. 30,293
(703) 684-1120

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

24956 7590 08/30/2019

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
NGUYEN, LUONG TRUNG	

ART UNIT	PAPER NUMBER
2698	

NOTIFICATION DATE	DELIVERY MODE
08/30/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

Corrected ***Notice of Allowability***	**Application No.** 15/959,774	**Applicant(s)** NAKANO et al.	
	Examiner LUONG T NGUYEN	**Art Unit** 2698	**AIA (FITF) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to IDS filed on 08/26/2019.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-20 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☑ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☑ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☑ Certified copies of the priority documents have been received in Application No. 14/661,227 .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 08/26/2019.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2698

Receipt date: 08/26/2019

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6335760	B1	2002-01-01	SATO	
	2	6018363	A	2000-01-25	HORII	
	3	7903162	B2	2011-03-08	JUEN	
	4	4740828	A	1988-04-26	KINOSHITA	
	5	6563535	B1	2003-05-13	ANDERSON	
	6	6529236	B1	2003-03-04	WATANABE	
	7	6661451	B1	2003-12-09	KIJIMA et al.	
	8	5502483	A	1996-03-26	TAKASE et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

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Receipt date: 08/26/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	9	4612575	A	1986-09-16	ISHMAN et al.	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	0 802 688	EP	A1	1997-10-22	HITACHI, LTD.		

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Apple Inc.'s Invalidity Contentions which were filed in the following litigation: MAXELL, LTD. v. APPLE INC., Civil Action No. 5:19-cv-00036-RWS (E.D. TX), filed August 14, 2019	
	2	The Sony Digital Video Recorder (DCR-TRV900) User Manual ("DCR-TRV900 Manual"), published by Sony Corporation in 1998	
	3	Sony Consumer Electronics Guide: DCR-TRV900 - More Specifications, webpage published by Sony Corporation, April 24, 1999, URL: https://web.archive.org/web/19990424085854/http://www.sel.sony.com/SEL/consumer/ss5/office/camcorder/digitalvideoproducts/dcr-trv900_specs.shtml	

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	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	4	Sony Consumer Electronics Guide: DCR-TRV900 - More Specifications, webpage published by Sony Corporation, January 28, 1999, URL: https://web.archive.org/web/19990128112515/http://www.sel.sony.com:80/SEL/consumer/ss5/office/camcorder/digitalvideoproducts/dcr-trv900.shtml
	5	Getting Started With the QuickTake 200 Camera, "QuickTake 200 User's Manual", published by Apple Inc. in 1997
	6	No copy submitted. ~~Using the QuickTake 200 AC Adapter, published by Apple Inc. in 1997~~
	7	Published advertisement from The Indianapolis News (Indianapolis, Indiana) dated September 4, 1998
	8	Published advertisement from The Indianapolis News (Indianapolis, Indiana) dated September 12, 1998
	9	No copy submitted. ~~J. Ozer, "Digital Video Cameras," PC Magazine, Vol. 18, No. 7, April 6, 1999~~
	10	No copy submitted. ~~Published advertisement from Popular Photography magazine dated October 1999~~
	11	Published advertisement from The Daily Sentinel (Grand Junction, Colorado) newspaper dated Sunday, June 13, 1999
	12	Digital Camcorder JVC GR-DVL9600 GR-DVL9500 User's Manual, "JVCVRDVL9500 Manual", published by the Victor Company of Japan, Ltd. in 1999
	13	Date not shown on submitted copy. Excerpts from the JVC America Website published ~~around January 1999~~ (from https://web.archive.org/web/19990117003015/http://jvc-america.com:80/digital_camcorders/digital_camcorders.html)
	14	Published review from the Iowa City Press (Iowa City, Iowa) newspaper dated January 12, 1999

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Receipt date: 08/26/2019

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	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	15	Published advertisement from The Courier-News (Bridgewater, New Jersey) newspaper dated February 17, 1999	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/LUONG T NGUYEN/	Date Considered	08/27/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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Receipt date: 08/26/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

X That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-08-26
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							

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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
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	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	1	Using the QuickTake 200 AC Adapter, published by Apple Inc. in 1997	
	2	J. Ozer, "Digital Video Cameras," PC Magazine, Vol. 18, No. 7, April 6, 1999	
	3	Published advertisement from Popular Photography magazine dated October 1999	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-08-30
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	37028676
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	30-AUG-2019
Filing Date:	23-APR-2018
Time Stamp:	11:10:27
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	9606-09-Request-Reconsideration-IDS-2.pdf	21313 d9bbd3d8fb1a93de0f7b83f4540a2cb46921e5bd	no	3

Warnings:

Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-Litigation-3-Resubmission08262019.pdf	1034394 a16e4fc263589622118240a90fe984b64b40a12f	no	4
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
3	Non Patent Literature	NPL6-AppleQuickTake.pdf	89174 4ff5cd27eb45e15c66b79f6ac349fc97f98d5201	no	1
Warnings:					
Information:					
4	Non Patent Literature	NPL9-DigitalVideoCameras.pdf	9989167 5ebf7c04ecdd6657fa2e4f71e36277583746b0c7	no	9
Warnings:					
Information:					
5	Non Patent Literature	NPL10-PopularPhotographyAd.pdf	1190584 ba8d10dab4c5802d8bbee4f13016edc8339c7586	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	12324632		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	Takahiro NAKANO et al.
		Confirmation No.: 2614
Serial No.	:	15/959,774
Filed	:	April 23, 2018
For	:	ELECTRIC CAMERA
Group	:	2698
Examiner	:	L. NGUYEN
Docket No.	:	ASA-9606-09
Customer No.:		24956

REQUEST FOR RECONSIDERATION OF INFORMATION DISCLOSURE STATEMENTS

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

August 30, 2019

Sir:

Applicant requests reconsideration of the Information Disclosure Statement filed August 26, 2019 in the above application. The Examiner has crossed through references submitted with the Information Disclosure Statement, as an indication that these references have not been fully considered. Each of the crossed through documents has been re-listed on a PTO/SB/08a form submitted herewith to assist the Examiner in providing his initials for each of the documents to be reconsidered for the following reasons.

A "Copy of Acknowledgement Receipt" document forms an Appendix to this Request in order to efficiently refer to the electronic filing acknowledgement of the documents submitted on August 26, 2019 by document number and page number, referring to the "Copy of Acknowledgement Receipt" document.

IDS form PTO/SB/08a submitted on August 26, 2019 (6 pages)

The following references have been crossed through, and the reason Applicant asserts that the references should be initialed as an indication of consideration of the references is set forth as follows.

(i) Using the QuickTake 200 AC Adapter, published by Apple Inc. in 1997

A copy of the document was submitted on August 26, 2019. See document number 23 on page 5 of the Copy of Acknowledgement Receipt. To assist the Examiner in reconsideration of the document, another copy is submitted with this Request for Reconsideration.

(ii) J. Ozer, "Digital Video Cameras," PC Magazine, Vol. 18, No. 7, April 6, 1999

A copy of the document was submitted August 26, 2019. See document number 16 on page 4 of the Copy of Acknowledgement Receipt. To assist the Examiner in reconsideration of the document, another copy is submitted with this submission.

(iii) Published advertisement from Popular Photography magazine dated October 1999

A copy of the document was submitted August 26, 2019. See document number 17 on page 4 of the Copy of Acknowledgement Receipt. To assist the Examiner in reconsideration of the document, another copy is submitted with this submission.

Conclusion

In view of the foregoing, Applicant respectfully asserts that all of the documents re-listed on the PTO/SB/08a form submitted herewith were previously submitted on August 26, 2019, and therefore the documents should be considered in accordance with this Request for Reconsideration. Accordingly, Applicant requests that the Examiner initial the documents on the PTO/SB/08a form submitted herewith as an indication that the Examiner has fully considered these references.

The Commissioner is authorized to charge any shortage in the fees due, or credit any overpayment, to Deposit Account No. 50-1417 (referencing Attorney Docket No. ASA-9606-09).

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Registration No. 30,293
703-684-1120

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

24956 7590 09/13/2019

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
NGUYEN, LUONG TRUNG	

ART UNIT	PAPER NUMBER
2698	

NOTIFICATION DATE	DELIVERY MODE
09/13/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

Corrected ***Notice of Allowability***	**Application No.** 15/959,774	**Applicant(s)** NAKANO et al.	
	Examiner LUONG T NGUYEN	**Art Unit** 2698	**AIA (FITF) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to IDS filed on 08/30/2019.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-20 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☑ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☑ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☑ Certified copies of the priority documents have been received in Application No. 14/661,227 .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 08/30/2019.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2698

Receipt date: 08/30/2019

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	15959774
Filing Date	2018-04-23
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-09

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button. Add

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							

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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

EFS Web 2.1.18

Receipt date: 08/30/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15959774
	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

	1	~~Using the QuickTake 200 AC Adapter, published by Apple Inc. in 1997~~ No copy submitted.	
	2	J. Ozer, "Digital Video Cameras," PC Magazine, Vol. 18, No. 7, April 6, 1999	
	3	Published advertisement from Popular Photography magazine dated October 1999	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/LUONG T NGUYEN/	Date Considered	09/10/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

EFS Web 2.1.18

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	Filing Date	2018-04-23
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-09

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-08-30
Name/Print	John R. Mattingly	Registration Number	30,293

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

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Attorney Docket Number	ASA-9606-09

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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	1							

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Attorney Docket Number	ASA-9606-09

	1	Using the QuickTake 200 AC Adapter, published by Apple Inc. in 1997

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-09-13
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt	
EFS ID:	36972329
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	26-AUG-2019
Filing Date:	23-APR-2018
Time Stamp:	13:56:43
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1440
RAM confirmation Number	E20198PD56143029
Deposit Account	501417
Authorized User	Emily Scotti
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	9606-09-NoticeOfPatentinLitigation-2.pdf	15977 dee30ea0a603157ac2fc0e97a1308f499a00e097	no	1
Warnings:					
Information:					
2	Request for Continued Examination (RCE)	9606-09-RCE.pdf	1349901 56b3368bba9bc562cf038ca9104d4878d79f2205	no	3
Warnings:					
Information:					
3	Quick Path Information Disclosure Statement	9606-09-QPIDS.pdf	178504 2da72412a2e6bcb21820ad17ab6a4b37ad353042	no	2
Warnings:					
Information:					
4	Non Patent Literature	NPL1-E5037-09EU_AppleslnvalidityContentions.pdf	867028 6b42c90ce96d05055e65dc9bee5c434df7b572f3	no	135
Warnings:					
Information:					
5	Non Patent Literature	NPL3-19-SonyConsumerElectronicsGuide-1999.pdf	280050 b51553c9b2857817f50fc867467dd182f7b4c0d3	no	4
Warnings:					
Information:					
6	Non Patent Literature	NPL4-20-SonyConsumerElectronicsGuide-1999.pdf	204803 d9b89abd1e7e78be43396d2c8baca0d7618a5269	no	2
Warnings:					
Information:					

7	Foreign Reference	EP0802688.pdf	1283490 756cb7c14bb3f95e03f170870dfde00babc5eb20	no	25
Warnings:					
Information:					
8	Non Patent Literature	NPL2-16-DigitalVideoRecorder-1998-A.pdf	16183592 e8cdc809187bafaad2e54fa9bcd38edd5e720591	no	40
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
9	Non Patent Literature	NPL2-16-DigitalVideoRecorder-1998-B.pdf	15704547 abd1443c6c4fc69ca138e208308c69839d6bfd0d	no	41
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
10	Non Patent Literature	NPL2-16-DigitalVideoRecorder-1998-C.pdf	12003303 31d3406f8d92359633b44b538719a5bae4feb095	no	30
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
11	Non Patent Literature	NPL2-16-DigitalVideoRecorder-1998-D.pdf	14226016 de0c04597789fda2c09c1bc3bef33ae0a94377b9	no	37
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
12	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-Litigation-3.pdf	1035781 51a184f9791caf8004953c6659eb6ff20f6c7e9b	no	6
Warnings:					
Information:					

13	Non Patent Literature	NPL5-QuickTake200UsersManual.pdf	1149829 71272070a7b08c79dcba1ae759decd5450eb03dc	no	98
Warnings:					
Information:					
14	Non Patent Literature	NPL7-ADfromIN.pdf	407117 6e76c5490e7ef7615d4bd731533bd0afda066389	no	1
Warnings:					
Information:					
15	Non Patent Literature	NPL8-AdfromIN.pdf	238370 53fc1ad5324331a4ece526d8deeb57a73d2eb54f	no	1
Warnings:					
Information:					
16	Non Patent Literature	NPL9-DigitalVideoCameras.pdf	9989167 5ebf7c04ecdd6657fa2e4f71e36277583746b0c7	no	9
Warnings:					
Information:					
17	Non Patent Literature	NPL10-PopularPhotographyAd.pdf	1190584 ba8d10dab4c5802d8bbee4f13016edc8339c7586	no	2
Warnings:					
Information:					
18	Non Patent Literature	NPL11-AdfromCO.pdf	455770 4464b95fba1fa8fc48b531ccfbe4bd2485beeef4	no	1
Warnings:					
Information:					
19	Non Patent Literature	NPL12-JVCVRDVL9500Manual.pdf	2669207 92857076f2ebb31569e705c11975cd1f1ac8a66d	no	80
Warnings:					
Information:					

20	Non Patent Literature	NPL14-AdfromIA.pdf	287636 885cb6252e25a1d709688fdd9d5b9d1e02c7a8e7	no	1
Warnings:					
Information:					
21	Non Patent Literature	NPL15-ADfromNJ.pdf	289529 c9f30a7f96701a20f00a1549875b6f2ac7f99c4b	no	1
Warnings:					
Information:					
22	Non Patent Literature	NPL13-JVCSite.pdf	287402 676516b2bb12d358faaee6a3e1a53383df8fcf1d	no	8
Warnings:					
Information:					
23	Non Patent Literature	NPL6-AppleQuickTake.pdf	89174 4ff5cd27eb45e15c66b79f6ac349fc97f98d5201	no	1
Warnings:					
Information:					
24	Petition automatically granted by EFS	petition-request.pdf	31540 a57c082388331e565bdfc167a49d17d312384d5e	no	2
Warnings:					
Information:					
25	Fee Worksheet (SB06)	fee-info.pdf	32137 04eca78c903b4e26045b3bc11917ef0c5fe72450	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	80450454		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

Decision Date : August 26, 2019

In re Application of :

Takahiro NAKANO

DECISION ON PETITION
UNDER CFR 1.313(c)(2)

Application No : 15959774

Filed : 23-Apr-2018

Attorney Docket No : ASA-9606-09

This is an electronic decision on the petition under 37 CFR 1.313(c)(2), filed August 26, 2019 , to withdraw the above-identified application from issue after payment of the issue fee.

The petition is **GRANTED.**

The above-identified application is withdrawn from issue for consideration of a submission under 37 CFR 1.114 (request for continued examination). See 37 CFR 1.313(c)(2).

Petitioner is advised that the issue fee paid in this application cannot be refunded. If, however, this application is again allowed, petitioner may request that it be applied towards the issue fee required by the new Notice of Allowance.

Telephone inquiries concerning this decision should be directed to the Patent Electronic Business Center (EBC) at 866-217-9197.

This application file is being referred to Technology Center AU 2698 for processing of the request for continuing examination under 37 CFR 1.114 .

Office of Petitions

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	Takahiro NAKANO et al.
		Confirmation No.: 2614
Serial No.	:	15/959,774
Filed	:	April 23, 2018
For	:	ELECTRIC CAMERA
Group	:	2698
Examiner	:	L. NGUYEN
Docket No.	:	ASA-9606-09
Customer No.:		24956

SECOND REQUEST FOR RECONSIDERATION OF INFORMATION DISCLOSURE STATEMENT

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

September 13, 2019

Sir:

Applicant respectfully requests, for a second time, reconsideration of the Information Disclosure Statement filed August 26, 2019 in the above application. The Examiner has crossed through a reference submitted with the Information Disclosure Statement, as an indication that this reference has not been fully considered. The crossed through document has been re-listed on a PTO/SB/08a form submitted herewith to assist the Examiner in providing his initials for the document to be reconsidered for the following reasons.

A "Copy of Acknowledgement Receipt" document forms an Appendix to this Request in order to efficiently refer to the electronic filing acknowledgement of the document submitted on August 26, 2019 (and resubmitted August 30, 2019) by document number and page number, referring to the "Copy of Acknowledgement Receipt" documents.

IDS form PTO/SB/08a submitted on August 30, 2019 (7 pages)

The following reference has been crossed through, and the reason Applicant asserts that the reference should be initialed as an indication of consideration of the reference is set forth as follows.

(i) Using the QuickTake 200 AC Adapter, published by Apple Inc. in 1997

A copy of the document was submitted on August 26, 2019. See document number 23 on page 5 of the "Copy of Acknowledgement Receipt".

(A copy of the document was also submitted on August 30, 2019.)

To assist the Examiner in reconsideration of the document, another copy is submitted with this Request for Reconsideration.

Conclusion

In view of the foregoing, Applicant respectfully asserts that the document re-listed on the PTO/SB/08a form submitted herewith was previously submitted on August 26,

2019 (and August 30, 2019), and therefore the document should be considered in accordance with this Second Request for Reconsideration. Accordingly, Applicant requests that the Examiner initial the document on the PTO/SB/08a form submitted herewith as an indication that the Examiner has fully considered this reference.

The Commissioner is authorized to charge any shortage in the fees due, or credit any overpayment, to Deposit Account No. 50-1417 (referencing Attorney Docket No. ASA-9606-09).

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Registration No. 30,293
703-684-1120

Electronic Acknowledgement Receipt

EFS ID:	37158424
Application Number:	15959774
International Application Number:	
Confirmation Number:	2614
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-09
Receipt Date:	13-SEP-2019
Filing Date:	23-APR-2018
Time Stamp:	13:21:22
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	9606-09-SB08A-Litigation-3-Resubmission09132019.pdf	1034259 993912b82c7e43bb6062811a0b84327b2bf76d53	no	4

Warnings:

Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
2	Non Patent Literature	NPL6-AppleQuickTake.pdf	89174 4ff5cd27eb45e15c66b79f6ac349fc97f98d5201	no	1
Warnings:					
Information:					
3	Transmittal Letter	9606-09-CopyOfAcknowledgementReceipt.pdf	522596 a7355ded1bce25a29ea7a64595e8e494b6bc1d3a	no	7
Warnings:					
The PDF file has been signed with a digital signature and the legal effect of the document will be based on the contents of the file not the digital signature.					
Information:					
4	Transmittal Letter	9606-09-Request-Reconsideration-IDS-3.pdf	20897 4b0c1f0828f5a5a118ffe6c4307888278b1c9a27	no	3
Warnings:					
Information:					
		Total Files Size (in bytes):	1666926		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

7590 10/01/2019

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
NGUYEN, LUONG TRUNG	

ART UNIT	PAPER NUMBER
2698	

NOTIFICATION DATE	DELIVERY MODE
10/01/2019	ELECTRONIC

NOTICE OF NON-COMPLIANT INFORMATION DISCLOSURE STATEMENT

An Information Disclosure Statement (IDS) filed 9-13-19 in the above-identified application fails to meet the requirements of 37 CFR 1.97(d) for the reason(s) specified below. Accordingly, the IDS will be placed in the file, but the information referred to therein has not been considered.

The IDS is not compliant with 37 CFR 1.97(d) because:

☐ The IDS lacks a statement as specified in 37 CFR 1.97(e).

☐ The IDS lacks the fee set forth in 37 CFR 1.17(p).

☑ The IDS was filed after the issue fee was paid. Applicant may wish to consider filing a petition to withdraw the application from issue under 37 CFR 1.313(c) to have the IDS considered. See MPEP 1308.

571-272-4200 or 1-888-786-0101
Application Assistance Unit
Office of Data Management

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	10/29/2019	10462403	ASA-9606-09	2614

24956 7590 10/09/2019

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Takahiro NAKANO, Tokyo, JAPAN;
Maxell, Ltd., Kyoto, JAPAN;
Ryuji NISHIMURA, Tokyo, JAPAN;
Toshiro KINUGASA, Tokyo, JAPAN;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/959,774	04/23/2018	Takahiro NAKANO	ASA-9606-09	2614

24956 7590 10/29/2019

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
NGUYEN, LUONG TRUNG	

ART UNIT	PAPER NUMBER
2698	

NOTIFICATION DATE	DELIVERY MODE
10/29/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

Notice to Vacate Previously Mailed Notice of Non-compliant Information Disclosure Statement	Application No. 15/959,774	Applicant(s) NAKANO et al.	
	Examiner LUONG T NGUYEN	Art Unit 2698	AIA (First Inventor to File) Status No

The USPTO mailed a Notice of Non-Compliant Information Disclosure Statement to your office on 01 October 2019. This notice was sent in error as the Information Disclosure Statement filed on 13 September 2019 is compliant.

The notice mailed on 01 October 2019 is hereby vacated.

Telephone inquires relating to this decision may be directed to the undersigned in the Office of Data Management at 571-272-4200.

Sincerely,

/Kimberly House, Manager
Office of Data Management Publications Branch

EXHIBIT 1012

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	T. NAKANO et al.
		Confirmation No.: TBD
Serial No.	:	To be assigned
Filed	:	December 21, 2016
For	:	ELECTRIC CAMERA
Group	:	To be assigned
Examiner	:	To be assigned
Docket No.	:	ASA-9606-08
Customer No.:		24956

PRELIMINARY AMENDMENT

Mail Stop Amendments
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

December 21, 2016

Sir:

Prior to examination, please amend the above-identified application as follows.

Amendments to the Specification begin on page 2;

Remarks are included following the amendments.

IN THE SPECIFICATION:

Please amend the first paragraph on page 1 of the specification following the heading "CROSS REFERENCE TO RELATED APPLICATION" as follows:

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application No. 14/661,227 filed March 18, 2015, which is a continuation of U.S. patent application No. 14/264,243, filed April 29, 2014, now U.S. Patent No. 9,100,604, which is a continuation of U.S. application serial no. 13/681,495, filed November 20, 2012, now U.S. Patent No. 8,736,729, which is a continuation of U.S. application serial no. 12/845,266, filed July 28, 2010, now U.S. Patent No. 8,339,493, issued December 25, 2012, which is a continuation of U.S. application serial no. 10/660,710, filed September 12, 2003, now U.S. Patent No. 8,059,177, issued November 15, 2011, and is related to U.S. application serial no. 10/660,711, filed September 12, 2003, now U.S. Patent No. 7,403,226, issued July 22, 2008, both of which are divisional applications of U.S. application Serial No. 09/520,836, filed March 8, 2000, now U.S. Patent No. 6,765,616, issued July 20, 2004, the subject matter of all the above is incorporated by reference herein.

REMARKS

Entry of the above amendments prior to examination is respectfully requested. No new matter is added by the amendments.

Please charge any shortage in fees due in connection with the filing of this paper, or credit any overpayment of fees, to the deposit account of MATTINGLY & MALUR, PC, Deposit Account No. 50-1417.

Respectfully submitted,

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ELECTRIC CAMERA

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application serial no. 13/681,495, filed November 20, 2012, which is a continuation of U.S. application serial no. 12/845,266, filed July 28, 2010, now U.S. Patent No. 8,339,493, issued December 25, 2012, which is a continuation of U.S. application serial no. 10/660,710, filed September 12, 2003, now U.S. Patent No. 8,059,177, issued November 15, 2011, and is related to U.S. application serial no. 10/660,711, filed September 12, 2003, now U.S. Patent No. 7,403,226, issued July 22, 2008, both of which are divisional applications of U.S. application Serial No. 09/520,836, filed March 8, 2000, now U.S. Patent No. 6,765,616, issued July 20, 2004, the subject matter of all the above is incorporated by reference herein.

BACKGROUND OF THE INVENTION

The present invention relates to a photography related to video cameras, camcorders, digital still cameras and others using a solid-state image sensing device, and more particularly to an electric camera using a solid-state image sensing device with a large number of pixels.

Electric cameras using solid-state image sensors such as CCDs (charge-coupled devices) include a so-called video camera or camcorder for taking moving images and a so-called digital still camera for taking still images. In recent years, video cameras with a still image taking function and digital still cameras with a moving image taking function have become available.

In a video camera to photograph moving images, it is generally assumed that the video is viewed on a display such as television monitor and thus the camera is designed to produce output signals conforming to a television system such as NTSC and

PAL. Therefore, the effective number of vertically arranged pixels or picture elements on the image sensing device used in such a camera is determined to enable television signals to be generated. The NTSC system, for example, performs interlaced scanning on two fields, each of which has an effective scanning line number of about 240 lines (the number of scanning lines actually

displayed on the monitor which is equal to the number of scanning lines in the vertical blanking period subtracted from the total number of scanning lines in each field). To realize this, the image sensing device has about 480 pixel rows as the standard effective number of vertically arranged pixels. That is, the signals of two vertically adjoining pixels in each field are mixed together inside or outside the image sensing device to generate about 240 scanning lines, and the combinations of pixels to be cyclically mixed together are changed from one field to another to achieve the interlaced scanning.

Some image sensing devices to take moving images according to the NTSC system have an area of pixels for image stabilization added to the area of effective pixel area, thus bringing the effective number of vertically arranged pixels to about 480 or more. In this case, an area beyond 480th pixels is read out at high speed during the vertical blanking period and therefore the signals thus read out are not used as effective signals. Therefore, the video signals can only be generated from those signals coming from the area of about 480 vertically arranged pixels. When such a camera is used to photograph a still image, it is relatively easy to generate a static image signal conforming to, for example, JPEG (Joint Photographic Expert Group) from the signals coming from the same pixel area that is used to take a moving image. A problem remains, however, that the number of vertically arranged pixels obtained is limited to around 480, making it

impossible to produce more detailed static image signals.

In a camera having an image sensing device with the area of pixels for image stabilization mentioned above, a method of alleviating this problem may involve using the entire area of effective pixels including the area of image stabilization pixels in photographing a still image. Even when photographing a still image, however, the photographed image needs to be monitored for check and, for that purpose, it is necessary to generate signals conforming to the television system from signals read out from all effective pixels.

An example of such a conventional camera has been proposed in JP-A-11-187306. In the camera disclosed in this publication, signals from all the effective pixels are read out taking two or more times the field period of the television system, stored in a memory means such as a field memory, and then subjected to interpolation processing for transformation into signals conforming to the field cycle and horizontal scan cycle of television.

This conventional camera, however, requires a large processing circuit, such as field memory, for signal conversion. Another drawback is that the image sensing device readout cycle is a plurality of times the field cycle, degrading the dynamic resolution. Even with the use of this circuit, the number of pixels obtained as the static image signals is limited to the number of effective pixels used for moving videos plus the area of image stabilization pixels.

In a digital still camera designed for taking still images, there has been a trend in recent years toward an increasing number of pixels used on the moving video image sensing device in order to obtain higher resolution static image signals. When taking a moving image or monitoring the video, it is necessary to generate signals that conform to the television system. The number of pixels on such an image sensing device, however, does not necessarily match the number of scanning lines of the television system and therefore some form of conversion means is required.

The conversion means may involve, as in the video camera with the area of image stabilization pixels, reading out signals from the image sensing device taking a longer time than the field cycle and interpolating them to generate television signals. This method has, in addition to the problem described above, a drawback that the readout cycle increases as the number of pixels increases, further degrading the dynamic resolution.

To mitigate this problem, JP-A-9-270959 discloses an apparatus which mixes together or culls the pixel signals inside the image sensing device to reduce the number of signals to be read and therefore the read cycle. Although this apparatus alleviates the problem of the degraded dynamic resolution, it requires a large processing circuit such as field memory to perform time-axis transformation to generate signals conforming to the television system and the image sensing device itself needs to have a

special structure for performing desired mixing and culling.

SUMMARY OF THE INVENTION

The present invention relates to a photography of video cameras, camcorders, digital still cameras and others using a solid-state image sensing device, and more particularly to an electric camera using a solid-state image sensing device with a large number of pixels.

The conventional electric cameras, as described above, have drawbacks that when taking a still picture by using a video camera, the number of pixels is not sufficient and that when taking a moving image with a still camera, the associated circuit inevitably increases and the dynamic image quality deteriorates. Taking both moving and static images of satisfactory quality with a single camera is difficult to achieve. In addition to solving the above problems, to obtain good dynamic picture quality by using an image sensing device having a large number of pixels intended for still images requires extracting a pixel area that is used to realize an image stabilizing function. The conventional art and cameras do not offer a means to accomplish this function.

An object of the present invention is to provide an electric camera that solves these problems and which uses an image sensing device with a sufficient number of pixels for still images and enables taking of highly detailed still images and a moving video taking with

reduced image quality degradation without increasing circuitry such as field memory. It is also an object of the present invention to provide an electric camera that can also realize the image stabilizing function.

According to one aspect of this invention, the electric camera to realize the above objectives has: an image sensing device with a light receiving surface having N vertically arranged pixels and an arbitrary number of pixels arranged horizontally, N being equal to or more than three times the number of effective scanning lines M of a display screen of a television system; a driver to drive the image sensing device to vertically mix or cull signal charges accumulated in individual pixels of every K pixels to produce a number of lines of output signals which corresponds to the number of effective scanning lines M, K being at least one of integers equal to or less than an integral part of a quotient of N divided by M (a number of lines of output signals corresponds to 1/K the number of vertically arranged pixels N of the image sensing device); and a signal processing unit to generate image signals by using the output signals of the image sensing device.

As explained above, since this invention eliminates the limit on the number of vertically arranged pixels, an electric camera can be provided which enables taking of highly detailed still images and a satisfactory moving video taking by using an image sensing device with a large enough pixel number even for still images.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram showing the configu

ration of a first embodiment of an electric camera according to the present invention.

Figure 2 is a schematic diagram showing the structure of an image sensing device in the first embodiment of the electric camera of the invention.

Figure 3 is a drive pulse timing diagram in the first embodiment of the electric camera of the invention.

Figure 4 is a schematic diagram showing a mixing operation in the first embodiment of the electric camera of the invention.

Figure 5 is a schematic diagram showing a readout area in the first embodiment of the electric camera of the invention.

Figure 6 is a schematic diagram showing a mixing operation in the first embodiment of the electric camera of the invention.

Figure 7 is a block diagram showing the configuration of a second embodiment of an electric camera according to the present invention.

Figure 8 is a schematic diagram showing a mixing operation in the second embodiment of the electric camera of the invention.

Figure 9 is a schematic diagram showing a readout area in the second embodiment of the electric camera of the invention.

Figure 10 is a schematic diagram showing the structure of an image sensing device in a third embodiment of the electric camera according to the present invention.

Figure 11 is a drive pulse timing diagram in the third embodiment of the electric camera of the invention.

Figure 12 is a schematic diagram showing an interpolation operation in the third embodiment of the electric camera of the invention.

Figures 13A and 13B are schematic diagrams showing the arrangement of color filters in the image sensing device in a fourth embodiment of the electric camera according to the present invention.

DESCRIPTION OF THE EMBODIMENTS

Now embodiments of the present invention will be described by referring to the accompanying drawings. Figure 1 is a block diagram showing the configuration of one embodiment of an electric camera according to the invention.

In Figure 1, reference number 1 represents a lens, 2 an aperture, 3 an image sensing device, 4 a drive circuit, 5 a gain adjust circuit, 6 an analog-digital (A/D) conversion circuit, 7 a signal processing circuit, 8 a vertical interpolation circuit to perform interpolation in a vertical direction, 9 a horizontal interpolation circuit to perform interpolation in a horizontal direction, 10 a recording unit including recording media such as magnetic tape, semiconductor memory and optical disk to record a video signal, 11 a control circuit to control these constitutional elements according to the operating state, 12 an encoder circuit to modulate the video signal into a

standard television signal, 13 a digital-analog (D/A) conversion circuit, 14 a mode selector switch to change over the operation mode between the moving video taking and the still image taking, 15 a record button to start or stop the recording, 16a and 16b gyro sensors to detect vertical image-unstability and lateral image-unstability, respectively, and 17 an image-unstability decision circuit to determine the image-instability from signals output from the gyro sensors.

In the above configuration, light coming from the lens 1 through the aperture 2 is focused on a light receiving surface of the image sensing device 3 where it is converted into an electric signal. In this embodiment the image sensing device 3 is of a CCD type. Figure 2 shows the structure of this image sensing device 3. In Figure 2, denoted 30 are pixels each formed of a photodiode, which are arranged horizontally and vertically in a grid pattern. On these grid-arrayed pixels three types of color filters that pass yellow (Ye), green (G) and cyan (Cy), respectively, are arranged in such a way that the combination of these three colors is repeated horizontally every three pixels and that the filters of the same colors are lined vertically in so-called vertical stripes. Although an arbitrary number of pixels may be used, this embodiment has an array of 1200 pixels vertically and 1600 pixels horizontally. A vertical transfer unit 32 is a CCD which is driven by three phase pulses V1, V2, V3. This CCD has a three-gate structure in which each pixel corresponds to

three phase pulses and thus can vertically transfer a signal charge of each pixel independently. Transfer gates 31 for transferring the charge of each pixel to the vertical transfer unit 32 are commonly connected to a gate of the vertical transfer unit 32 that corresponds to the V2 pulse. An operation to transfer the charge from each pixel to the vertical transfer unit 32 in response to a peak value of the pulse applied to the commonly connected gate and an operation to transfer the charge vertically are performed separately. A horizontal transfer unit 33 horizontally transfers the charges supplied from the vertical transfer units 32 and outputs them successively through an output amplifier 34 from the output terminal.

Referring back to Figure 1, the operation performed when the moving video mode is selected by the mode selector switch 14 will be explained. The number of vertically arranged pixels on the image sensing device in this embodiment is 1200, so if the number of effective scanning lines in the field of the NTSC system is assumed to be 240 lines, then vertically mixing five pixels (= 1200 pixel rows/240 scanning lines) can match the number of lines of output signals from the image sensing device to the number of effective scanning lines.

However, in this embodiment, to realize the image stabilizing function described later, four vertically arranged pixels are mixed together during motion image taking mode. When four vertically arranged pixels are to be cyclically mixed together, the signals from the area of

960 pixels (= 240 scanning lines × 4 pixels) out of the 1200 vertically arranged pixels are used as effective signals and the remaining 240 pixels (= 1200 (all pixels) - 960 (effective pixels)) are not used for image forming. Figure 3 shows the timing of a vertical drive pulse for the image sensing device in this operation mode, with V1, V2 and V3 representing three phase drive pulses applied to each gate of the CCD or vertical transfer unit 32.

In Figure 3, in a period T1 included in the vertical blanking period, the drive pulse V2 is held high to transfer the signal charge accumulated in each pixel to under the V2 gate of the vertical CCD. Next, in a period T2, while the V2 pulse is still at middle level, the V3 pulse is raised from low level to middle level; next, while the V3 pulse is at middle level, the V2 pulse is changed from middle level to low level, after which the V1 pulse is changed from low level to middle level; next, while the V1 pulse is at middle level, the V3 pulse is changed from middle level to low level, after which the V2 pulse is changed to middle level and finally the V1 pulse is changed from middle level to low level. With this sequence of pulse operations, the signal charges under the V2 gate for one pixel row are transferred and held again under the V2 gate.

By repeating this series of operations, the signal charges for a desired number of pixel rows can be transferred. In Figure 3, during a period T3 included in the vertical blanking period before the vertical effective

scanning period (the vertical scanning period minus the vertical blanking period which corresponds to the actually displayed image) and during a period T4 included in the vertical blanking period after the vertical effective scanning period, the above transfer operation for one pixel row is repeated a total of 240 times to transfer the signal charges of the 240 pixel rows not used for image generation to the horizontal transfer unit 33 during the vertical blanking period. For example, if this transfer operation is performed 120 times during the period T3 and 120 times during the period T4, the signal charges from upper 120 pixel rows and lower 120 pixel rows on the light receiving surface are transferred to the horizontal transfer unit 33 during the period T3 and period T4 within the vertical blanking period. During each of the subsequent periods T5 and T6 in the vertical blanking period, the horizontal transfer unit 33 is driven for a predetermined period to output the charges transferred to the horizontal transfer unit 33 from the output terminal. These charges are not used as valid signals as they are output during the vertical blanking period.

Next, in the vertical effective scanning period of Figure 3, the above one-pixel-row transfer operation is performed four times during each horizontal blanking period to transfer the signal charges of four pixel rows to the horizontal transfer unit 33 where they are mixed together. Then, during a horizontal effective scanning period (the horizontal scanning period minus the horizontal blanking

period which corresponds to the actually displayed image), the horizontal transfer unit 33 is driven to read out the signal charges from the horizontal transfer unit to produce an output signal conforming to the television system. If the above operation is performed on the A field and if, on the B field, the number of pixel rows transferred during the period T3 is set to 122 rows and that during the period T4 is set to 118 rows, then the combination of four pixel rows to be cyclically mixed together shifts by two rows between the two fields, thus allowing the interlaced scanning to be performed as shown in Figure 4. (Figure 4 shows the light receiving surface of the image sensing device and its relation to the displayed screen is vertically inverted.)

Let us return to Figure 1. The output signal from the image sensing device 3 is adjusted in gain by the gain adjust circuit 5 and then converted by the A/D conversion circuit 6 into a digital signal. The digital signal is then processed by the signal processing circuit 7 that performs color signal processing and luminance signal processing, such as generation of color signals, gamma correction, white balance processing and outline enhancement. The image sensing device in this embodiment has an array of vertical stripes of yellow (Ye), green (G) and cyan (Cy) color filters, so the color signals for Ye, G and Cy are obtained as a series of color points from one line of output signals at all times no matter how many pixels are vertically combined. From these color signals three

primary color signals R, G, B can be obtained from the following calculations.

$$R = Ye - G$$

$$B = Cy - G$$

$$G = G$$

The R, G and B signals undergoes the white balance processing and gamma correction processing in the signal processing circuit 7 and are then converted into color difference signals such as R-Y, B-Y or U and V. The luminance signals and the color difference signals are then entered through the vertical interpolation circuit 8 into the horizontal interpolation circuit 9. In this operation state the signals just pass through the vertical interpolation circuit 8 without being processed. The horizontal interpolation circuit 9 performs interpolation on the signals in the horizontal direction.

Figure 5 shows the light receiving surface of the image sensing device. As described above, in the operating state of this embodiment, the signals read out during the vertical effective scanning period correspond to an area having 960 of the 1200 vertically arranged pixels and a horizontal width of 1600 pixels, as shown shaded at A in Figure 5. If the entire light receiving surface of the image sensing device has a 4-to-3 (width to height) aspect ratio, the shaded area A is more laterally elongate than this aspect ratio. Hence, if the signals of all horizontal pixels of the light receiving surface are displayed, for example, on an NTSC standard television monitor with the

4-to-3 aspect ratio, the image displayed is compressed horizontally and looks vertically elongate, compared with the original image. It is therefore necessary to output during the horizontal effective scanning period only those signals coming from a pixel area with the horizontal width conforming to the aspect ratio of the television system, as shown by a shaded area B. When the television system has an 4-to-3 aspect ratio, the number of pixels in the horizontal width of the shaded area B is 1280 (= 960 (vertical effective pixels) × 4/3).

Returning back to Figure 1, the horizontal interpolation circuit 9 performs interpolation processing on the signals from the horizontal 1280 pixels to expand the signals so that they can be output over the entire horizontal effective scanning period. It also performs switching among different clocks as required. With the above operation, an area having 960 pixels in height and 1280 pixels in width is demarcated from the light receiving surface as signals conforming to the television system. Then, the luminance signal and the color difference signal are encoded by the encoder circuit 12 into television signals, which are then converted by the D/A conversion circuit 13 into analog signals for output. When the recording is specified by the record button 15, the signals are recorded by the recording unit 10. At this time, the signals may be compressed in the MPEG (Moving Picture Expert Group) format.

Next, the image stabilizing operation will be

explained. Image-unstability information obtained by the gyro sensors 16a, 16b that detect vertical and horizontal image-unstabilities is entered into the image-unstability decision circuit 17, which checks the received information for the amount and direction of the image-unstability and converts them into the number of pixels in vertical and horizontal directions on the light receiving surface of the image sensing device. Based on the converted pixel numbers, the position of an extracted area (effective pixel area) on the light receiving surface is shifted in a direction that cancels the image-unstability. This can correct the image-unstability. The positional shifting of the extracted area is performed as follows. The shifting in the vertical direction can be made by changing the number of pixel rows transferred during the periods T3 and T4 in Figure 3 and the shifting in the horizontal direction made by changing the interpolation start position in the horizontal interpolation circuit 9.

The operation during the moving video mode has been described above. Next, the operation performed when the static image mode is selected by the mode selector switch 14 will be explained.

In the static image mode, too, until the recording is requested by the record button 15, the camera outputs signals compatible with the television system to monitor the angle of view. Unlike the moving video photographing, all of the effective pixels on the image sensing device are used in this embodiment during the still image

photographing to produce signals with as high a resolution as possible. Hence, during the monitoring the television signals need to be generated from the signals coming from the entire pixel area.

The image sensing device of this embodiment has 1200 vertically arranged pixels, and the number of lines of output signals from the image sensing device can be made to match the number of effective scanning lines of NTSC system, which is assumed to have 240 scanning lines, by vertically mixing five pixels (= 1200/240). To make the image sensing device operate in this manner, the one-pixel-row transfer operation is performed five times during each horizontal blanking period in the vertical effective scanning period shown in the pulse timing diagram of Figure 3. With this operation, the signal charges of five pixel rows can be mixed by the horizontal transfer unit 33. As for the transfer operations during the periods T3 and T4 in the vertical blanking period, because the interlaced scanning is carried out, only two pixel rows are transferred during the period T3 on the B field, with no transfer operations performed in other vertical blanking periods (In this embodiment, 1200/240 = 5 with no remainder produced, so no further transfer is necessary; if, however, a remainder occurs, the remaining pixels need only be transferred during the periods T3 and T4).

The charges mixed by the horizontal transfer unit 33 are read out by driving the horizontal transfer unit 33 during the horizontal effective scanning period. With the

above operations, the signal charges of all pixels on the image sensing device can be read out in a manner conforming to the television system. The output signal from the image sensing device 3 is, as during the moving image photographing, adjusted in gain by the gain adjust circuit 5 and converted by the A/D conversion circuit 6 into a digital signal, which is then subjected to the color signal processing and the luminance signal processing in the signal processing circuit 7 before being entered into the vertical interpolation circuit 8. During the static image monitoring, the vertical interpolation circuit 8 performs a vertical gravity center correction on the received signals.

Figure 6 shows combinations of pixels to be cyclically mixed on the A field and the B field and also the vertical position of the gravity center of the mixed signals. In the interlaced scanning, scanning lines of the A field and the B field are located at the centers of adjoining scanning lines on other field. Hence, the signal samplings in the camera system for the two fields must be 180 degrees out of phase in the vertical direction. In the operating state of this embodiment, however, because five pixels are mixed together, the gravity centers of the output signals for the A field and the B field are deviated 36 degrees (= 1/2 pixel or 1/10 the line-to-line distance on the same field) from the ideal sampling phase difference of 180 degrees, as shown in Figure 6. To correct this requires generating a signal from two adjoining output lines by interpolation. For example, if we let an nth

output line on a field be Sn and an (n+1)th output line on the same field be Sn+1, then a signal Sn' obtained by calculating Sn'=(Sn × 9/10) + (Sn+1 × 1/10) is one whose gravity center is shifted by 1/10 output line from the gravity center of the nth output line toward the (n+1)th output line. The above calculation can also be performed on the signals for the B field to correct the gravity center deviation of sampling. In this embodiment, however, to equalize the effects of interpolation of the A field and the B field, the following calculations are performed to correct the nth output line by 1/20 line toward the (n-1) line on the A field and by 1/20 line toward the (n+1)th line on the B field.

A field: Sn' = (Sn × 19/20) + (Sn-1 × 1/20)

B field: Sn' = (Sn × 19/20) + (Sn+1 × 1/20)

While this embodiment performs the interpolation based on the calculation of two adjoining lines of output signals, a greater number of lines may be used for the interpolation processing. The output signal of the vertical interpolation circuit 8 is supplied to the horizontal interpolation circuit 9, which in this operating state does nothing but passes the signal. Then, as in the case of the moving image photographing, the signal is encoded by the encoder circuit 12 into a television signal, which is then converted by the D/A conversion circuit 13 into an analog signal for output. As described above, the television signals can be generated from all of the pixel area of the image sensing device also during the static

image mode.

Next, the operation performed when the recording is requested by the record button 15 will be described. During the monitoring in the static mode, the signals are mixed together inside the image sensing device to reduce the number of signals and thereby generate television signals. During recording, however, the mixing processing is not performed and all the pixel signals need to be read out independently of each other in order to produce high resolution signals. To realize this, the one-pixel-row transfer operation is performed only once during each horizontal blanking period in the vertical effective scanning period shown in the pulse timing diagram of Figure 3. This causes only the signal charges for one pixel row to be transferred into the horizontal transfer unit 33, which is then driven to read out the signal charges for one pixel row. Repeating this operation the number of times equal to the number of vertically arranged pixel rows enables the signal charges of all pixel rows to be read out independently of each other. The transfer operation is not done during the periods T3 and T4 in the vertical blanking period.

The signal charges thus read out are adjusted in gain by the gain adjust circuit 5 and converted by the A/D conversion circuit 6 into digital signals, which are then subjected to the color signal processing and the luminance signal processing in the signal processing circuit 7, after which the signals are supplied through the vertical inter-

polation circuit 8 and the horizontal interpolation circuit 9 to the recording unit 10 where they are recorded. At this time, no interpolation processing is performed by the vertical interpolation circuit 8 or horizontal interpolation circuit 9. The recording unit 10 may compress the signals in the JPEG (Joint Photographic Expert Group) format, for example. Because during the static image recording, no television signal can be generated, an image immediately before starting the recording or a single color image is output as the television signal for monitoring purpose. With the above operation, high resolution signals obtained from all the pixels of the image sensing device can be recorded. Although in this embodiment the recording unit is used commonly for the moving video mode and for the static image mode, dedicated recording units may be provided separately for these modes.

As explained above, since there is no limit on the number of vertically arranged pixels in this embodiment, an image sensing device with a large enough pixel number even for still images can be used to photograph highly detailed still images and satisfactory moving images.

Further, the signal mixing and the vertical signal transfer during the vertical blanking period allow the signals from the image sensing device with a large number of pixels to be read out in a manner that conforms to the television system. This in turn can reduce image quality degradation and realize the moving image photo-

graphing with an image stabilizing function and the monitoring during still image photographing.

Only the output signals from that horizontal segment which virtually corresponds to the television system's aspect ratio with respect to the vertical segment are extracted and output over the entire horizontal effective scanning period of the television system. This ensures that the output signals obtained conform to the television system's aspect ratio regardless of the extracted vertical segment position.

Further, the image sensing device is driven in such a way as to shift the position of the pixels to be cyclically mixed together every display cycle of the television system in order to output interlaced signals. With this arrangement, the interlaced scanning can be performed even when an image sensing device with a large number of pixels is used.

Further, the output signals produced by the mixing are interpolated so that the gravity centers of the output signals interlaced every display cycle have a phase difference of 180 degrees in the vertical direction. This ensures that the interlaced output signals have no deviation from the ideal 180-degree phase difference during interlacing even when an interlace phase deviation would normally occur, as when odd numbered pixels are mixed together.

In this embodiment, the image sensing device has 1200 vertically arranged pixels, and four pixels are mixed

together during the moving video mode and five pixels during the static image mode. Because the area of image-stabilization pixels may or may not be used and set to any desire size, the number of pixels to be cyclically mixed together in each mode needs only to be equal to or less than the integral part of a quotient of the number of vertically arranged pixels divided by the number of television system's effective scanning lines (in the above example, 5 or less). (The number of vertically arranged pixels does not need to be divisible and, in the above example, may be more than 1200).

The number of vertically arranged pixels for static image photographing needs only to be three or more times the number of effective scanning lines on each field of the television system. In this embodiment the vertically adjoining pixels are mixed together to reduce the number of output lines from the image sensing device during the vertical effective scanning period. The number of lines of output signals can also be reduced by a so-called culling operation, by which only one line of signal charges of pixels is read out for every predetermined number of lines.

While in this embodiment the vertical transfer unit of the image sensing device is formed as a CCD that is driven by three phase pulses for each pixel, the image sensing device may have any desired structure as long as it can realize the mixing or culling of pixels that meets the above conditions.

Although this embodiment described the case of NTSC system, the invention can also be applied to other television systems, such as PAL standard, with different numbers of effective scanning lines.

In summary, a variety of constructions essentially equal in the working principle to this embodiment can be realized by the use of an image sensing device that has an arbitrary number of vertically arranged pixels N three or more times the number of effective scanning lines M of each field of the television system and which allows the vertical mixing or culling of that number of pixels which is at least one of integers equal to or less than the integral part of a quotient of N divided by M (a number of lines of output signals corresponds to 1/K the number of vertically arranged pixels N of the image sensing device).

Next, another embodiment of the present invention will be described by referring to Figure 7 showing the configuration of the embodiment. The configuration shown in Figure 7 differs from that of Figure 1 in that it has a view angle change switch 18. In Figure 7 constitutional elements identical with those shown in Figure 1 are assigned like reference numbers and explanations on the constitutional elements performing the same operations as those in Figure 1 are omitted here.

The operations of the moving video mode, the monitoring during the static image mode and the static image recording are similar in normal condition to the operations of the previous embodiment which was explained with reference to the configuration diagram of Figure 1. An operation performed when during the moving video mode a

request to change the angle of view is made by the view angle change switch 18 will be described.

In the normal condition of this embodiment, as explained in the previous embodiment, the mixing of four vertically arranged pixels, the vertical transfer during the vertical blanking period and the horizontal interpolation processing are performed to extract an area of 960 pixels in height and 1280 pixels in width from the entire pixel area to generate television signals. When a view angle change (which means a zooming function without image quality degradations in the vertical direction) is requested by the view angle change switch 18, three vertically arranged pixels are mixed together and the signals from the excess vertically arranged pixels are read out during the vertical blanking periods before and after the vertical effective scanning period.

In this embodiment, signals of 480 pixels (= 1200 - 240×3) or 160 lines of output signals after mixing (= 480/3) need to be read out during the vertical blanking period. This allows the signals of 720 vertically arranged pixels to be read out as 240 lines of output signals conforming to the television system. To carry out this reading requires, in the pulse timing diagram of Figure 3, transferring the signals of three pixel rows during each horizontal blanking period in the vertical effective scanning period and also transferring a total of 480 pixel rows (= 160 lines of output signals) during the T3 and T4 periods in the vertical blanking period. The combinations

of pixels to be cyclically mixed together are changed from one field to another to achieve the interlaced scanning.

The output signals of the image sensing device 3 are supplied to the gain adjust circuit 5. Because the signal level produced as a result of the 3-pixel mixing is 3/4 the signal level of the 4-pixel mixing, the again of the gain adjust circuit 5 is increased to 4/3 the gain of the 4-pixel mixing to make the 3- and 4-pixel-mixed input signal levels to the subsequent circuit equal. Then, the signals are processed by the A/D conversion circuit 6 and the signal processing circuit 7 before being supplied to the vertical interpolation circuit 8. The combinations of pixels to be cyclically mixed on the A field and the B field and the vertical positions of the gravity centers of the mixed signals are shown in Figure 8. As in the static image monitoring of the previous embodiment, the phase difference between the two fields is 180 degrees. Because the sampling phases of the fields are deviated from the ideal 180-degree phase difference, the vertical position of the gravity centers are corrected by the vertical interpolation circuit 8. The amount of phase deviation in this operating state is 60 degrees (= 1/2 pixel or 1/6 the line-to-line distance on the same field). To correct the phase deviation evenly on the both fields, the following calculations should be performed.

A field: $Sn' = (Sn \times 11/12) + (Sn-1 \times 1/12)$

B field: $Sn' = (Sn \times 11/12) + (Sn+1 \times 1/12)$

As described earlier, the interpolation process-

ing may use three or more output lines. Next, the horizontal interpolation circuit 9 horizontally expands the signals from that horizontal segment which corresponds to the 4-to-3 aspect ratio with respect to the 720 vertically arranged pixels (i.e., signals from a horizontal 960-pixel segment (=1600 × 720/1200) in this operating state) so that the expanded signals can be output during the entire horizontal effective scanning period. With the above operation, an area of 720 pixels in height and 960 pixels in width can be extracted from the light receiving surface.

Next, when the view angle change is requested again by the view angle change switch 18, two vertically arranged pixels are mixed together, an area of 480 vertically arranged pixels is read out during the vertical effective scanning period, and the horizontal interpolation circuit 9 expands the signals from the horizontal 640-pixel segment and outputs the expanded signals during the entire horizontal effective scanning period to extract an area of 480 pixels in height and 640 pixels in width. (During the two-pixel mixing, because the interlace phase deviation does not occur, the gravity center position correction by the vertical interpolation circuit 8 is not performed.) If a further view angle change is requested by the view angle change switch 18, the operation is restored to a normal state where four vertically arranged pixels are mixed together.

As a result of the above operation, the area extracted from the light receiving surface of the image

sensing device can be changed to three different areas: (A) 960 pixels high by 1280 pixels wide, (B) 720 pixels high by 960 pixels wide and (C) 4880 pixels high by 640 pixels wide. That is, the angle of view can be changed to three different angles. With the area A produced by the 4-pixel mixing taken as a reference, the area B produced by the 3-pixel mixing can provide an image enlarged by 1.33 times and the area C produced by the 2-pixel mixing can provide an image enlarged by two times. It should be noted here that because the three different areas are chosen by changing the number of pixel to be cyclically mixed together in order to make the number of the effective output lines from the imaging device agree with the number of the effective scanning lines of the television system, the angle of view can be changed while maintaining a good image with no image quality degradation in the vertical direction, when compared with an ordinary so-called digital zoom which generates effective scanning lines of signals by interpolating a small number of output lines. During the monitoring of a static image, too, it is possible to perform the similar operation of changing the angle of view by changing the number of pixel rows to be cyclically mixed together.

As described above, in addition to the advantages provided by the previous embodiment, this embodiment can also realize the view angle change with little image quality degradation even for still images by using an image sensing device with a large number of pixels and changing

the number of pixels to be cyclically mixed together.

Further, because changes in signal level caused when the number of pixels to be cyclically mixed is changed are absorbed by the gain adjust means, the input signal level to the subsequent signal processing means can be kept constant.

While in this embodiment, the view angle change is performed by the view angle change switch 18, the angle of view may be changed continuously by a zoom switch. In this case, when the magnification factor does not reach the value that is obtained by changing the pixel mixing, the digital zoom performs the ordinary interpolation processing. In this embodiment, when the magnification factor is 1 or more and less than 1.33, the 4-pixel mixing is performed; for the factor of 1.33 or more and less than 2, the 3-pixel mixing is done; and for the factor of 2 or higher, the 2-pixel mixing is carried out. The mixing operation may be interlocked with an optical zooming mechanism.

Regardless of the number of pixels in the image sensing device, the structure of the image sensing device or the television system employed, this embodiment, as in the previous embodiment, may also use an image sensing device that has an arbitrary number of vertically arranged pixels N three or more times the number of effective scanning lines M of each field and which allows the vertical mixing or culling of those numbers of pixels which are at least two of integers equal to or less than the integral

part of a quotient of N divided by M. The use of this image sensing device can form a variety of constructions essentially equal in the working principle to this embodiment.

Next, a further embodiment of the present invention will be described. The overall configuration of this embodiment is similar to that of Figure 1, except that the inner structure of the image sensing device 3 is different. The configuration of the image sensing device in this embodiment is shown in Figure 10. In Figure 10, denoted 30 are pixels formed of photodiodes, which are arranged horizontally and vertically in a grid pattern. On these grid-arrayed pixels three types of color filters that pass yellow (Ye), green (G) and cyan (Cy), respectively, are arranged in so-called vertical stripes.

In this embodiment, the image sensing device has an array of pixels measuring 864 pixels vertically and 1152 pixels horizontally. A vertical transfer unit 32 is a CCD which is driven by six phase pulses V1, V2, V3, V4, V5, V6. This CCD has a two-gate structure in which each pixel corresponds to two phase pulses and six gates corresponding to the six phase pulses are repeated for every three pixels. Transfer gates 31 for transferring the signal charge of each pixel to the vertical transfer unit 32 are commonly connected to respective gates of the vertical transfer unit 32 corresponding to the pulses V1, V3, V5. An operation to transfer the signal charge from each pixel to the vertical transfer unit 32 in response to peak values

of pulses applied to the commonly connected gates and an operation to transfer the charge vertically are performed separately.

A horizontal transfer unit 33 horizontally transfers the charges supplied from the vertical transfer units 32 and outputs them successively through an output amplifier 34 from the output terminal. This image sensing device, unlike the one in the previous embodiment, cannot vertically transfer all pixels independently of each other, but can mix together the signal charges of three vertically adjoining pixels inside the vertical transfer unit 32 before transferring them.

First, the operation performed in this embodiment during the moving video mode will be explained. In the image sensing device of this embodiment the effective number of vertically arranged pixels is 864. If three pixels are vertically mixed, the signals of the 720 (=240×3) of the 864 vertically arranged pixels can be used as the effective signals and the remaining 144 (= 864 - 720) pixels can be used as the image-unstability correction pixel area.

Figure 11 shows the timings of vertical drive pulses for the image sensing device of Figure 10 during this operation mode, with V1, V2, V3, V4, V5, V6 representing the six phase drive pulses applied to the respective gates of the CCD or vertical transfer unit 32. In Figure 11, during a period T1 included in the vertical blanking period, the drive pulses V1, V3 and V5 are held high to

cause the signal charge of each pixel to be transferred to under the V1, V3 and V5 gates of the vertical CCD. Then, the V2 and V4 pulses are changed from low level to middle level to mix the charges of the adjoining three pixels. After the mixing, the V5 pulse is changed from middle level to low level to hold the mixed signal charges under the V1, V2, V3, V4 gates.

Next, a series of operations performed during a period T2 (changing the drive pulses from middle level to low level or from low level to middle level in the order of V1, V2, V3, V4, V5 and V6) causes one mixed output line (3 pixel rows) to be transferred and held again under the V1, V2, V3, V4 gate. By repeating this series of operations, a desired number of output lines of mixed signal charges can be transferred.

In Figure 11, during a period T3 included in the vertical blanking period before the vertical effective scanning period and during a period T4 included in the vertical blanking period after the vertical effective scanning period, the transfer operation for one output line is repeated a total of 144 times to transfer 144 output lines of signal charges not used for image forming to the horizontal transfer unit 33 at high speed during the vertical blanking periods. During subsequent periods T5 and T6 in the vertical blanking periods, the horizontal transfer unit 33 is driven for predetermined periods to output the signal charges transferred to the horizontal transfer unit 33 from the output terminal.

Next, in the vertical effective scanning period of Figure 11, the one-output-signal-line transfer operation is performed during each horizontal blanking period. Then, during the horizontal effective scanning period, the horizontal transfer unit 33 is driven to read out the signal charges from the horizontal transfer unit 33. With this operation the signal charges of three pixels mixed together can be read out in a way conforming to the television system. As shown in Figure 11, the signals for the A field are mixed by changing the V2 and V4 pulses to middle level after transferring the signals from the pixels to the vertical transfer unit 32. The signals for the B field, on the other hand, are mixed by changing the V2 and V6 pulses to middle level. With this mixing method, the combinations of pixels to be cyclically mixed together can be changed from one field to another, thereby realizing the interlaced scanning. The output signals from the image sensing device are processed in the similar manner to that of the previous embodiment. A vertical interpolation circuit 8 performs the gravity center correction, as in the 3-pixel mixing in the previous embodiment, and a horizontal interpolation circuit 9 performs interpolation processing to match the aspect ratio with that of the television system.

Next, the operation during the monitoring in the static image mode will be explained. It is assumed that the still image photographing is done by using all effective pixels of the image sensing device, as in the previous

embodiment. The image sensing device of this embodiment has 864 vertically arranged pixels and, when 3-pixel mixing is done as in the moving video taking, the number of output lines is 288 (=864/3), which means that these signal lines cannot be read out in a manner conforming to the television system. Hence, during the monitoring in the static image mode, vertical 6-pixel mixing is performed. The 6-pixel mixing can be achieved by transferring to the horizontal transfer unit 33 in each horizontal blanking period two output lines of signal charges each of which line has been generated by vertically mixing three pixels within the vertical transfer unit 32. The 6-pixel mixing can reduce the number of output lines from the image sensing device down to 144 (= 864/6) lines. The output signals of the image sensing device that were reduced to 144 output lines are interpolated by the vertical interpolation circuit 8 to transform the 144 output lines of signals into 240 lines of signals, which conform to the television system. To generate 240 lines of signals from the 144 lines requires interpolation processing that generates five lines from three lines (144/240 = 3/5).

Figure 12 shows how the interpolation is performed using two adjoining output lines. Let three output lines of the image sensing device be n, n+1 and n+2. The five output lines of signals can be generated from the following calculations.

$$n' = n$$

$$n' + 1 = n/2 + (n+1)/2$$

$$n' + 2 = n + 1$$

$$n' + 3 = (n+1)/2 + (n+2)/2$$

$$n' + 4 = n + 2$$

Three or more output lines of signals may be used for interpolation processing. With the above operation, television signals can be generated by using signals of all pixels of the image sensing device also during the monitoring in the static image mode.

Next, the operation performed when the recording is requested by the record button 15 will be explained. In the recording process, the mixing processing is not performed and signals of all pixels need to be read independently of each other in order to obtain high-resolution signals. To realize this, the aperture 2 is first closed and then, during the period T2 in the pulse timing diagram of Figure 11, only the V1 pulse is raised to high level to transfer the signal charge of only the pixel adjacent to the V1 gate to the vertical transfer unit 32. Then, the vertical transfer unit 32 and the horizontal transfer unit 33 are successively driven to read out the signal charges. Similarly, the V3 pulse is raised to high level to read the signal charge of the pixel adjacent to the V3 gate, followed by raising the V5 pulse to high level to read the signal charge of the pixel adjacent to the V5 gate. With the above processing, the signal charges of all pixels can be read out independently in three successive operations. The signal charges thus read out are recorded in the recording unit 10. At this time, they are

rearranged properly to reconstruct the pixel arrangement on the light receiving surface of the image sensing device.

As described above, this embodiment offers the following advantages. If the number of vertically arranged pixels is not an integral multiple of the number of scanning lines of the television system, the signals conforming to the television system can be generated from the whole area of effective pixels by performing the pixel mixing and the vertical interpolation.

In this embodiment, as in the previous embodiment, regardless of the number of pixels in the image sensing device, the structure of the image sensing device or the television system employed, a variety of constructions essentially equal in the working principle to this embodiment can be realized by using an image sensing device that has an arbitrary number of vertically arranged pixels N three or more times the number of effective scanning lines M of each field and which allows the vertical mixing or culling of that number of pixels which is greater by at least one than the integral part of a quotient of N divided by M.

Next, a further embodiment of the present invention will be explained. This embodiment differs from the previous embodiments in that the image sensing device have different arrangements of color filters. Figures 13A and 13B show arrangements of color filters in this embodiment. These color filters in both examples are arranged in vertical stripes and, regardless of the number of pixels to

be vertically mixed or culled, the R, G, B primary color signals can be generated from one line of output signals. Figure 13A shows a color filter arrangement on the image sensing device in which white filters (W = passing all colors) are used instead of the green (G) filters used in the previous embodiment. The R, G, B signals can be obtained by the following calculations.

$$R = W - Cy$$

$$G = Ye + Cy - W$$

$$B = W - Ye$$

When this color filter arrangement is used, a higher sensitivity can be obtained than the color filter arrangement of the previous embodiment. Figure 13B show a color filter arrangement that uses, in stead of complementary colors, color filters that pass the primary colors R, G, B. This color filter arrangement can directly produce the primary color signals, R, G, B and can provide a camera with good color purity and good color S/N.

With the above color filter arrangements, it is possible to produce color signals corresponding to the three kinds of color filters from each line of output signals at all times no matter how many pixels are vertically mixed or culled. Therefore, color signals conforming to the television system can be generated easily.

CLAIMS:

1. An electric camera comprising:

an image sensing device with a light receiving surface having N vertically arranged pixels and an arbitrary number of pixels arranged horizontally, N being equal to or more than three times the number of effective scanning lines M of a display screen of a television system;

a driver to drive the image sensing device to vertically mix or cull signal charges accumulated in individual pixels of every K pixels to produce a number of lines of output signals which corresponds to the number of effective scanning lines M, K being at least one of integers equal to or less than an integral part of a quotient of N divided by M; and

a signal processing unit to generate image signals by using the out put signals of the image sensing device.

ABSTRACT OF THE DISCLOSURE:

An electric camera includes an image sensing device with a light receiving surface having N vertically arranged pixels and an arbitrary number of pixels arranged horizontally, N being equal to or more than three times the number of effective scanning lines M of a display screen of a television system, a driver to drive the image sensing device to vertically mix or cull signal charges accumulated in individual pixels of K pixels to produce, during a vertical effective scanning period of the television system, a number of lines of output signals which corresponds to 1/K the number of vertically arranged pixels N of the image sensing device, K being an integer equal to or less than an integral part of a quotient of N divided by M, and a signal processing unit having a function of generating image signals by using the output signals of the image sensing device.

FIG.1

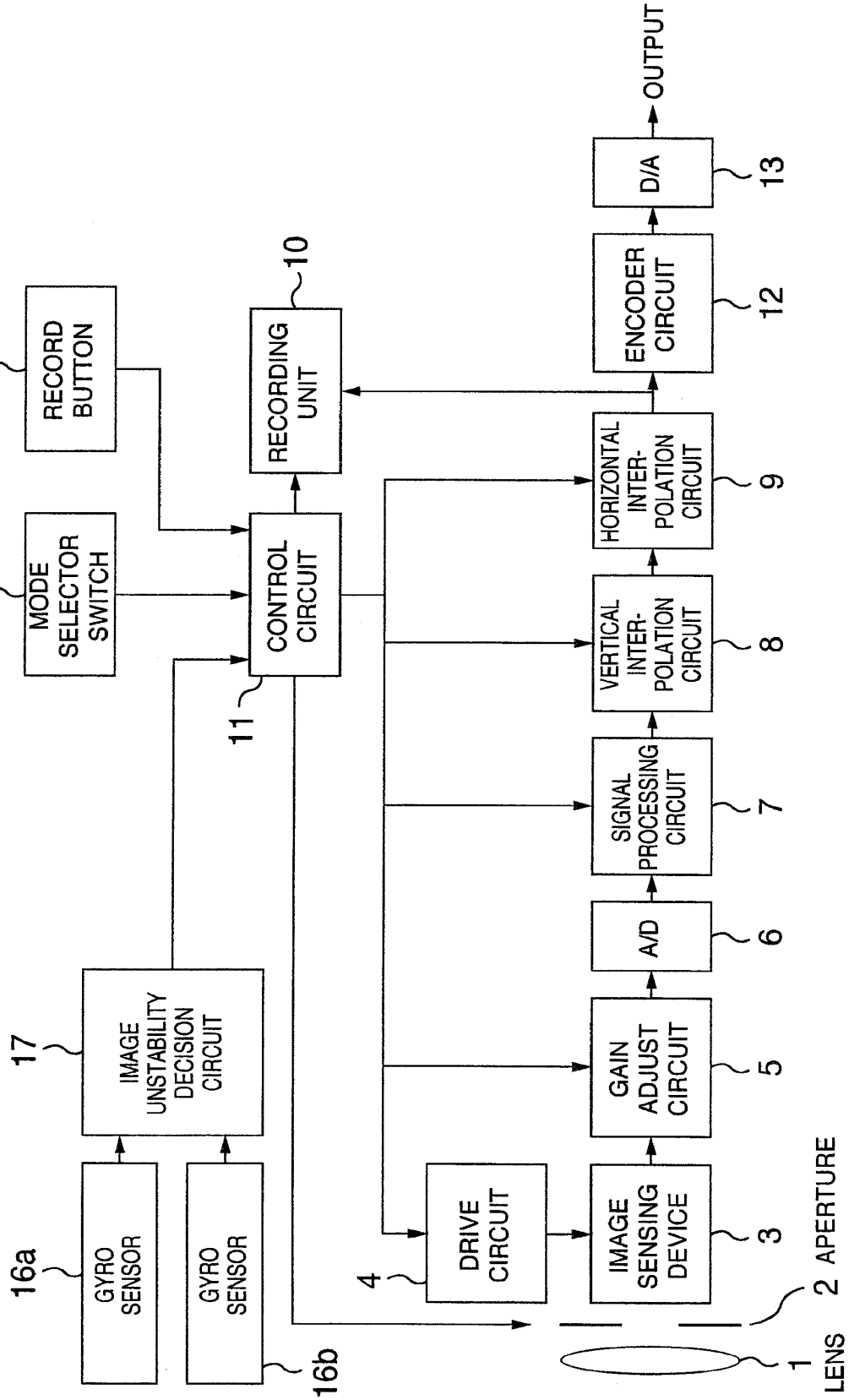

LENS
1
APERTURE
2
IMAGE SENSING DEVICE
3
DRIVE CIRCUIT
4
GAIN ADJUST CIRCUIT
5
A/D
6
SIGNAL PROCESSING CIRCUIT
7
VERTICAL INTER-POLATION CIRCUIT
8
HORIZONTAL INTER-POLATION CIRCUIT
9
RECORDING UNIT
10
CONTROL CIRCUIT
11
ENCODER CIRCUIT
12
D/A
13
OUTPUT
RECORD BUTTON
15
MODE SELECTOR SWITCH
14
IMAGE UNSTABILITY DECISION CIRCUIT
17
GYRO SENSOR
16a
GYRO SENSOR
16b

FIG.2

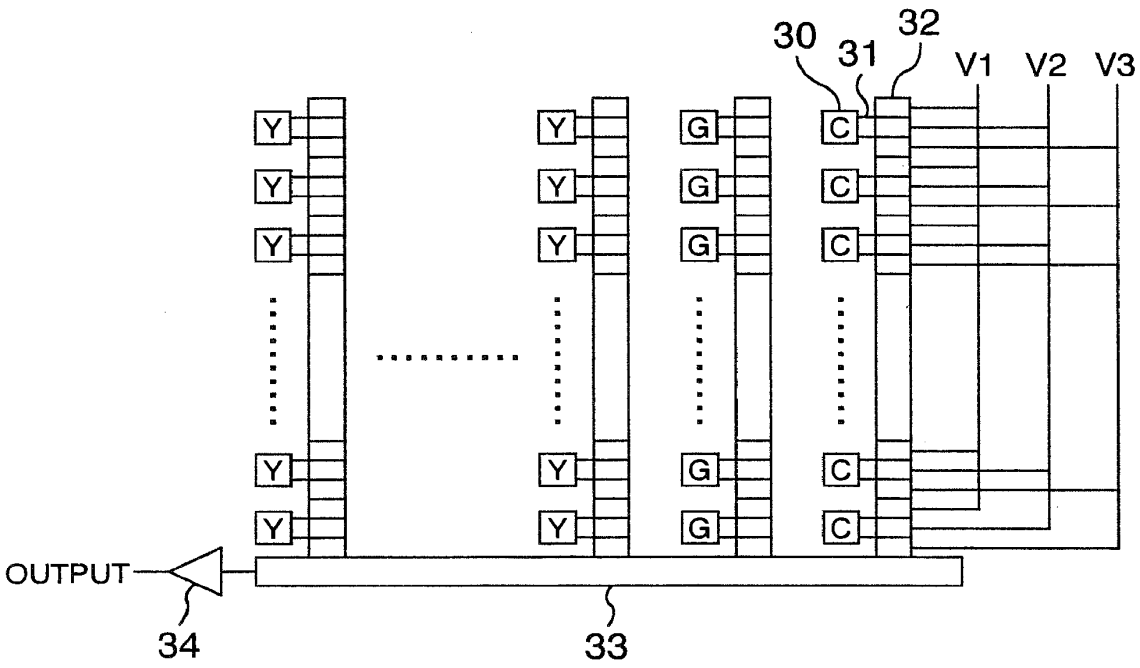

30
31
32
V1
V2
V3
Y
G
C
OUTPUT
34
33

FIG.4

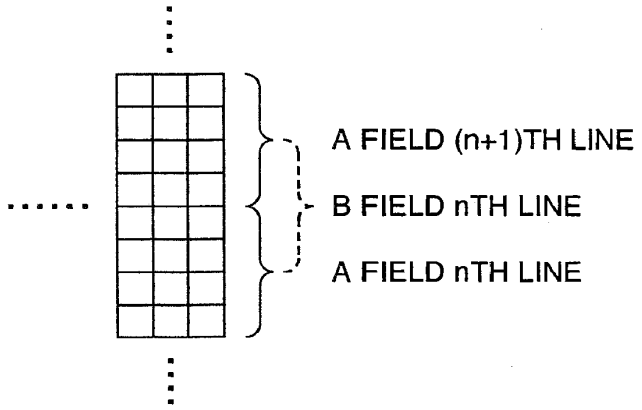

A FIELD (n+1)TH LINE
B FIELD nTH LINE
A FIELD nTH LINE

FIG.3

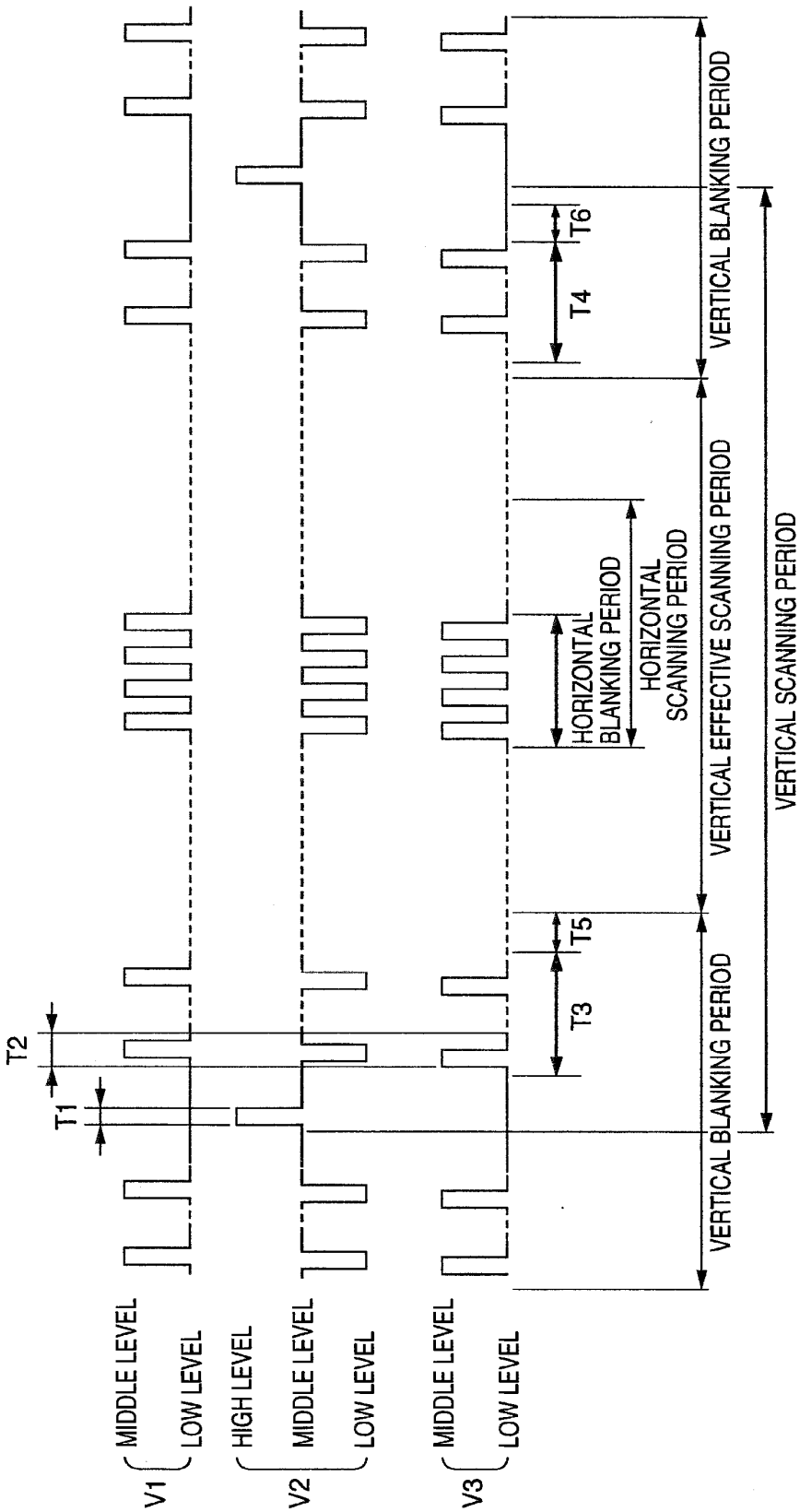

V1
MIDDLE LEVEL
LOW LEVEL
V2
HIGH LEVEL
MIDDLE LEVEL
LOW LEVEL
V3
MIDDLE LEVEL
LOW LEVEL
T1
T2
T3
T4
T5
T6
HORIZONTAL BLANKING PERIOD
HORIZONTAL SCANNING PERIOD
VERTICAL BLANKING PERIOD
VERTICAL EFFECTIVE SCANNING PERIOD
VERTICAL BLANKING PERIOD
VERTICAL SCANNING PERIOD

FIG.5

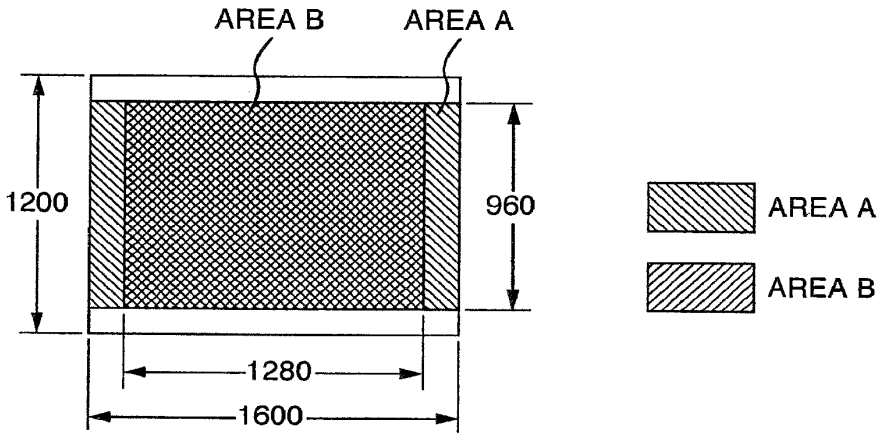

AREA B
AREA A
1200
960
1280
1600
AREA A
AREA B

FIG.6

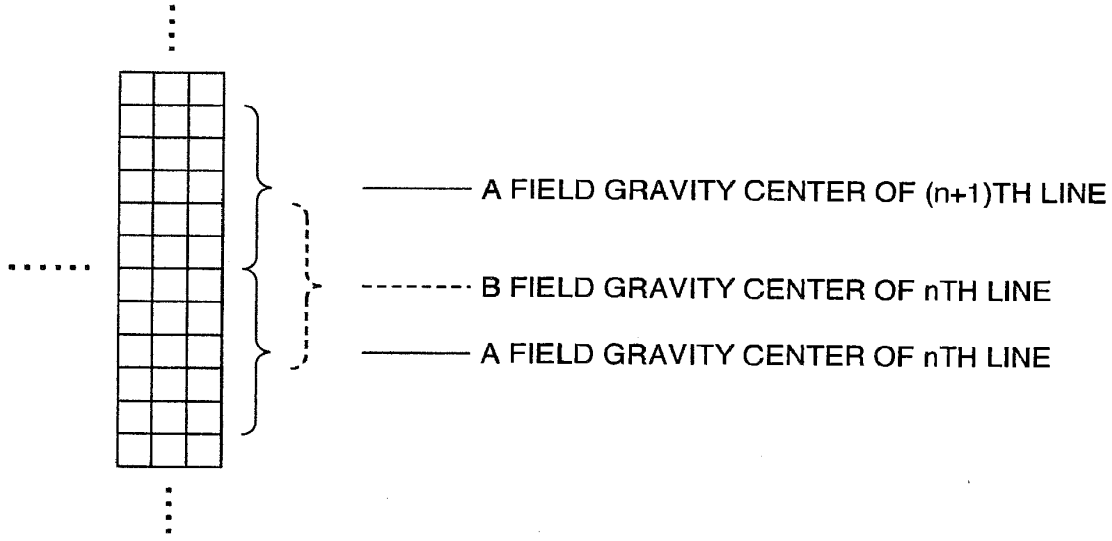

A FIELD GRAVITY CENTER OF (n+1)TH LINE
B FIELD GRAVITY CENTER OF nTH LINE
A FIELD GRAVITY CENTER OF nTH LINE

FIG.7

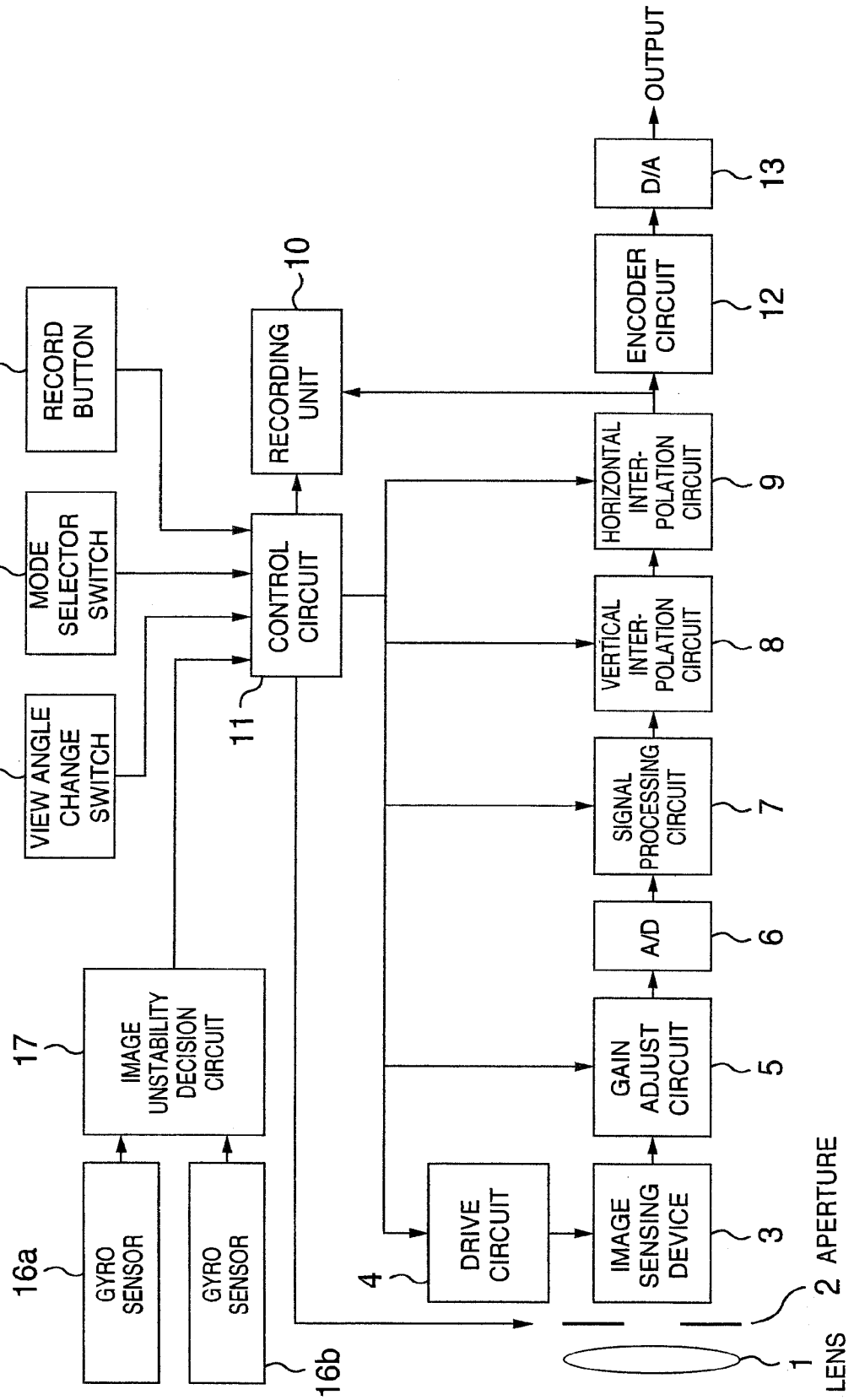

LENS
1
APERTURE
2
IMAGE SENSING DEVICE
3
DRIVE CIRCUIT
4
GAIN ADJUST CIRCUIT
5
A/D
6
SIGNAL PROCESSING CIRCUIT
7
VERTICAL INTER-POLATION CIRCUIT
8
HORIZONTAL INTER-POLATION CIRCUIT
9
RECORDING UNIT
10
CONTROL CIRCUIT
11
ENCODER CIRCUIT
12
D/A
13
OUTPUT
RECORD BUTTON
15
MODE SELECTOR SWITCH
14
VIEW ANGLE CHANGE SWITCH
18
IMAGE UNSTABILITY DECISION CIRCUIT
17
GYRO SENSOR
16a
GYRO SENSOR
16b

FIG.8

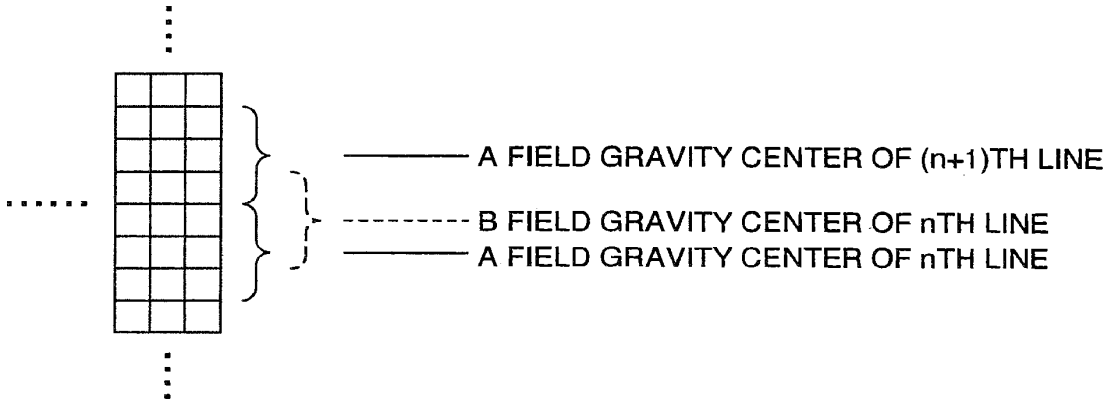

A FIELD GRAVITY CENTER OF (n+1)TH LINE
B FIELD GRAVITY CENTER OF nTH LINE
A FIELD GRAVITY CENTER OF nTH LINE

FIG.9

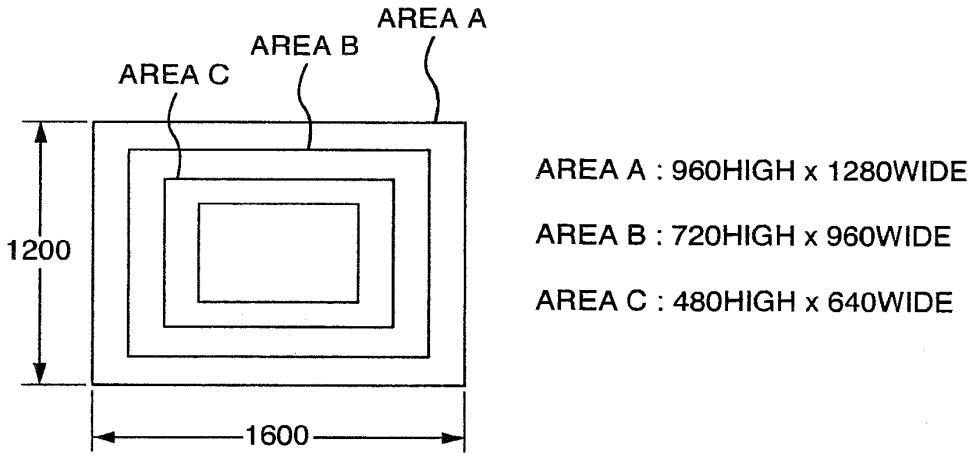

AREA A
AREA B
AREA C
1200
1600
AREA A : 960HIGH x 1280WIDE
AREA B : 720HIGH x 960WIDE
AREA C : 480HIGH x 640WIDE

FIG.10

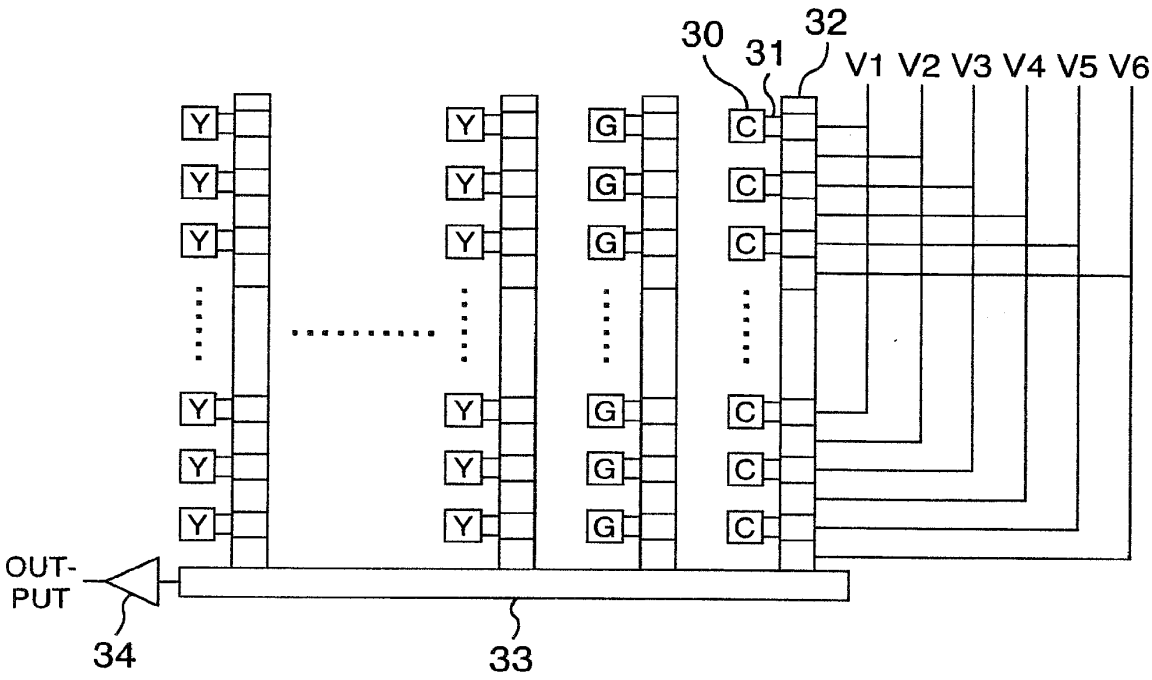


FIG.12

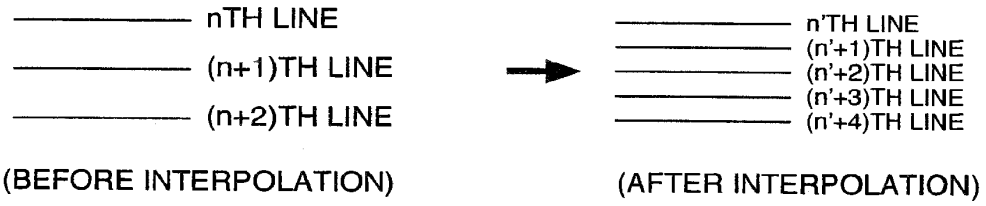


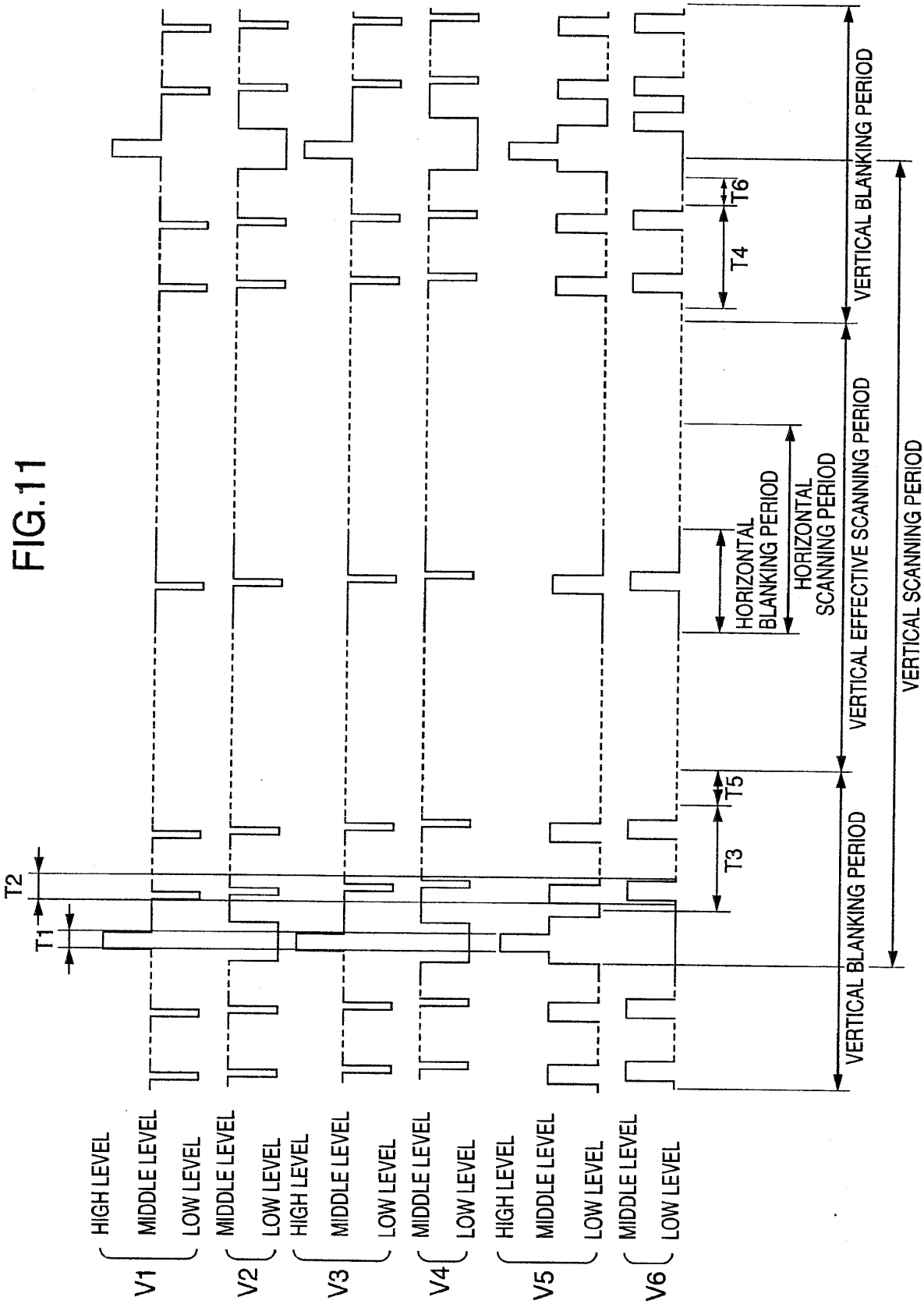
FIG.13A

Ye	W	Cy
Ye	W	Cy
Ye	W	Cy
Ye	W	Cy
Ye	W	Cy

FIG.13B

R	G	B
R	G	B
R	G	B
R	G	B
R	G	B

FIG.11


V1
V2
V3
V4
V5
V6
HIGH LEVEL
MIDDLE LEVEL
LOW LEVEL
T1
T2
T3
T4
T5
T6
HORIZONTAL BLANKING PERIOD
HORIZONTAL SCANNING PERIOD
VERTICAL BLANKING PERIOD
VERTICAL EFFECTIVE SCANNING PERIOD
VERTICAL BLANKING PERIOD
VERTICAL SCANNING PERIOD

E5037-05

申請データシート(37 CFR 1.76)を使った実用及び意匠登録出願宣言書(37 CFR 1.63)

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

発明の名称 Title of Invention	ELECTRIC CAMERA

下記発明者である私は、つぎのことがらを宣言します。

As the below named inventor, I hereby declare that:

本宣言は

This declaration is directed to:

☐ 添付されている、あるいは
The attached application, or

_____に、米国出願あるいは PCT 国際出願番号_____として出願されているものに宛てられています。

☒ United States application or PCT international application number 13/681495 fled on November 20, 2012 .

上記の出願は私自身、あるいは私が権限を譲与したものによって行われたものです。

The above-identified application was made or authorized to be made by me.

私は本出願書中にあらわれるもともとの発明者、あるいはもともとの共同発明者です。

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

私は本宣言書において故意に虚偽の申し立てを行った場合は 18 U.S.C. 1001 により、罰金あるいは最高五(5)年の禁固刑、あるいはその両方による罰則の対象となることを認めます。

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

私は、特許請求の範囲を含む上記の明細書を確認し内容を理解しています。

I have reviewed and understand the contents of the above-identified application, including the claims.

私は、連邦規則法典第 37 編規則 1.56 に定義されている、特許性について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

発明者の正式氏名:
LEGAL NAME OF INVENTOR: Takahiro NAKANO

署名:
Signature: Takahiro Nakano

日付(任意):
Date (Optional): Dec. 17, 2012

備考:出願データシート(PTO/AIA/14 あるいはその同等用紙)は、発明の自主独立体全体の命名を含め、本用紙に添付すること。なお残余の発明者ごとにこの用紙の写しを使用する。

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional copy of the present form for each additional inventor.

E 5037-05

申請データシート(37 CFR 1.76)を使った実用及び意匠登録出願宣言書(37 CFR 1.63)

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私は本宣言書において故意に虚偽の申し立てを行った場合は 18 U.S.C. 1001 により、罰金あるいは最高五(5)年の禁固刑、あるいはその両方による罰則の対象となることを認めます。
I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

私は、特許請求の範囲を含む上記の明細書を確認し内容を理解しています。
I have reviewed and understand the contents of the above-identified application, including the claims.

私は、連邦規則法典第 37 編規則 1.56 に定義されている、特許性について重要な情報を開示する義務があることを認めます。
I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

発明者の正式氏名:
LEGAL NAME OF INVENTOR: Ryuji NISHIMURA

署名:
Signature: Ryuji Nishimura

日付(任意):
Date (Optional): Dec. 18 / 2012

備考:出願データシート(PTO/AIA/14 あるいはその同等用紙)は、発明の自主独立体全体の命名を含め、本用紙に添付すること。なお残余の発明者ごとにこの用紙の写しを使用する。
Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional copy of the present form for each additional inventor.

F5037-05

申請データシート(37 CFR 1.76)を使った実用及び意匠登録出願宣言書(37 CFR 1.63)

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

発明の名称 Title of Invention	ELECTRIC CAMERA

下記発明者である私は、つぎのことがらを宣言します。
As the below named inventor, I hereby declare that:

本宣言は
This declaration is directed to:

☐ 添付されている、あるいは
The attached application, or

_____に、米国出願あるいは PCT 国際出願番号_____として出願されているものに宛てられています。

☒ United States application or PCT international application number 13/681495 filed on November 20, 2012 .

上記の出願は私自身、あるいは私が権限を譲与したものによって行われたものです。
The above-identified application was made or authorized to be made by me.

私は本出願書中にあらわれるもともとの発明者、あるいはもともとの共同発明者です。
I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

私は本宣言書において故意に虚偽の申し立てを行った場合は 18 U.S.C. 1001 により、罰金あるいは最高五(5)年の禁固刑、あるいはその両方による罰則の対象となることを認めます。
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I have reviewed and understand the contents of the above-identified application, including the claims.

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I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

発明者の正式氏名:
LEGAL NAME OF INVENTOR: Toshiro KINUGASA

署名:
Signature: Toshiro Kinugasa

日付(任意):
Date (Optional): 12/19/12

備考:出願データシート(PTO/AIA/14 あるいはその同等用紙)は、発明の自主独立体全体の命名を含め、本用紙に添付すること。なお残余の発明者ごとにこの用紙の写しを使用する。
Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional copy of the present form for each additional inventor.

CERTIFICATE OF TRANSLATION

I, the below-named translator, of 6-6, Marunouchi 1-chome, Chiyoda-ku, Tokyo, Japan hereby declare that I am conversant with the Japanese and English languages and that to the best of my knowledge and belief the attached Declaration includes a true and accurate translation into English of the Japanese text contained in the Declaration.

Dated July 17, 2014 Signature of Translator: Takeshi Kanai

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	To be assigned
Filing Date	December 21, 2016
First Named Inventor	T. NAKANO
Title	ELECTRIC CAMERA
Art Unit	
Examiner Name	
Attorney Docket Number	ASA-9606-08

SIGNATURE of Applicant or Patent Practitioner

Signature	/JOHN R. MATTINGLY/	Date (Optional)	December 21, 2016
Name	JOHN R. MATTINGLY	Registration Number	30293
Title (if Applicant is a juristic entity)	ATTORNEY		
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Doc Code: PA
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
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出願人による委任状
POWER OF ATTORNEY BY APPLICANT

私はここに、添付の伝送書もしくは下記枠内で特定された出願に対して、現時点より前に与えられたすべての委任状を破棄します。
I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

出願番号 Application Number	出願日 Filing Date

(注記：PTO/AIA82Aに同じ情報が明記されている場合、上の枠内は空欄でも可)
(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ 私は、下記顧客番号に関連する特許弁護士を、当方の弁護士あるいは代理人に指名し、添付の伝送書（PTO/ATA/82A）内もしくは上記に記載の特許出願に関連した米国特許商標庁との業務の全てを同弁護士あるいは代理人に委任します。
I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 24956

又は
OR

☐ 私は、添付のリスト(PTO/ATA/82C)に記載の特許弁護士を、当方の弁護士あるいは代理人に指名し、添付の伝送書（PTO/ATA/82A）内もしくは上記に記載の特許出願に関連した米国特許商標庁との業務の全てを同弁護士あるいは代理人に委任します。（注記: PTO/AIA/82C を記入すること。）
I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

添付の伝送書又は上記枠内にて特定された出願に対する郵便物送付先を下記のいずれかに登録または変更してください。
Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ 上記顧客番号に付随する住所
The address associated with the above-mentioned Customer Number

又は
OR

☐ 顧客番号に付随する住所
The address associated with Customer Number:

又は
OR

事務所または個人名 Firm or Individual Name					
住所 Address					
市 City		州 State		郵便番号 Zip	
国 Country					
電話番号 Telephone		メールアドレス Email			

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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出願人による委任状
POWER OF ATTORNEY BY APPLICANT

私は出願人であり（出願人が法人の場合、出願人名を下記枠内に記入）：
I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

HITACHI MAXELL, LTD.

☐ 発明者もしくは共同発明者である（下記役職の明記は不要）
Inventor or Joint Inventor (title not required below)

☐ 死亡したもしくは成年被後見人である発明者の法定代理人である（下記役職の明記は不要）
Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ 被譲渡人もしくは発明者が譲渡する義務を負う人物である
Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ 上記以外で、十分な独占的所有権を示す人物である（例：37 CFR 1.46(b)(2)に基づく申請が本出願において認められた、又は本書類と共にその申請がなされている場合）（出願人が法人の場合、署名者の役職を明記すること）
Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

特許出願人の署名
SIGNATURE of Applicant for Patent

下記署名者（役職は下記に記載）は出願人の代理人と認められている（出願人が法人の場合等）
The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

署名 Signature	Yoshihiro Senzai	署名日（任意） Date (Optional)	27/08/2014
氏名 Name	Yoshihiro SENZAI		
役職 Title	President & Chief Executive Officer, HITACHI MAXELL, LTD.		

注記: 署名　本書類は37 CFR 1.33に基づき署名されなければならない。署名の要件および証明に関しては37 CFR 1.4を参照。出願人が複数いる場合は、複数の書類を使うこと。
NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ 提出書類　計＿＿＿＿＿枚。
Total of _____ forms are submitted.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly/Krista Hargrove
Attorney Docket Number:	ASA-9606-08

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	280	280
UTILITY SEARCH FEE	1111	1	600	600
UTILITY EXAMINATION FEE	1311	1	720	720
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1600**

Electronic Acknowledgement Receipt	
EFS ID:	27860037
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly
Filer Authorized By:	
Attorney Docket Number:	ASA-9606-08
Receipt Date:	21-DEC-2016
Filing Date:	
Time Stamp:	15:13:23
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1600
RAM confirmation Number	122216INTEFSW15140000
Deposit Account	501417
Authorized User	Krista Hargrove
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	9606-08-ads.pdf	1793627 afbd9bb4bc399e4b8e65bdae5882fc0f1a63404a	no	9
Warnings:					
Information:					
2	Transmittal Letter	9606-08-NoticeRelatedPatentsLitigation.pdf	17315 7c44fe9a65207c14c1ab86d63c10f1900483dd46	no	1
Warnings:					
Information:					
3	Transmittal Letter	9606-08-IDS.pdf	16003 624e949ed377d4414c6cfac211a9936c72f7761f	no	2
Warnings:					
Information:					
4	Information Disclosure Statement (IDS) Form (SB08)	9606-08-SB08.pdf	613282 64fd19b407122f247a5c4bdec5d47bdee01c0957	no	6
Warnings:					
Information:					
5	Preliminary Amendment	9606-08-prelim.pdf	18598 3634bb72812f1d80e4ba8bfa96e619b88c127711	no	3
Warnings:					
Information:					
6		9606-08-spec.pdf	2386723 7e55bb95bcb62d26917c8db279a93ca13d6ca766	yes	40
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	

	Specification		1	38	
	Claims		39	39	
	Abstract		40	40	
Warnings:					
Information:					
7	Drawings-only black and white line drawings	9606-08-drawings.pdf	195922 6182feb1f3a8bb9581b75b10e012918c47013fa3	no	8
Warnings:					
Information:					
8	Oath or Declaration filed	9606-08-AIA-declarations.pdf	225995 8967b89f7744acc370f51df6695e92adc2262e0a	no	4
Warnings:					
Information:					
9	Power of Attorney	9606-08-POA.pdf	243513 65d3fb76c49ae79fb9d189ed60fb218f66ee676c	no	4
Warnings:					
Information:					
10	Fee Worksheet (SB06)	fee-info.pdf	34790 f10435df735d309d112fde88db555259dec4d1ec	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	5545768		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/14 (11-15)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-08
	Application Number	
Title of Invention	ELECTRIC CAMERA	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Takahiro		NAKANO	

Residence Information (Select One) US Residency ● Non US Residency Active US Military Service

City	Tokyo	Country of Residence [i]	JP

Mailing Address of Inventor:

Address 1	c/o Hitachi, Ltd., Intellectual Property Group
Address 2	6-1, Marunouchi 1-chome
City	Chiyoda-ku, Tokyo
State/Province	
Postal Code	100-8220
Country [i]	JP

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Ryuji		NISHIMURA	

Residence Information (Select One) US Residency ◉ Non US Residency Active US Military Service

City	Tokyo	Country of Residence [i]	JP

Mailing Address of Inventor:

Address 1	c/o Hitachi, Ltd., Intellectual Property Group
Address 2	6-1, Marunouchi 1-chome
City	Chiyoda-ku, Tokyo
State/Province	
Postal Code	100-8220
Country [i]	JP

Inventor 3 Remove

Legal Name

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-08
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Prefix	Given Name	Middle Name	Family Name	Suffix
	Toshiro		KINUGASA	

Residence Information (Select One) US Residency ◉ Non US Residency Active US Military Service

City	Tokyo	Country of Residence [i]	JP

Mailing Address of Inventor:

Address 1	c/o Hitachi, Ltd., Intellectual Property Group		
Address 2	6-1, Marunouchi 1-chome		
City	Chiyoda-ku, Tokyo	State/Province	
Postal Code	100-8220	Country [i]	JP

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	24956		
Email Address	ptomail@mmiplaw.com	Add Email	Remove Email

Application Information:

Title of the Invention	ELECTRIC CAMERA		
Attorney Docket Number	ASA-9606-08	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	8	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

[i]

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-08
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	24956		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)	
	Continuation of	14661227	2015-03-18	

Prior Application Status	Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14661227	Continuation of	14264243	2014-04-29	9100604	2015-08-04

Prior Application Status	Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14264243	Continuation of	13681495	2012-11-20	8736729	2014-05-27

Prior Application Status	Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13681495	Continuation of	12845266	2010-07-28	8339493	2012-12-25

PTO/AIA/14 (11-15)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-08
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12845266	Continuation of	10660710	2003-09-12	8059177	2011-11-15
Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
10660710	Division of	09520836	2000-03-08	6765616	2004-07-20

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)
00-006064	JP	2000-01-11	

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-08
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-08
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	Hitachi Maxell, Ltd.		
Mailing Address Information For Applicant:			
Address 1	1-88, Ushitora 1-Chome		
Address 2			
City	Ibaraki-shi, Osaka	**State/Province**	
Country	JP	Postal Code	567-8567
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-08
	Application Number	
Title of Invention	ELECTRIC CAMERA	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/John R. Mattingly/			Date (YYYY-MM-DD)	2016-12-21
First Name	John R.	Last Name	Mattingly	Registration Number	30293

Additional Signature may be generated within this form by selecting the Add button. Add

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	ASA-9606-08
	Application Number	
Title of Invention	ELECTRIC CAMERA	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Atty. Docket No. ASA-9606-08

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: To be assigned	Confirmation No.	:
Applicant	: Hitachi Maxell, Ltd.	TC/GAU	:
Filed	: December 21, 2016	Examiner	:
Title	: ELECTRIC CAMERA		

Customer No.: 24956

NOTICE OF RELATED PATENTS INVOLVED IN LITIGATION

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

December 21, 2016

Sir:

Applicant notifies the Office that two related patents, U.S. Patent Nos. 8,339,493 and 8,736,729, which matured from applications 12/845,266 and 13/681,495, respectively, and from which the above-identified application claims priority under 35 U.S.C. 120, are involved in the following litigation:

Hitachi Maxell, Ltd. v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-179 RWS (E.D. Tex.), filed November 18, 2016.

A Complaint for Patent Infringement was filed on November 18, 2016 and an Answer was filed on December 14, 2016. To date, none of the documents submitted to the Court present material information which should be brought to the attention of the U.S. Patent and Trademark Office in the above identified application.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly, Reg. No. 30,293
(703) 684-1120

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	T. NAKANO et al.
		Confirmation No.: TBD
Serial No.	:	To be assigned
Filed	:	December 21, 2016
For	:	ELECTRIC CAMERA
Group	:	To be assigned
Examiner	:	To be assigned
Docket No.	:	ASA-9606-08
Customer No.:		24956

INFORMATION DISCLOSURE STATEMENT (IDS)
UNDER § 1.97 AND § 1.98

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

December 21, 2016

Sir:

In the matter of the above-identified application, Applicant is submitting herewith a copy, where required, of the documents listed in the attached form PTO/SB/08a. It is requested that the information be considered by the Examiner during prosecution of the application, and that the references be made of record therein.

Applicants note that:

One or more references cited on the attached PTO/SB/08a was cited by or submitted to the U.S. Patent and Trademark Office in parent application No. 14/661,227, filed March 18, 2015, which is relied upon for an earlier filing date under 35 U.S.C. §120. No copies of the references are attached pursuant to 37 CFR §1.98(d).

The Commissioner is authorized to charge any shortage in the fees due, or credit any overpayment, to Deposit Account No. 50-1417.

If the PTO determines that part(s) of the required content is inadvertently omitted, then it is requested that the Applicant(s) be given additional time and specific identification of such omission(s) to enable full compliance.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Registration No. 30,293
703-684-1120

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2016-12-21
First Named Inventor	T. NAKANO
Art Unit	
Examiner Name	
Attorney Docket Number	ASA-9606-08

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6765616	B1	2004-07-20	NAKANO et al.	
	2	7403226	B2	2008-07-22	NAKANO et al.	
	3	6781634	B1	2004-08-24	SHIOZAKI et al.	
	4	5402173		1995-03-28	NOGUCHI et al.	
	5	5438365		1995-08-01	YAMASHITA et al.	
	6	5638132		1997-06-10	HOKARI et al.	
	7	7352391	B1	2008-04-01	HATAKEYAMA	
	8	6661451	B1	2003-12-09	KIJIMA et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2016-12-21
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-08

	9	7154539	B1	2006-12-26	NISHIMURA et al.	
	10	5828406		1998-10-27	PARULSKI et al.	
	11	4054915		1977-10-18	SUGIHARA	
	12	5170249		1992-12-08	OHTSUBO et al.	
	13	5187569		1993-02-16	TANI	
	14	6195125	B1	2001-02-27	UDAGAWA et al.	
	15	6906746	B2	2005-06-14	HIJISHIRI et al.	
	16	6519000	B1	2003-02-11	UDAGAWA	
	17	5847758		1998-12-08	IIZUKA	
	18	6970191	B1	2005-11-29	SASE et al.	
	19	6734424		1998-03-31	SASAKI	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2016-12-21
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-08

	20	6798448	B1	2004-09-28	MOTONO et al.	
	21	5287192		1994-02-15	IIZUKA	
	22	8059177	B2	2011-11-15	NAKANO et al.	
	23	9100604	B2	2015-08-04	NAKANO; Takahiro	
	24	5986698	A	1999-11-16	NOBUOKA; Kousuke	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	9-270959	JP		1997-10-14	SONY CORP.		

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2016-12-21
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-08

	2	11-187306	JP		1999-07-09	SHARP CORP.		
	3	04-323973	JP		1992-11-13	HITACHI, LTD.		
	4	11-004456	JP		1999-01-06	FUJI PHOTO FILM CO., LTD.		
	5	11-355665	JP		1999-12-24	FUJI PHOTO FILM CO., LTD.		

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2016-12-21
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-08

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2016-12-21
Name/Print	John R. Mattingly	Registration Number	30293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 15/386,656

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	600
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	1 minus 20 =	*			OR	x 80 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	1 minus 3 =	*				x 420 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1600

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/386,656	12/21/2016	2673	1600	ASA-9606-08	1	1

CONFIRMATION NO. 3687

FILING RECEIPT

24956
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

OC000000088247596

Date Mailed: 01/05/2017

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Takahiro NAKANO, Tokyo, JAPAN;
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Applicant(s)

Hitachi Maxell, Ltd., Osaka, JAPAN;

Power of Attorney: The patent practitioners associated with Customer Number 24956

Domestic Priority data as claimed by applicant

This application is a CON of 14/661,227 03/18/2015 PAT 9544517
which is a CON of 14/264,243 04/29/2014 PAT 9100604
which is a CON of 13/681,495 11/20/2012 PAT 8736729
which is a CON of 12/845,266 07/28/2010 PAT 8339493
which is a CON of 10/660,710 09/12/2003 PAT 8059177
which is a DIV of 09/520,836 03/08/2000 PAT 6765616

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
JAPAN 00-006064 01/11/2000

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 01/03/2017

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 15/386,656**

Projected Publication Date: 04/13/2017

Non-Publication Request: No

Early Publication Request: No

Title

ELECTRIC CAMERA

Preliminary Class

358

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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NOT GRANTED

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08	3687

24956 7590 02/08/2017

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EXAMINER
NGUYEN, LUONG TRUNG

ART UNIT	PAPER NUMBER
2663	

NOTIFICATION DATE	DELIVERY MODE
02/08/2017	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

Office Action Summary	Application No. 15/386,656	Applicant(s) NAKANO ET AL.	
	Examiner LUONG T. NGUYEN	Art Unit 2663	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *12/21/2016*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *12/21/2016* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☒ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☒ Certified copies of the priority documents have been received in Application No. 14/661,227.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

DETAILED ACTION

1. The present application is being examined under the pre-AIA first to invent provisions.

Priority

2. Acknowledgment is made of applicant's claim for foreign priority under 35 U.S.C. 119 (a)-(d). The certified copy has been filed in parent Application No. 14/661,227, filed on 03/18/2015.

It should be noted that the certified copy, which has been filed in parent Application No. 14/661227, is foreign application number **JP 2000-006064**, filed on 01/11/2000; however, the Application Data Sheet indicates in Foreign Priority Information the foreign application number **JP 00-006064**, filed on 01/11/2000; therefore, the correction of Foreign Priority Information in Application Data Sheet is required.

Information Disclosure Statement

3. The information disclosure statement (IDS) submitted on 12/21/2016 is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner.

Claim Objections

4. Claim 1 is objected to because of the following informalities:

Claim 1 (line 11), "the out put" should be changed to --the output--.

Appropriate correction is required.

Claim Interpretation - 35 USC § 112

5. The following is a quotation of 35 U.S.C. 112(f):

> (f) Element in Claim for a Combination. – An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

The following is a quotation of pre-AIA 35 U.S.C. 112, sixth paragraph:

> An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

6. Use of the word "means" (or "step for") in a claim with functional language creates a rebuttable presumption that the claim element is to be treated in accordance with 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112, sixth paragraph). The presumption that 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112, sixth paragraph) is invoked is rebutted when the function is recited with sufficient structure, material, or acts within the claim itself to entirely perform the recited function.

Absence of the word "means" (or "step for") in a claim creates a rebuttable presumption that the claim element is not to be treated in accordance with 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112, sixth paragraph). The presumption that 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112,

sixth paragraph) is not invoked is rebutted when the claim element recites function but fails to recite sufficiently definite structure, material or acts to perform that function.

Claim elements in this application that use the word "means" (or "step for") are presumed to invoke 35 U.S.C. 112(f) except as otherwise indicated in an Office action. Similarly, claim elements that do not use the word "means" (or "step for") are presumed not to invoke 35 U.S.C. 112(f) except as otherwise indicated in an Office action.

7. Claim limitation "signal processing unit" as recited in claim 1 has been interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because it uses a generic placeholder "unit" coupled with functional language "to generate image signals" without reciting sufficient structure to achieve the function. Furthermore, the generic placeholder is not preceded by a structural modifier. Note that "signal processing" is not a structural modifier.

Since the claim limitation invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, claim 1 has been interpreted to cover the corresponding structure described in the specification that achieves the claimed function, and equivalents thereof.

A review of the specification shows that the following appears to be the corresponding structure described in the specification for the 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph limitation:

"signal processing circuit 7" disclosed in Figures 1, 7, Specification, pages 9, 27 for claim limitation "signal processing circuit unit."

If applicant wishes to provide further explanation or dispute the examiner's interpretation of the corresponding structure, applicant must identify the corresponding structure with reference to the specification by page and line number, and to the drawing, if any, by reference characters in response to this Office action.

If applicant does not intend to have the claim limitation(s) treated under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112 , sixth paragraph, applicant may amend the claim(s) so that it/they will clearly not invoke 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, or present a sufficient showing that the claim recites/recite sufficient structure, material, or acts for performing the claimed function to preclude application of 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

For more information, see MPEP § 2173 *et seq.* and *Supplementary Examination Guidelines for Determining Compliance With 35 U.S.C. 112 and for Treatment of Related Issues in Patent Applications*, 76 FR 7162, 7167 (Feb. 9, 2011).

Double Patenting

8. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the claims at issue are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); In re Vogel, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the reference application or patent either is shown to be commonly owned with

this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/forms/. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to http://www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

9. Claim 1 is rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1, 13 of U.S. Patent No. 6,765,616. Although the claims at issue are not identical, they are not patentably distinct from each other because of the following reasons.

Claim 1 of the instant application is anticipated by patent claim 1 in that claim 1 of the patent contains all the limitations of claim 1 of the instant application. Claim 1 of the instant application therefore is not patently distinct from the earlier patent claim and as such is unpatentable for obvious-type double patenting.

Claim 1 of the instant application is anticipated by patent claim 13 in that claim 13 of the patent contains all the limitations of claim 1 of the instant application. Claim 1 of the instant application therefore is not patently distinct from the earlier patent claim and as such is unpatentable for obvious-type double patenting.

10. Claim 1 is rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claim 1 of U.S. Patent No. 7,403,226. Although the conflicting claims are not identical, they are not patentably distinct from each other because of the following reasons.

Claim 1 of the instant application is anticipated by patent claim 1 in that claim 1 of the patent contains all the limitations of claim 1 of the instant application. Claim 1 of the instant application therefore is not patently distinct from the earlier patent claim and as such is unpatentable for obvious-type double patenting.

11. Claim 1 is rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claim 1 of U.S. Patent No. 8,059,177. Although the conflicting claims are not identical, they are not patentably distinct from each other because of the following reasons.

Claim 1 of the instant application is anticipated by patent claim 1 in that claim 1 of the patent contains all the limitations of claim 1 of the instant application. Claim 1 of the instant application therefore is not patently distinct from the earlier patent claim and as such is unpatentable for obvious-type double patenting.

12. Claim 1 is rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claim 1 of U.S. Patent No. 9,100,604. Although the conflicting claims are not identical, they are not patentably distinct from each other because of the following reasons.

Claim 1 of the instant application is anticipated by patent claim 1 in that claim 1 of the patent contains all the limitations of claim 1 of the instant application. Claim 1 of the instant application therefore is not patently distinct from the earlier patent claim and as such is unpatentable for obvious-type double patenting.

13. Claim 1 is rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1, 4 of U.S. Patent No. 9,544,517. Although the conflicting claims are not identical, they are not patentably distinct from each other because of the following reasons.

Claim 1 of the instant application is anticipated by patent claim 1 in that claim 1 of the patent contains all the limitations of claim 1 of the instant application. Claim 1 of the instant application therefore is not patently distinct from the earlier patent claim and as such is unpatentable for obvious-type double patenting.

Claim 1 of the instant application is anticipated by patent claim 4 in that claim 4 of the patent contains all the limitations of claim 1 of the instant application. Claim 1 of the instant application therefore is not patently distinct from the earlier patent claim and as such is unpatentable for obvious-type double patenting.

Claim Rejections - 35 USC § 102

14. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

15. Claim 1 is rejected under 35 U.S.C. 102(e) as being anticipated by Kijima et al. (US 6,661,451).

Regarding claim 1, Kijima et al. discloses an electric camera comprising:

an image sensing device (CCD 12, figure 1, column 3, lines 25-34; column 4, line 57 – column 5, line 42) with a light receiving surface having N vertically arranged pixels and an arbitrary number of pixels arranged horizontally, N being equal to or more than three times the number of effective scanning lines M of a display screen of a television system;

a driver (figure 1, column 3, lines 25-34; column 4, line 57 – column 5, line 42) to drive the image sensing device to vertically mix or cull signal charges accumulated in individual pixels of every K pixels to produce a number of lines of output signals which corresponds to the number of effective scanning lines M, K being at least one of integers equal to or less than an integral part of a quotient of N divided by M; and

a signal processing unit (image processing portion 26, figure 1, column 2, lines 62-67) to generate image signals by using the output signals of the image sensing device.

Conclusion

16. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Alston (US 4,541,010) discloses electronic imaging camera.

Nobuoka (US 5,986,698) discloses image sensing apparatus with a moving image mode and a still image mode.

Nishimura et al. (US 7,154,539) discloses image pickup device for still and motion images.

Silver (US 4,691,253) discloses electronic imaging camera for recording either moving or still images.

17. Any inquiry concerning this communication or earlier communications from the examiner should be directed to LUONG T. NGUYEN whose telephone number is (571)272-7315. The examiner can normally be reached on 7:30AM - 5:00PM, MONDAY -THURSDAY.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, TWYLER HASKINS can be reached on (571) 272-7406. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2663
02/01/17

/TWYLER HASKINS/
Supervisory Patent Examiner, Art Unit 2663

Notice of References Cited	Application/Control No. 15/386,656	Applicant(s)/Patent Under Reexamination NAKANO ET AL.	
	Examiner LUONG T. NGUYEN	Art Unit 2663	Page 1 of 1

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*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-5,986,698 A	11-1999	Nobuoka; Kousuke	H04N5/23248	348/208.3
*	B	US-7,154,539 B1	12-2006	Nishimura; Ryuji	H04N5/232	348/220.1
*	C	US-4,691,253 A	09-1987	Silver; Bruce R.	H04N1/0044	358/906
*	D	US-4,541,010 A	09-1985	Alston; Lawrence E.	H04N1/0044	348/283
*	E	US-9,544,517 B2	01-2017	Nakano; Takahiro	H04N5/23248	1/1
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	2	14/661227	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 14:44
S2	268	(("NAKANO") near3 ("Takahiro")).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 14:55
S3	39	(("NISHIMURA") near3 ("Ryuji")).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 15:03
S4	41	(("KINUGASA") near3 ("Toshiro")).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 15:07
S5	12448	(scan$4 with line) and (NTSC or standard) and (television or TV) and (mix$3 or combin$3 or cull$3 or add$3) and (pixel$1 or charge$1 or signal$1) and (sensor$1 or CCD$1 or CMOS)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 15:19
S6	15982	(H04N5/372 or H04N5/23248 or H04N5/3741 or H04N5/23258).CPC.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 15:20
S7	114	S5 and S6	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 15:21
S8	8	("4875101" | "4896211" | "5233428" | "5694167" | "5777670" | "5920343" | "5926219" | "6040859").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 15:23
S9	1	("6075565").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 15:25
S10	9	("4496980" | "4626916" | "4876534" | "5097305" | "5260592" | "5276407" | "5276521" | "5289023" | "5324958").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 15:28
S11	22084	(H04N9/045 or H04N5/3454).CPC.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 15:32

S12	485	S5 and S11	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 15:32
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S14	10	("20030122941" | "5170249" | "5343243" | "5502483" | "5668597" | "5734427" | "5786852" | "5986698" | "6148031" | "6614477").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 15:38
S15	4	("4714963" | "5051832" | "5734933" | "5809353").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 15:40
S16	9	("4541010" | "4691253" | "4714963" | "4876590" | "4928137" | "5418565" | "5440343" | "5444483" | "5943335").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 15:42
S17	360	(scan$4 with line) same (NTSC or standard) same (television or TV) and (mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (sensor$1 or CCD$1 or CMOS)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 15:47
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S22	514	S21 and (S6 or S11)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 15:54
S23	98	S22 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 15:54
S24	271	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (sensor$1 or CCD$1 or CMOS) same quotient	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 15:57
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		@rlad<="20000111")	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			15:57
S26	581	H04N5/23274.CPC.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 16:24
S27	142	S26 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 16:24
S28	9	("4638362" | "4689686" | "4858020" | "4942473" | "4963981" | "5019912" | "5144445" | "5196939" | "5402169").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 16:26
S29	42	S26 and (S5 or S21)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 16:33
S30	10	("20020171759" | "20040105029" | "20040212732" | "20050001929" | "20050094030" | "20050180654" | "20050264692" | "5832101" | "6493008" | "6931062").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 16:36
S31	4	("5420631" | "5894325" | "6091449" | "6215113").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/02/01 16:37
S32	16	S26 and S17	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 16:38
S33	17	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (sensor$1 or CCD$1 or CMOS) same (quotient or ratio) same (display$3 or monitor or screen) same television	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 16:40
S34	16633	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (sensor$1 or CCD$1 or CMOS) same ratio	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 16:42
S35	513	S34 and (S6 or S11 or S26)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/01 16:43
S36	97	S35 and (@ad<="20000111" or	US-PGPUB;	OR	ON	2017/02/01

		@rlad<="20000111")	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			16:43

EAST Search History (Interference)

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2/1/2017 8:34:18 PM
C:\Users\lnguyen2\Documents\EAST\Workspaces\15386656.wsp

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15386656	NAKANO ET AL.
	Examiner	**Art Unit**
	LUONG T NGUYEN	2663

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	02/01/2017								
	1	✓								

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2016-12-21
First Named Inventor	T. NAKANO
Art Unit	
Examiner Name	NGUYEN, L.
Attorney Docket Number	ASA-9606-08

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6765616	B1	2004-07-20	NAKANO et al.	
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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2016-12-21
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	NGUYEN, L.
	Attorney Docket Number	ASA-9606-08

	9	7154539	B1	2006-12-26	NISHIMURA et al.	
	10	5828406		1998-10-27	PARULSKI et al.	
	11	4054915		1977-10-18	SUGIHARA	
	12	5170249		1992-12-08	OHTSUBO et al.	
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2016-12-21
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	NGUYEN, L.
	Attorney Docket Number	ASA-9606-08

	20	6798448	B1	2004-09-28	MOTONO et al.	
	21	5287192		1994-02-15	IIZUKA	
	22	8059177	B2	2011-11-15	NAKANO et al.	
	23	9100604	B2	2015-08-04	NAKANO; Takahiro	
	24	5986698	A	1999-11-16	NOBUOKA; Kousuke	

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	1	9-270959	JP		1997-10-14	SONY CORP.		

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2016-12-21
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	NGUYEN, L
	Attorney Docket Number	ASA-9606-08

	2	11-187306	JP		1999-07-09	SHARP CORP.		
	3	04-323973	JP		1992-11-13	HITACHI, LTD.		
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	5	11-355665	JP		1999-12-24	FUJI PHOTO FILM CO., LTD.		

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
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Examiner Signature	/LUONG T NGUYEN/	Date Considered	02/01/2017

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Application Number	
	Filing Date	2016-12-21
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	
	Attorney Docket Number	ASA-9606-08

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2016-12-21
Name/Print	John R. Mattingly	Registration Number	30293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15386656	NAKANO ET AL.
	Examiner	Art Unit
	LUONG T NGUYEN	2663

CPC- SEARCHED		
Symbol	Date	Examiner
H04N5/372; H04N5/23248; H04N5/3741; H04N5/23258; H04N9/045; H04N5/3454; H04N5/23274	2/1/2017	LTN

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	2/1/2017	LTN
Inventorship search	2/1/2017	LTN

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 3687

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
15/386,656	12/21/2016 RULE	348	2663	ASA-9606-08

APPLICANTS
Hitachi Maxell, Ltd., Osaka, JAPAN;

INVENTORS
Takahiro NAKANO, Tokyo, JAPAN;
Ryuji NISHIMURA, Tokyo, JAPAN;
Toshiro KINUGASA, Tokyo, JAPAN;

**** CONTINUING DATA ***************************
This application is a CON of 14/661,227 03/18/2015 PAT 9544517
which is a CON of 14/264,243 04/29/2014 PAT 9100604
which is a CON of 13/681,495 11/20/2012 PAT 8736729
which is a CON of 12/845,266 07/28/2010 PAT 8339493
which is a CON of 10/660,710 09/12/2003 PAT 8059177
which is a DIV of 09/520,836 03/08/2000 PAT 6765616

**** FOREIGN APPLICATIONS ***************************
JAPAN ~~00-006064 01/11/2000~~ 2000-006064 01/11/2000

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ************************
01/03/2017

Foreign Priority claimed	Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
☑ Yes ☐ No	☐	JAPAN	8	1	1
35 USC 119(a-d) conditions met ☑ Yes ☐ No					
Verified and Acknowledged /LUONG TRUNG NGUYEN/ Examiner's Signature	Initials				

ADDRESS
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314
UNITED STATES

TITLE
ELECTRIC CAMERA

FILING FEE RECEIVED		
1600	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

BIB (Rev. 05/07).

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

CORRECTED ADS FORM

Application Number	15386656
Title of Invention	ELECTRIC CAMERA

Inventor Information

****If no data is shown, no data has been corrected****

	Data of Record	Updated Data
Order Number		
Name		
Residence Information		
Residency		
City		
State		
Country of Residence		
Mailing Address of Inventor		
Address 1		
Address 2		
City,State/Province, Postal Code		
Country		

Corrected ADS 1.0

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

Application Information

	Data of Record	Updated Data
Title of Invention	ELECTRIC CAMERA	
Attorney Docket Number	ASA-9606-08	
Entity Type	Regular Undiscounted	

Domestic Benefit/National Stage Information

****If no data is shown, no data has been corrected****

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121,365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S. C. 119(e) or 120, and 37 CFR 1.78(a).

		Data of Record	Updated Data
	Prior Application Status		
	Application Number		
	Continuity Type		
	Prior Application Number		
	Filing Date (YYYY-MM-DD)		
	Patent Number		
	Issue Date (YYYY-MM-DD)		

Foreign Priority Information

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

****If no data is shown, no data has been corrected****

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

		Data of Record	Updated Data
	Application Number	~~00-006064~~	2000-006064
	Country	JP	
	Filing Date	2000-01-11	
	Access Code		

Applicant Information

****If no data is shown, no data has been corrected****
Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

	Data of Record	Updated Data
Applicant Type		
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is		
Name of the Deceased or Legally Incapacitated Inventor		
Applicant is an Organization		
Name		
Organization Name		
Address 1		
Address 2		

Corrected ADS 1.0

City,State/Province,Postal Code		
Country		
Phone Number		
Fax Number		
Email Address		

Assignee Information including Non-Applicant Assignee Information

****If no data is shown, no data has been corrected****
Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office

	Data of Record	Updated Data
Order		
Applicant is an Organization		
Name		
Organization Name		
Mailing Address		
Address 1		
Address 2		
City,State/Province,Postal Code		
Country		
Phone Number		
Fax Number		
Email Address		

Corrected ADS 1.0

Signature

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b).

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/John R. Mattingly/	Registration Number	30293
First Name	John	Last Name	Mattingly

Attorney Docket No.: ASA-9606-08

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: 15/386,656	Confirmation No.	: 3687
Applicant(s)	: Hitachi Maxell, Ltd.	TC/GAU	: 2663
Filed	: December 21, 2016	Examiner	: NGUYEN, L. T.

Title : ELECTRIC CAMERA

Customer No.: 24956

REQUEST TO CHANGE CLAIM FOR PRIORITY BY CORRECTING FOREIGN PRIORITY APPLICATION NUMBER AND REQUEST FOR CORRECTED OFFICIAL FILING RECEIPT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

February 9, 2017

Sir:

Applicant submits the following request to change the claim for Foreign Priority by correcting the Foreign Priority Application Number.

Applicants submit herewith a corrected Application Data Sheet correcting the Foreign Priority Information section. The Application Number should read “2000-006064”. It is also respectfully requested that a Corrected Official Filing Receipt be issued in connection with this filing.

Applicant hereby requests a Corrected Official Filing Receipt. The Foreign Applications section currently reads “JAPAN 00-006064 01/11/2000” and should read “JAPAN 2000-006064 01/11/2000”. A copy of the Official Filing Receipt with the changes indicated thereon is attached hereto.

Atty Docket No.: ASA-9606-08

The Commissioner is hereby authorized to charge any fee or additional fee that may be required and credit any excess to Deposit Account No. 50-1417.

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly, Reg. No. 30,293
(703) 684-1120

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/386,656	12/21/2016	2673	1600	ASA-9606-08	1	1

CONFIRMATION NO. 3687

24956
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

FILING RECEIPT

OC000000088247596

Date Mailed: 01/05/2017

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Takahiro NAKANO, Tokyo, JAPAN;
Ryuji NISHIMURA, Tokyo, JAPAN;
Toshiro KINUGASA, Tokyo, JAPAN;

Applicant(s)

Hitachi Maxell, Ltd., Osaka, JAPAN;

Power of Attorney: The patent practitioners associated with Customer Number 24956

Domestic Priority data as claimed by applicant

This application is a CON of 14/661,227 03/18/2015 PAT 9544517
which is a CON of 14/264,243 04/29/2014 PAT 9100604
which is a CON of 13/681,495 11/20/2012 PAT 8736729
which is a CON of 12/845,266 07/28/2010 PAT 8339493
which is a CON of 10/660,710 09/12/2003 PAT 8059177
which is a DIV of 09/520,836 03/08/2000 PAT 6765616

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)

~~JAPAN 00-006064 01/11/2000~~

JAPAN 2000-006064 01/11/2000

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Electronic Acknowledgement Receipt

EFS ID:	28301260
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-08
Receipt Date:	09-FEB-2017
Filing Date:	21-DEC-2016
Time Stamp:	14:59:55
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet to update/ correct info	CorrectedADS.pdf	63760 05bf9126b3966b06945246a1bcb81ac52177b2b0	no	5

Warnings:

Information:					
2	Transmittal Letter	9606-08-ReqChgPriority.pdf	15198 3ae2f6ac0a99081016d2fad4b8274cf9f27fc0bc	no	2
Warnings:					
Information:					
3	Request for Corrected Filing Receipt	9606-08-MarkedUpOFR.pdf	960226 4460d76b23c7c32281b02604d0cf12a443bde637	no	1
Warnings:					
Information:					
		Total Files Size (in bytes):	1039184		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
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www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/386,656	12/21/2016	2663	1600	ASA-9606-08	1	1

CONFIRMATION NO. 3687

CORRECTED FILING RECEIPT

24956
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

OC000000089199527

Date Mailed: 02/14/2017

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Takahiro NAKANO, Tokyo, JAPAN;
Ryuji NISHIMURA, Tokyo, JAPAN;
Toshiro KINUGASA, Tokyo, JAPAN;

Applicant(s)

Hitachi Maxell, Ltd., Osaka, JAPAN;

Power of Attorney: The patent practitioners associated with Customer Number 24956

Domestic Priority data as claimed by applicant

This application is a CON of 14/661,227 03/18/2015 PAT 9544517
which is a CON of 14/264,243 04/29/2014 PAT 9100604
which is a CON of 13/681,495 11/20/2012 PAT 8736729
which is a CON of 12/845,266 07/28/2010 PAT 8339493
which is a CON of 10/660,710 09/12/2003 PAT 8059177
which is a DIV of 09/520,836 03/08/2000 PAT 6765616

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
JAPAN 2000-006064 01/11/2000

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

Request to Retrieve - This application either claims priority to one or more applications filed in an intellectual property Office that participates in the Priority Document Exchange (PDX) program or contains a proper **Request to Retrieve Electronic Priority Application(s)** (PTO/SB/38 or its equivalent). Consequently, the USPTO will attempt to electronically retrieve these priority documents.

If Required, Foreign Filing License Granted: 02/13/2017

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 15/386,656**

Projected Publication Date: 04/13/2017

Non-Publication Request: No

Early Publication Request: No

Title

ELECTRIC CAMERA

Preliminary Class

348

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor

community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

日　本　国　特　許　庁
JAPAN PATENT OFFICE

別紙添付の書類に記載されている事項は下記の出願書類に記載されている事項と同一であることを証明する。

This is to certify that the annexed is a true copy of the following application as filed with this Office.

出願年月日 Date of Application:	２０００年　１月１１日
出願番号 Application Number:	特願２０００－００６０６４
パリ条約による外国への出願に用いる優先権の主張の基礎となる出願の国コードと出願番号 The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is	ＪＰ２０００－００６０６４
出願人 Applicant(s):	株式会社日立製作所

２０１７年　２月１５日

特許庁長官
Commissioner,
Japan Patent Office

小宮義則

【書類名】　特許願
【整理番号】　D99010231A
【提出日】　平成12年 1月11日
【あて先】　特許庁長官殿
【国際特許分類】　H04N　5/00
【発明の名称】　撮像装置
【請求項の数】　16
【発明者】
【住所又は居所】　茨城県ひたちなか市稲田１４１０番地　株式会社日立製作所デジタルメディア製品事業部内
【氏名】　中野　孝洋
【発明者】
【住所又は居所】　神奈川県横浜市戸塚区吉田町２９２番地　株式会社日立製作所デジタルメディア開発本部内
【氏名】　西村　龍志
【発明者】
【住所又は居所】　神奈川県横浜市戸塚区吉田町２９２番地　株式会社日立製作所デジタルメディア開発本部内
【氏名】　衣笠　敏郎
【特許出願人】
【識別番号】　000005108
【氏名又は名称】　株式会社　日立製作所
【代理人】
【識別番号】　100075096
【弁理士】
【氏名又は名称】　作田　康夫
【手数料の表示】
【予納台帳番号】　013088
【納付金額】　21,000円

【提出物件の目録】

【物件名】　明細書　1

【物件名】　図面　1

【物件名】　要約書　1

【プルーフの要否】　要

【書類名】　明細書

【発明の名称】　撮像装置

【特許請求の範囲】

【請求項１】

テレビジョン方式の一表示画面の有効走査線数Mの３倍以上の数Nの画素を垂直方向に、任意の数の画素を水平方向に配した受光面を備えた撮像素子と、

該画素配列の各画素に蓄積された信号電荷を、NをMで除した商の整数部またはそれ以下の整数の内少なくとも一つの整数であるところのK画素周期で、垂直方向に混合または間引きを行い、前記有効走査線数Mに相当するライン数の出力信号を得るように該撮像素子を駆動する駆動手段と、

前記撮像素子の出力信号を用いて画像信号を生成する信号処理手段とを備えていることを特徴とする撮像装置。

【請求項２】

前記駆動手段は、前記撮像素子の垂直方向の画素数Nから前記混合または間引き周期Kと前記有効走査線数Mとの積K･Mを減じた数の垂直画素に対応する画素領域の信号電荷を前記テレビジョン方式の垂直帰線期間内に読み出しまたは掃き捨てることにより、前記テレビジョン方式の有効垂直走査期間内に、前記撮像素子の画素の内K･Mの垂直画素に相当する画素領域の信号電荷を切り出して、前記有効走査線数Mに相当するライン数の出力信号を得るように前記撮像素子を駆動することを特徴とする請求項１記載の撮像装置。

【請求項３】

前記信号処理手段は、該撮像素子の該受光面の内、該切り出した垂直領域に対して該テレビジョン方式の縦横比と略等しくなる水平領域部分に相当する出力信号期間のみを切り出して該テレビジョン方式の有効水平走査期間全体にわたって出力する機能を有することを特徴とする請求項１または２記載の撮像装置。

【請求項４】

前記駆動手段は、該テレビジョン方式の表示周期毎に該混合または間引きの画素位置をずらすことによりインターレース信号を出力するように該撮像素子を駆動することを特徴とする請求項１～３のいずれか１項に記載の撮像装置。

【請求項５】

前記信号処理手段は、該混合または間引きによって得られるインターレース出力信号の垂直方向の重心位置が表示周期毎に１８０度の位相差となるように補間する機能を有することを特徴とする請求項４記載の撮像装置。

【請求項６】

前記撮像素子は、該垂直方向の画素数Nを該有効走査線数Mで除した商の整数部またはそれ以下の整数の内少なくとも二つの整数画素周期で垂直方向に混合または間引きすることができ、該駆動手段は、該少なくとも二つの整数に対応した少なくとも二つのモードで、該撮像素子を駆動することを特徴とする請求項１～５のいずれか１項に記載の撮像装置。

【請求項７】

前記撮像素子の該駆動手段は、装置内部または外部に設けたズームスイッチ等の画角変化を指示するスイッチ手段からの入力情報に対応して、該混合または間引きの画素周期を変化させることを特徴とする請求項６記載の撮像装置。

【請求項８】

前記撮像素子の出力信号の利得を調整する利得調整手段を有し、該撮像素子の混合の画素周期が変化した時にも、該利得調整手段の出力信号レベルが同一になるように、混合画素周期に対応して該利得調整手段の利得を変化させることを特徴とする請求項６または７記載の撮像装置。

【請求項９】

前記撮像装置の手振れを検出する手振れ検出手段を有し、該手振れ検出手段で検出した手振れ量に応じて、該受光面内における垂直方向及び水平方向の切り出し位置を、該手振れを補正するように変化させることを特徴とする請求項１～８のいずれか１項に記載の撮像装置。

【請求項１０】

テレビジョン方式の一表示画面の有効走査線数Mの３倍以上の数Nの画素を垂直方向に、任意の数の画素を水平方向に配した受光面を備えた撮像素子と、該画素配列の各画素に蓄積された信号電荷を、NをMで除した商の整数部より大きな整数であるところのK画素周期で、垂直方向に混合または間引きを行い、前記テレビ

ジョン方式の有効垂直走査期間内に、前記撮像素子の垂直画素数NのK分の一のライン数の出力信号を得るように前記撮像素子を駆動する駆動手段と、
前記撮像素子の出力信号を用いて画像信号を生成する機能を有する信号処理手段とを備えていることを特徴とする撮像装置。

【請求項１１】

テレビジョン方式の一表示画面の有効走査線数Mの３倍以上の数Nの画素を垂直方向に、任意の数の画素を水平方向に配した受光面を備えた撮像素子と、

該画素配列の各画素に蓄積された信号電荷を、NをMで除した商の整数部またはそれ以下の整数の内少なくとも一つの整数であるところのK画素周期で、垂直方向に混合または間引きを行い、前記有効走査線数Mに相当するライン数の出力信号を得るように該撮像素子を駆動する第１の駆動手段と、

該画素配列の各画素に蓄積された信号電荷を、NをMで除した商の整数部より大きな整数であるところのK画素周期で、垂直方向に混合または間引きを行い、前記テレビジョン方式の有効垂直走査期間内に、前記撮像素子の垂直画素数NのK分の一のライン数の出力信号を得るように前記撮像素子を駆動する第２の駆動手段と、

前記撮像素子の出力信号を用いて画像信号を生成する信号処理手段とを備え、前記第１の駆動手段による駆動と前記第２の駆動手段による駆動とを、装置内部または外部に設けたスイッチ手段からの入力情報に対応して選択、切り替えを行うことを特徴とする撮像装置。

【請求項１２】

シャッターボタン等のトリガー手段を有し、該トリガー手段によりトリガーが発生した時には、該撮像素子の各画素に蓄積した信号電荷を混合せずに全画素独立で読み出すことを特徴とする請求項１～１１のいずれか１項に記載の撮像装置。

【請求項１３】

前記撮像素子の受光面を構成する画素配列の各画素に対して、水平方向に第一、第二、および第三の各色を各々透過する色フィルターを三画素周期で周期的に配し、垂直方向には同一種類の色を透過する色フィルターを配したことを特徴と

する請求項１～１２のいずれか１項に記載の撮像装置。

【請求項１４】

前記第一、第二、および第三の各色は各々黄色、緑、シアンであることを特徴とする請求項１３記載の撮像装置。

【請求項１５】

前記第一、第二、および第三の各色は各々黄色、白色、シアンであることを特徴とする請求項１３記載の撮像装置。

【請求項１６】

前記第一、第二、および第三の各色は各々赤、緑、青であることを特徴とする請求項１３記載の撮像装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】

本発明は、固体撮像素子を用いたビデオカメラ、ＶＴＲ一体型カメラ、電子スチルカメラ等の撮像技術に係り、特に、画素数の多い固体撮像素子を用いた撮像装置に関する。

【０００２】

【従来の技術】

ＣＣＤ（Charge Coupled Device）等の固体撮像素子を用いた撮像装置として、動画撮影を目的としたいわゆるビデオカメラと、静止画撮影を目的としたいわゆる電子スチルカメラが存在する。また、近年では、動画撮影用の装置であっても静止画撮影機能を有したもの、或いは静止画撮影用の装置であっても動画撮影機能を有したものも存在している。

【０００３】

動画撮影を目的としたいわゆるビデオカメラでは、一般的にテレビモニター等の表示装置での表示を前提としており、ＮＴＳＣ、ＰＡＬ等のテレビジョン方式に準拠した出力信号を得るように構成されている。そのため、このような装置に用いられる撮像素子の垂直方向の有効画素数は、テレビジョン信号の生成を前提として定まっている。例えば、ＮＴＳＣ方式ではフィールドあたりの有効走査線

数（フィールドあたりの全走査線数から垂直帰線期間に含まれる走査線数を除いた走査線数であり、実際に表示装置に表示される走査線数の意味）は約２４０本でかつフィールド毎に飛び越し走査（インターレース走査）を行うが、これを実現するために撮像素子の垂直方向の有効画素数は約４８０画素が基準となっている。すなわち、各フィールドで垂直方向に隣接する２画素の信号を撮像素子内部或いは撮像素子外部で混合することによって約２４０本の走査線を生成し、かつフィールド毎に混合する画素の組み合わせを変えることによって飛び越し走査を実現している。

【０００４】

また、ＮＴＳＣ方式の動画撮像用の撮像素子として、手振れ補正用の画素領域を有効画素領域に付加して、垂直方向に約４８０画素以上の有効画素を有するものもあるが、この場合でも約４８０以上の画素領域は垂直帰線期間中に高速に読み出されて、有効な信号としては用いられず、画像信号はあくまでも垂直約４８０画素領域の信号から生成される。このような撮像装置で静止画を撮影する場合、動画撮影時と同一の画素領域の信号からＪＰＥＧ（Joint Photographic Expert Gpoup）等の静止画信号を生成することは比較的容易であるが、得られる画素数が垂直４８０画素程度に限定されてしまい、より高精細の静止画信号を得ることが出来ないという問題が有る。

【０００５】

この問題を軽減する手段として、前述の手振れ補正領域を持つ撮像素子を用いた撮像装置においては、静止画撮影時には手振れ補正用画素領域を含めた全有効画素領域を用いる事が考えられるが、静止画撮影時においても撮影画像確認などの為にモニタリングをする必要が有り、その為には読み出した全有効画素の信号からテレビジョン方式に準拠した信号を生成する必要が有る。

【０００６】

このような装置の従来例として特開平１１－１８７３０６号公報に記載の装置が提案されている。この公報に開示された装置では、先ず、テレビジョン方式の１フィールド期間の複数倍の時間を要して全有効画素の信号を読み出してフィールドメモリー等の記憶手段に記憶し、しかる後に補間処理等によってテレビジョ

ンのフィールド周期、水平走査周期に対応した信号への変換を行っている。

【０００７】

しかしながら、この従来例では、信号変換のために、フィールドメモリー等の大規模な処理回路が必要であり、また、撮像素子からの読み出し周期がフィールド周期の複数倍となるため動解像度が劣化する。また、このような手段を用いても、静止画信号として得られる画素数は動画時の有効画素数に手振れ補正画素領域を加えた画素数が限度である。

【０００８】

一方、静止画撮影を目的としたいわゆる電子スチルカメラでは、より高精細な静止画信号を得るために、近年動画撮影用の撮像素子に対してより多画素化した撮像素子を用いる傾向に有る。このような装置で動画撮影、またはモニタリングを行う場合には、やはりテレビジョン方式に準拠した信号を生成する必要があるが、前記多画素化した撮像素子では、画素数が必ずしもテレビジョン方式の走査線数に対応していないため、何らかの変換手段が必要である。

【０００９】

このような変換手段としては、例えば、前述の手振れ補正用画素領域を有した動画撮像装置と同様に、フィールド周期よりも長い時間を用いて撮像素子から信号を読み出し、補間によってテレビジョン信号を生成する方法が有るが、この場合には前述の問題点と共に、画素数が多くなるにつれて、更に読み出し周期が長くなり動解像度が更に劣化する。

【００１０】

また、この問題を軽減する手段として、撮像素子内部で画素信号を混合または間引きすることにより、読み出すべき信号数を減少し、読み出し周期を短くする装置の例が特開平９―２７０９５９号公報に開示されている。この装置においては、前記動解像度劣化の問題は軽減されるが、テレビジョン方式に同期した信号を生成するための時間軸変換を行うために、フィールドメモリー等の大規模な処理回路を必要とし、また、所望の混合、間引きを行うために撮像素子自体も特殊な構造を取る必要が有る。

【００１１】

【発明が解決しようとする課題】

上述のように従来技術の撮像装置では、動画撮像装置で静止画撮影を行う場合には画素数の不足、静止画撮像装置で動画撮影する場合には、回路規模の増加と共に、動画画質の劣化という問題が有り、一つの撮像装置で動画、静止画とも十分な画像を得ることが難しい。また、静止画用の多画素撮像素子を用いて十分な動画画質を得るためには、前記問題点の解決の他に、手振れ補正機能等を実現するための読み出し領域の切り出しを行う必要も有るが、上記従来技術ではこれを実現する手段も提供されていない。

【００１２】

本発明の目的は、かかる問題を解決し、静止画に対しても十分な画素数をもつ多画素の撮像素子を用いて、高精細な静止画に加えて、フィールドメモリー等により回路規模を増加すること無く、画質劣化を低減した動画撮影を可能とする撮像装置を提供すること、、また、併せて手振れ補正機能の実現も可能とした撮像装置を提供することにある。

【００１３】

【課題を解決するための手段】

上記目的を達成するため、本発明のうち、その一つとしては、テレビジョン方式の一表示画面の有効走査線数Mの３倍以上の数Nの画素を垂直方向に、任意の数の画素を水平方向に配した受光面を備えた撮像素子と、該画素配列の各画素に蓄積された信号電荷を、NをMで除した商の整数部またはそれ以下の整数の内少なくとも一つの整数であるところのK画素周期で、垂直方向に混合または間引きを行い、前記有効走査線数Mに相当するライン数の出力信号を得るように該撮像素子を駆動する駆動手段と、前記撮像素子の出力信号を用いて画像信号を生成する信号処理手段とを備えた撮像装置とする。

【００１４】

【発明の実施の形態】

以下、本発明の実施形態を図面を用いて説明する。図１は、本発明の撮像装置の一つの実施形態を示す構成図である。

【００１５】

図１において、符号１はレンズ、符号２は絞り、符号３は撮像素子、符号４は撮像素子を駆動する駆動回路、符号５は利得調整回路、符号６はアナログ―デジタル変換（Ａ／Ｄ変換）回路、符号７は信号処理回路、符号８は垂直方向の補間処理を行う垂直補間回路、符号９は水平方向の補間処理を行う水平補間回路、符号１０は画像信号を記録する磁気テープ、半導体メモリー、光ディスク等の記録媒体を含む記録部、符号１１は動作状態に応じてこれらの構成要素の制御を行う制御回路、符号１２は標準テレビジョン信号への変調処理等を行うエンコーダ回路、符号１３はデジタル―アナログ変換（Ｄ／Ａ変換）回路、符号１４は動画撮影、静止画撮影等の動作モードの切り替えを行うモード切り替えスイッチ、符号１５は記録開始／停止の指示を行うための記録ボタン、符号１６ａ、１６ｂはそれぞれ撮像装置の縦方向、横方向の手振れを検出する手振れセンサー、符号１７は手振れセンサーの出力信号から撮像装置の手振れを判定する手振れ判定回路を示している。

【００１６】

上記の構成において、レンズ１から入射された光は、絞り２を介して撮像素子３の受光面上に結像して電気信号に変換される。本実施形態では、撮像素子３をＣＣＤ型撮像素子としている。図２にこの撮像素子３の構成を示す。図２において、符号３０はフォトダイオードで構成されている画素であり、水平、垂直方向に格子状に配置されている。格子状に配された画素には、それぞれ黄色（Ｙｅ），緑（Ｇ），シアン（Ｃｙ）の各色を透過する色フィルターが、水平方向に３画素周期で繰り返し配され、垂直方向には同一の色を配されたいわゆる縦ストライプ状に配されている。画素数は任意であるが、本実施形態では垂直方向に１２００画素、水平方向に１６００画素が配置されているものとする。垂直転送部３２は、Ｖ１，Ｖ２，Ｖ３の３相のパルスで駆動されるＣＣＤである。本ＣＣＤは１画素あたり３相パルスに対応する３ゲート構成となっており、各画素の信号電荷を独立で垂直方向に転送することが可能である。画素の電荷を垂直転送部に転送するための転送ゲート３１は、垂直転送部３２のＶ２パルスに対応するゲートと共通化されており、共通化されたゲートに対して印加するパルスの波高値によっ

て画素からの電荷を垂直転送部に転送する動作と、垂直方向への転送動作とが区別して行われる。水平転送部３３は、垂直転送部３２から転送された電荷を水平方向に転送し、出力アンプ３４を介して順次出力端子から出力する。

【００１７】

図１の説明に戻る。以下、まずモード切り替えスイッチ１４によって動画撮影モードが選択された時の動作について説明する。本実施形態における撮像素子の垂直方向の画素数は１２００であるため、ＮＴＳＣ方式の場合のフィールド有効走査線数を２４０ラインとすると、垂直方向に５（＝１２００画素／２４０ライン）画素の混合を行うことにより撮像素子からの出力信号ライン数を有効走査線数と一致させることが出来る。

【００１８】

しかしながら、本実施形態では、後に説明する手振れ補正機能を実現するために、動画撮影モード時には、垂直方向に４画素の混合を行うこととする。垂直方向に４画素の混合を行う場合には、垂直方向１２００画素の内、９６０（＝２４０ライン×４画素）画素分の領域の信号を有効な信号として用い、残りの２４０（＝１２００（全画素）－９６０（有効画素））画素分の領域の信号は出画に用いない。図３は本動作モードにおける撮像素子の垂直駆動パルスのタイミングを示した図であり、Ｖ１，Ｖ２，Ｖ３は前記垂直転送部３２であるＣＣＤの各ゲートに入力される３相の駆動パルスである。

【００１９】

図３において、垂直帰線期間に含まれる期間Ｔ１において駆動パルスＶ２をハイレベルの電圧とすることによって各画素に蓄積された信号電荷は垂直ＣＣＤのＶ２ゲート下に転送される。次にＴ２で示す期間における動作、すなわちＶ２パルスがミドルレベルの期間にＶ３パルスをローレベルからミドルレベルに変化させ、次にＶ３パルスがミドルレベルの期間にＶ２パルスをミドルレベルからローレベルに変化させた後、Ｖ１パルスをローレベルからミドルレベルに変化させ、次にＶ１パルスがミドルレベルの期間にＶ３パルスをミドルレベルからローレベルに変化させた後、Ｖ２パルスをローレベルからミドルレベルに変化させ、最後にＶ１パルスをミドルレベルからローレベルに変化させるという一連の動作によ

って、Ｖ２ゲート下の信号電荷は一ライン分転送されて再びＶ２ゲート下に保持される。

【００２０】

この一連の動作を繰り返すことによって、信号電荷を任意のライン数分転送することができる。図３において、垂直有効走査期間（垂直帰線期間を除いた実際に表示させる画像に対応する垂直走査期間の意味）の前の垂直帰線期間に含まれる期間Ｔ３および垂直有効走査期間の後の垂直帰線期間に含まれる期間Ｔ４において、合わせて２４０回上記一行分の転送動作を繰り返すことによって出画に用いない２４０行分の信号電荷を垂直帰線期間中に水平転送部３３に転送する。例えば期間Ｔ３で１２０回、期間Ｔ４で１２０回の一連の転送を行うと、受光面上の上下それぞれ１２０行分の信号電荷が垂直帰線期間内の期間Ｔ３及び期間Ｔ４に水平転送部３３に転送される。その後の垂直帰線期間内の期間Ｔ５及び期間Ｔ６に水平転送部３３をそれぞれ一定期間駆動することによって水平転送部に転送された電荷は出力端から出力されるが、垂直帰線期間中であるので有効な信号としては用いられない。

【００２１】

次に、図３の垂直有効走査期間では、各水平帰線期間に上記一行分の転送動作を４回行うことにより４行分の信号電荷が水平転送部３３に転送され水平転送部３３で混合される。その後水平有効走査期間（水平帰線期間を除いた実際に表示させる画像に対応する水平走査期間の意味）に水平転送部３３を駆動して水平転送部の信号電荷を読み出すことによって、テレビジョン方式に同期した出力信号を得ることができる。また、Ａフィールドで上記動作を行い、Ｂフィールドでは期間Ｔ３の転送行数を１２２行、期間Ｔ４の転送行数を１１８行とすると、フィールド毎に混合される４行の組み合わせが２行分ずれ、図４に示すようにインターレース走査を行う事ができる。（図４は撮像素子受光面を示しているため、表示画面上とは上下反転している）

図１の説明に戻る。撮像素子３の出力信号は利得調整回路５で利得調整された後、Ａ／Ｄ変換回路６でデジタル信号に変換され、信号処理回路７で色信号の生成、ガンマ補正、ホワイトバランス処理、輪郭強調等の色信号処理、輝度信号処

理を施される。ここで本実施形態における撮像素子は、前記黄色（Ｙｅ），緑（Ｇ），シアン（Ｃｙ）の縦ストライプ状の色フィルターが配されたものであるため、どのような画素数で垂直方向に混合を行っても、常に１ラインの出力信号から、Ｙｅ，Ｇ，Ｃｙの各色信号が点順次で得られる。これらの色信号から、３原色信号Ｒ、Ｇ、Ｂ信号は以下の演算で得ることが出来る。

【００２２】

Ｒ＝Ｙｅ－Ｇ

Ｂ＝Ｃｙ－Ｇ

Ｇ＝Ｇ

Ｒ，Ｇ，Ｂ信号は信号処理回路７でホワイトバランス処理、ガンマ補正処理等を施された後、Ｒ－Ｙ，Ｂ－ＹまたはＵ，Ｖ等の色差信号に変換される。その後、輝度信号および色差信号は垂直補間回路８を介して水平補間回路９に入力される。本動作状態では垂直補間回路では処理は行われず通過するのみである。水平補間回路では水平方向の補間処理が行われる。

【００２３】

図５は撮像素子の受光面を示した図である。前述のように本実施形態の本動作状態では、垂直有効走査期間に読み出される信号は垂直１２００画素の内の９６０画素に相当し、水平方向は全画素（１６００画素）に相当するする領域であり、図５に斜線部Ａで示している。ここで、撮像素子の受光面全体の縦横比が縦：横＝３：４であった場合、斜線部Ａの領域はそれに対して横長となるため、水平方向全画素分の信号をＮＴＳＣ方式等縦横比３：４のテレビジョン方式の表示機器で表示すると水平方向が圧縮された縦長の画像となる。従って、図５において斜線部Ｂで示した、テレビジョン方式の縦横比と合致した水平領域の信号のみを水平有効走査期間に出力する必要が有る。テレビジョン方式の縦横比が３：４の場合には斜線部Ｂの水平画素数は１２８０（＝９６０（垂直方向有効画素）×（４／３））となる。

【００２４】

図１の説明に戻る。水平補間回路９では水平１２８０画素分の信号を補間処理により水平方向に伸長し水平有効走査期間全体にわたって出力できるようにし、

また、必要に応じてクロックの乗せ替え等を行う。以上の動作によって、受光面上の垂直９６０画素、水平１２８０画素の領域を切り出して、テレビジョン方式に同期した信号として得ることが可能となる。その後、輝度信号及び色差信号はエンコーダ１２でテレビジョン信号へのエンコード処理を施され、Ｄ／Ａ変換回路１３でアナログ信号に変換されて出力される。また、記録ボタン１５によって記録の指示がなされた場合には、記録部１０で信号の記録が行われる。この時、必要に応じてＭＰＥＧ（Moving Picture Expert Group）等の圧縮処理を施すこともできる。

【００２５】

次に、手振れ補正の動作に関して説明する。撮像装置の縦方向、横方向の手振れを検出する手振れセンサー１６ａ、１６ｂによって検出された振れ情報は手振れ判定回路１７に入力され、ここで手振れ量、方向などが判定され、撮像素子の受光面上での垂直方向、水平方向の画素数に換算される。換算された画素数に対して手振れを打ち消す方向に受光面上での切り出し位置（有効画素領域）をずらすことによって手振れを補正することができる。切り出し位置の移動は、垂直方向に関しては、前述の図３の期間Ｔ３および期間Ｔ４における転送行数を変化させることにより実現でき、水平方向に関しては前述の水平補間回路における、補間開始位置を変化させることにより実現することができる。

【００２６】

以上動画撮影モード時の動作に関して説明した。次に、モード切り替えスイッチ１４によって静止画撮影モードが選択された時の動作について説明する。

【００２７】

静止画撮影モードにおいても、記録ボタン１５によって記録の指示がなされるまでは、撮影画角の確認等のためのモニタリングを行うために、テレビジョン方式に準拠した信号の出力を行う。ただし、静止画撮影時にはできるだけ高精細な信号を得るために、本実施形態では、動画撮影時とは異なり撮像素子の全有効画素数を用いて撮影を行う。従って、モニタリング時には、全画素領域の信号から、テレビジョン信号を生成する必要がある。

【００２８】

本実施形態の撮像素子の垂直方向の画素数は１２００画素であるため、ＮＴＳＣ方式の有効走査線数を２４０ラインとすると、垂直方向に５（＝１２００／２４０）画素の混合を行うことにより、出力信号ライン数を有効走査線数と一致させることができる。このように撮像素子を動作させるために、図３に示したパルスタイミング図において、垂直有効走査期間中の各水平帰線期間に前記１行分の転送動作を５回行う。これにより５ライン数分の信号電荷を水平転送部３３で混合することができる。また、垂直帰線期間中の期間Ｔ３およびＴ４での転送動作は、インターレース走査を行うために、Ｂフィールドの期間Ｔ３において２行分の転送のみを行い、他の垂直帰線期間では転送動作は行わない（本実施形態では１２００／２４０＝５であり、余りが生じないため、上記以外の転送は不要だが、仮に余りが生じる場合には、余りの画素数分を期間Ｔ３，Ｔ４で転送すれば良い）。

【００２９】

水平転送部３３で混合された電荷は水平有効走査期間に水平転送部を駆動して読み出す。以上により撮像素子の全画素の信号電荷をテレビジョン方式に同期して読み出すことができる。撮像素子３の出力信号は動画撮影時と同様に利得調整回路５で利得調整された後、Ａ／Ｄ変換回路６でデジタル信号に変換され、信号処理回路７で色信号処理、輝度信号処理を施され、垂直補間回路８に入力される。静止画撮影モニタリング時には垂直補間回路８で垂直方向の重心補正の処理を行う。

【００３０】

図６に本動作状態におけるＡフィールド、Ｂフィールドにおける混合される画素の組み合わせおよび混合された信号の垂直方向の重心位置を示す。インターレース走査では、Aフィールド、Bフィールドでの走査線の位置は相互に他フィールドの走査線間の中心の位置であるため、これに対応して撮像系での信号の垂直方向のサンプリングはそれぞれのフィールドで１８０度の位相差となる必要が有る。ところが、本実施形態の本動作状態では混合画素数が５画素であるため、図６に示すように、Ａフィールド、Ｂフィールドでの出力信号の重心位置が１８０度

の位相差に対して、３６度（＝１／２画素、同一フィールドのライン間距離の１／１０）ずれている。これを補正するには、隣接２ラインの信号から補間によって信号を生成すれば良く、例えば同一フィールドのｎラインの信号をSn、ｎ＋１ラインの信号Sn+1とすると、Sn’＝（Sn×９／１０）＋（Sn+1×１／１０）の演算で得られるSn’はｎラインの信号の重心位置に対して１／１０ライン分ｎ＋１ライン方向に重心位置のずれた信号である。Bフィールドの信号に対して上記演算を行うことによってサンプリングの重心ずれの補正が可能であるが、本実施形態では、Aフィールド、Bフィールドの補間の影響を均一にするために、ｎラインの信号を、Aフィールドでは１／２０ライン分ｎ－１ライン方向に、Ｂフィールドでは１／２０ライン分ｎ＋１ライン方向に補正するために、以下の演算を行う。

【００３１】

Ａフィールド：　Sn’＝（Sn×１９／２０）＋（Sn-1×１／２０）

Ｂフィールド：　Sn’＝（Sn×１９／２０）＋（Sn+1×１／２０）

尚、本実施形態では隣接２ラインの信号からの演算によって補間処理を行っているが、更に複数ラインの信号を用いた補間処理を行う事もできる。垂直補間回路８の出力信号は水平補間回路９に入力されるが、本動作状態では水平補間回路では処理は行われず通過するのみである。その後は、動画撮影時と同様に、エンコーダ１２でテレビジョン信号へのエンコード処理を施され、Ｄ／Ａ変換回路１３でアナログ信号に変換されて出力される。以上説明したように、静止画撮影モードでのモニタリング時にも、撮像素子の全画素領域の信号から、テレビジョン信号を生成する事ができる。

【００３２】

次に、記録ボタン１５によって記録の指示がなされた場合について説明する。静止画撮影モードにおけるモニタリング時には、テレビジョン信号を生成するために、撮像素子内で信号を混合する事によって信号量の削減を行っているが、記録する際には高精細な信号を得るために混合処理を行わずに、全画素の信号を独立で読み出す必要がある。これを実現するためには、図３に示したパルスタイミング図において、垂直有効走査期間中の各水平帰線期間の前記１行分の転送動作

を１回のみ行う。これにより１行分の信号電荷のみが水平転送部３３に転送される。その後水平転送部３３を駆動して１行分の信号電荷を読み出す。上記動作を垂直画素数分繰り返す事によって全画素の信号電荷を独立で読み出す事ができる。尚、垂直帰線期間中の期間Ｔ３およびＴ４での転送動作は行わない。

【００３３】

読み出された信号電荷は、利得調整回路５で利得調整された後、Ａ／Ｄ変換回路６でデジタル信号に変換され、信号処理回路７で色信号処理、輝度信号処理を施され、垂直補間回路８、水平補間回路９を介して記録部１０で記録される。この時、垂直補間回路８、水平補間回路９では補間処理は行われない。記録部１０では、記録に際してＪＰＥＧ（Joint Photographic Expert Gpoup）等の圧縮処理を施すこともできる。尚、上記静止画記録動作中はテレビジョン信号の生成はできないため、モニタリング用の出力には、記録開始直前の画像、または単一色の信号等に置き換えたテレビジョン信号を出力する。以上の動作により、撮像素子全画素から得られる高精細な信号を記録する事ができる。なお、本実施形態においては、動画撮影モード時と静止画撮影モード時の記録部は共通としているが、モードによって記録部を各々専用に設けても良い。

【００３４】

以上説明したように、本実施形態では、垂直方向の画素数に上限がなくなるため、静止画に対しても十分な画素数をもつ多画素の撮像素子を用いて、高精細な静止画に加えて、良好な動画撮影が可能になる。

【００３５】

また、信号の混合と垂直帰線期間中の垂直転送により、多画素の撮像素子においてもテレビジョン方式に同期した信号読み出しを可能とし、よって画質劣化を低減し、かつ手振れ補正機能を有した動画撮影および静止画撮影におけるモニタリングを実現することができる。

【００３６】

また、切り出した垂直領域に対してテレビジョン方式の縦横比と略等しくなる水平領域部分に相当する出力信号のみを切り出してテレビジョン方式の有効水平走査期間全体にわたって出力するように構成することによって、垂直方向の切り

出し位置をどのように行っても、テレビジョン方式の縦横比に等しい出力信号を得ることができる。

【００３７】

また、テレビジョン方式の表示周期毎に混合する画素位置をずらすことによりインターレース信号を出力するように撮像素子を駆動することによって、多画素の撮像素子を用いてもインターレース走査を行うことができる。

【００３８】

また、混合によって得られるインターレース出力信号の垂直方向の重心位置が表示周期毎に１８０度の位相差となるように補間することによって、混合周期が奇数の場合のようにインターレースの位相ずれが生じる場合であっても、インターレースずれのない出力信号を得ることができる。

【００３９】

なお、本実施形態においては、撮像素子の垂直画素数を１２００、動画撮影モード時の混合画素数を４、静止画撮影モード時の混合画素数を５としているが、手振れ補正用の画素領域の有無、大きさは任意であるため、各モードにおける混合画素数は、垂直画素数をテレビジョン方式の有効走査線数で除した商の整数部（上記実施例では５）以下であれば任意で良い（必ずしも割り切れる必要はなく、上記例の場合、垂直画素数は１２００以上であっても良い）。

【００４０】

また、静止画撮影時の画素数はテレビジョン方式のフィールド有効走査線数の３倍以上程度の垂直画素数をもてば良い。また、本実施形態では撮像素子の垂直有効走査期間中の出力ライン数を減じるために垂直方向の画素混合を行ったが、画素からの信号電荷を複数ライン中の一ラインしか読み出さない、いわゆる間引きによっても同様に出力ライン数を減じる事ができる。

【００４１】

また、本実施形態では撮像素子の垂直転送部を１画素あたり３相のパルスで駆動するＣＣＤとしたが、上記条件を満たす画素周期での混合または間引きの実現できる形態であれば、撮像素子の構造は任意で良い。

【００４２】

また、本実施形態ではＮＴＳＣ方式の場合について説明を行ったが、ＰＡＬ方式等有効走査線数の異なるテレビジョン方式であっても同様に実現する事ができる。

【００４３】

従って、以上まとめると、テレビジョン方式のフィールド有効走査線数Mの３倍以上の任意の垂直画素数Ｎをもち、かつ、NをMで除した商の整数部以下の整数の内少なくとも一つの整数周期での垂直方向の混合または間引きを行うことのできる撮像素子を用いる事により、本実施形態と要旨を同一にする種々の構成を取る事ができる。

【００４４】

次に本発明による他の実施形態を図７に示した構成図によって説明する。図７の構成図は、図１に示す構成図に対して画角変化指示スイッチ１８を追加したものである。図７において図１に示した構成要素と同一の構成要素に対しては同一の符号を付し、同一の動作を行う場合には説明を省略する。

【００４５】

本実施形態における、動画撮影モード、静止画撮影モード時のモニタリング、および静止画記録の動作は、通常状態においては図１の構成図により説明した前述の実施形態の動作と同様である。次に動画撮影モード時に画角変化指示スイッチ１８により画角変化が指示された時の動作に関して説明する。

【００４６】

本実施形態の通常状態では、前述の実施形態にて説明したのと同様、垂直方向４画素の画素混合と垂直帰線期間中の垂直転送、および水平方向の補間処理により全画素領域の内、垂直９６０画素、水平１２８０画素の領域を切り出してテレビジョン信号を生成するものとする。ただし、画角変化（垂直方向の画質劣化を伴わないズーム機能の意味）指示スイッチ１８により画角変化が指示された時には、まず垂直方向の混合画素数を３画素とし、垂直有効走査期間の前後の垂直帰線期間中に余分な垂直画素領域の信号を読み出す。

【００４７】

本実施形態の場合には、４８０（＝１２００―２４０×３）画素分、混合後のライン数としては１６０（＝４８０／３）ライン分の信号を垂直帰線期間中に読み出せば良い。これにより、垂直７２０画素分の領域の信号を２４０ラインの信号としてテレビジョン方式に同期して読み出す事ができる。前記読み出しを実現するには、図３に示したパルスタイミング図において、垂直有効走査期間中の各水平帰線期間に３ライン数分の転送動作を行い、垂直帰線期間中の期間Ｔ３およびＴ４での転送行数を１６０ラインとすれば良い。また、フィールド毎に混合の組み合わせを変えてインターレース走査を行う。

【００４８】

撮像素子３の出力信号は利得調整回路５に入力されるが、３画素混合時の信号レベルは４画素混合時に比べて３／４倍になっているため、利得調整回路の利得を４画素混合時に対して４／３倍して後段の回路の入力信号レベルを同一にする。その後Ａ／Ｄ変換回路６、信号処理回路７で各々処理を施され、垂直補間回路８に入力される。３画素混合の場合のＡフィールド、Ｂフィールドにおける混合される画素の組み合わせおよび混合された信号の垂直方向の重心位置は図８に示す通りであり、前述の実施形態における静止画撮影モニタリング時と同様にフィールド間のサンプリング位相が１８０度の位相差からずれているため、垂直補間回路８で垂直方向の重心補正の処理を行う。本動作状態における位相のずれ量は６０度（＝１／２画素、同一フィールドのライン間距離の１／６）であり、これを両フィールドで均一に補正するためには、以下の演算を行えば良い。

【００４９】

Ａフィールド：　Sn’＝（Sn×１１／１２）＋（Sn-1×１／１２）

Ｂフィールド：　Sn’＝（Sn×１１／１２）＋（Sn+1×１／１２）

尚、前述のように、３ライン以上の複数ラインの信号を用いた補間処理を行う事もできる。次に水平補間回路９で、垂直７２０画素に対して縦横比が３：４となる水平領域（本動作状態では水平９６０（＝１６００×７２０／１２００）画素の領域）の信号を補間処理により水平方向に伸長し水平有効走査期間全体にわたって出力できるようにする。以上の動作によって、受光面上の垂直７２０画素

、水平９６０画素の領域を切り出すことができる。

【００５０】

次に、画角変化指示スイッチ１８により再度画角変化が指示された時には、垂直方向の混合画素数を２画素とし、垂直４８０画素分の領域を垂直有効走査期間に読み出し、水平補間回路で６４０画素分の領域の信号を伸長し水平有効走査期間全体にわたって出力する事により、受光面上の垂直４８０画素、水平６４０画素の領域を切り出す（２画素混合時にはインターレースずれが生じないので垂直補間回路での重心補正は行わない）。更に、画角変化指示スイッチ１８により画角変化が指示された時には、垂直方向の混合画素数を４画素とし、通常の状態に戻す。

【００５１】

以上の動作により、図９に示すように撮像素子受光面上の切り出し領域を（Ａ）垂直９６０×水平１２８０、（Ｂ）垂直７２０×水平９６０、（Ｃ）垂直４８０×水平６４０の３種類に変化させる事ができ、すなわち、撮影画角を３種類に変化させる事ができる。４画素混合時の領域Ａを基準とすると、３画素混合時の領域Ｂでは１．３３倍、２画素混合時の領域Ｃでは２倍に拡大した画像を得る事ができる。ここで、３種類の領域の読み出しに際しては、画素混合数を変える事によって、常に、撮像素子からの有効出力ライン数をテレビジョン方式の有効走査線数に一致させているため、少ない出力ライン数から補間処理によって有効走査線数の信号を生成する通常のいわゆる電子ズームと比較して、垂直方向の画質劣化の無い良好な画像を保ったまま、画角を変化させる事ができる。なお、静止画モニタリング時においても画素混合数を変化させて切り出し画角を変化させる同様の動作を行っても良い。

【００５２】

以上説明したように、本実施形態では、上述の実施形態によって得られる効果のほか、静止画に対しても十分な画素数をもつ多画素の撮像素子を用い、かつ画素混合数を変化させる事によって、画質劣化の少ない画角変化を実現する事ができる。

【００５３】

また、混合の画素周期が変化したときに生じる信号レベルの変化を利得調整手段で吸収することにより、後段の信号処理手段の入力信号レベルを一定に保つことができる。

【００５４】

なお、本実施形態においては、画角変化指示スイッチによって間欠的に画角変化を行ったが、ズームスイッチによって連続的に変化させても良い。この時には、倍率変化が画素混合を変化させた時の倍率まで達しない間は通常の補間処理による電子ズームを行う事とする。本実施形態の場合には１倍以上１．３３倍未満の間は４画素混合、１．３３倍以上２倍未満の関は３画素混合、２倍以上では２画素混合となる。また、この時に光学ズーム機構と連動させても良い。

【００５５】

また、本実施形態においても前記実施形態の場合と同様に、撮像素子の画素数、撮像素子の構造、テレビジョン方式等にかかわらず、フィールド有効走査線数Ｍの３倍以上の任意の垂直画素数Ｎをもち、かつ、NをMで除した商の整数部以下の整数の内少なくとも二つ整数周期での垂直方向の混合または間引きを行うことのできる撮像素子を用いる事により、本実施形態と要旨を同一にする種々の構成を取る事ができる。

【００５６】

次に本発明による他の実施形態について説明する。ここで説明する実施形態の全体構成は、図１に示す構成図と同一であるが、撮像素子３の内部構成が異なっている。本実施形態における、撮像素子の構成を図１０に示す。図１０において、３０はフォトダイオードで構成されている画素であり、水平、垂直方向に格子状に配置されており、これらの画素にはそれぞれ黄色（Ｙｅ），緑（Ｇ），シアン（Ｃｙ）の各色を透過する色フィルターが縦ストライプ状に配されている。

【００５７】

本実施形態においては垂直方向に８６４画素、水平方向に１１５２画素が配置されているものとする。垂直転送部３２は、Ｖ１，Ｖ２，Ｖ３、Ｖ４、Ｖ５，Ｖ６の６相のパルスで駆動されるＣＣＤであり、１画素あたり２相パルスに対応す

る２ゲート構成となっており、３画素周期で６相パルスに対応する６ゲートが繰り返すように構成されている。画素の電荷を垂直転送部３２に転送するための転送ゲート３１は、垂直転送部３２のＶ１、Ｖ３、Ｖ５の各パルスに対応するゲートと共通化されており、共通化されたゲートに対して印加するパルスの波高値によって画素からの電荷を垂直転送部に転送する動作と、垂直方向への転送動作とが区別して行われる。

【００５８】

水平転送部３３は、垂直転送部３２から転送された電荷を水平方向に転送し、出力アンプ３４を介して順次出力端子から出力する。本撮像素子は、前記実施形態における撮像素子とは異なり、全画素を独立した状態で垂直転送を行う事はできないが、垂直方向に隣接する３画素の信号電荷を垂直転送部内で混合した後に転送する事ができる。

【００５９】

まず、本実施形態における動画撮影モード時の動作について説明する。本実施形態における撮像素子の垂直方向の有効画素数は８６４であるため、垂直方向に３画素の混合を行うと垂直８６４画素の内、７２０（＝２４０×３）画素分の領域の信号を有効な信号として用い、残りの１４４（＝８６４―７２０）画素分の領域を手振れ補正領域とする事ができる。

【００６０】

図１１は本動作モードにおける図１０の撮像素子の垂直駆動パルスのタイミングを示した図であり、Ｖ１，Ｖ２，Ｖ３，Ｖ４，Ｖ５，Ｖ６は前記垂直転送部３２であるＣＣＤの各ゲートに入力される６相の駆動パルスである。図１１において、垂直帰線期間に含まれる期間Ｔ１において駆動パルスＶ１，Ｖ３およびＶ５をハイレベルの電圧とすることによって各画素に蓄積された信号電荷は垂直ＣＣＤのＶ１，Ｖ３およびＶ５ゲート下に各々転送される。その後Ｖ２およびＶ４パルスをローレベルからミドルレベルに変化させる事によって隣接３画素分の電荷を混合し、混合後Ｖ５パルスをミドルレベルからローレベルに変化させる事によって、混合された電荷はＶ１，Ｖ２，Ｖ３，Ｖ４ゲート下に保持される。

【００６１】

次に、Ｔ２で示す期間における一連の動作（駆動パルスをＶ１、Ｖ２、Ｖ３、Ｖ４、Ｖ５，Ｖ６の順にミドルレベルからローレベルあるいはローレベルからミドルレベルに変化させる）によって、信号電荷は混合後の一行分（３画素分）転送されて再びＶ１，Ｖ２，Ｖ３，Ｖ４ゲート下に保持される。この一連の動作を繰り返すことによって、混合された信号電荷を任意の行数分転送することができる。

【００６２】

図１１において、垂直有効走査期間の前の垂直帰線期間に含まれる期間Ｔ３および垂直有効走査期間の後の垂直帰線期間に含まれる期間Ｔ４において、合わせて１４４回上記一行分の転送動作を繰り返すことによって出画に用いない１４４行分の信号電荷を垂直帰線期間中に高速に水平転送部３３に転送する。その後の垂直帰線期間内の期間Ｔ５及びＴ６にに水平転送部３３をそれぞれ一定期間駆動することによって水平転送部に転送された電荷は出力端から出力される。

【００６３】

次に、図１１の垂直有効走査期間では、各水平帰線期間に上記一行分の転送動作を行い、その後水平有効走査期間に水平転送部を駆動して水平転送部３３の信号電荷を読み出すことによって、３画素分混合された信号電荷をテレビジョン方式に同期して読み出す事ができる。また、図１１に示すように、Ａフィールドでは信号を画素から垂直転送部３２に転送した後Ｖ２，Ｖ４パルスをミドルレベルにして混合を行うのに対して、ＢフィールドではＶ２，Ｖ６パルスをミドルレベルにして混合を行う。これによって、フィールド毎に混合する画素の組み合わせを変えてインターレース走査を実現する事ができる。撮像素子の出力信号は前記実施形態と同様に処理される。ここで、垂直補間回路８では前記実施形態の３画素混合の場合と同様に重心補正の処理がなされ、水平補間回路９ではテレビジョン方式と縦横比を一致させる補間がなされる。

【００６４】

次に、静止画撮影モードのモニタリング時の動作について説明する。静止画撮影時には前記実施形態と同様に撮像素子の全有効画素数を用いて撮影を行うもの

とする。本実施形態の撮像素子の垂直方向の画素数は８６４画素であり、動画撮影時と同様に３画素混合を行った場合には、出力ライン数が２８８（＝８６４／３）ラインとなりテレビジョン方式に同期して信号を読み出す事ができないため、静止画撮影モードのモニタリング時には、垂直方向６画素の混合を行うものとする。６画素の混合は、垂直転送部内で３画素混合された信号電荷を各水平帰線期間内に２ライン数分水平転送部に転送する事によって行う事ができる。６画素混合を行うと撮像素子からの出力ライン数を１４４（＝８６４／６）ラインに減少する事ができる。１４４ラインに減少された撮像素子の出力信号を垂直補間回路８で補間処理によって２４０ラインの信号に変換することにより、テレビジョン方式に同期した信号を得る事ができる。ここで、１４４ラインの信号から２４０ラインの信号を生成する為には、３ラインから５ラインを生成する補間処理を行えば良い（１４４／２４０＝３／５）。

【００６５】

図１２に隣接２ラインの信号を用いて補間を行う場合について示す。撮像素子の３ラインの出力信号をｎ，ｎ＋１，ｎ＋２とすると、以下の演算によって５ラインの信号を生成する事ができる。

【００６６】

ｎ’＝ｎ

ｎ’＋１＝ｎ／２＋（ｎ＋１）／２

ｎ’＋２＝ｎ＋１

ｎ’＋３＝（ｎ＋１）／２＋（ｎ＋２）／２

ｎ’＋４＝ｎ＋２

尚、３ライン以上の複数ラインの信号を用いた補間処理を行う事もできる。以上により、静止画撮影モードでのモニタリング時にも、撮像素子の全画素領域の信号から、テレビジョン信号を生成する事ができる。

【００６７】

次に、記録ボタン１５によって記録の指示がなされた場合について説明する。記録する際には高精細な信号を得るために混合処理を行わずに、全画素の信号を独立で読み出す必要がある。これを実現するためには、まず絞り２を閉じ、次に

図１１に示したパルスタイミング図のＴ２期間において、Ｖ１パルスのみをハイレベルとしＶ１ゲートに隣接した画素の信号電荷のみを垂直転送部に転送し、その後垂直転送部、水平転送部を順次駆動して信号電荷を読み出す。同様にＶ３パルスをハイレベルとしてＶ３ゲートに隣接した画素の信号電荷を読み出し、最後にＶ５パルスをハイレベルとしてＶ５ゲートに隣接した画素の信号電荷を読み出す。以上により、全画素の電荷を３回に分けて独立に読み出す事ができる。読み出された信号電荷は、記録部１０に記録されるが、その際、撮像素子の受光面上での画素配列を再現するように適宜並べ替えを行う。

【００６８】

以上説明したように、本実施形態では、垂直方向の画素数がテレビジョン方式における走査線数の整数倍でない場合でも、画素混合および垂直方向の補間処理により全有効画素領域の信号からテレビジョン方式に準拠した信号の生成が可能である。

【００６９】

なお、本実施形態においても前記実施形態の場合と同様に、撮像素子の画素数、撮像素子の構造、テレビジョン方式等にかかわらず、フィールド有効走査線数Ｍの３倍以上の任意の垂直画素数Ｎをもち、かつ、ＮをＭで除した商の整数部より一つ以上大きい整数周期での垂直方向の混合または間引きを行うことのできる撮像素子を用いる事により、本実施形態と要旨を同一にする種々の構成を取る事ができる。

【００７０】

次に、本発明による他の実施形態について説明する。ここで説明する実施形態は、上述の各実施形態において撮像素子の色フィルタ配列を異ならせたものである。図１３に本実施形態における色フィルター配列を示す。いずれも縦ストライプ状に配置したものであり垂直方向の混合または間引きの周期にかかわらず一つの出力ラインの信号からＲ，Ｇ，Ｂの各原色信号を生成できる。図１３（ａ）は前述の実施形態の撮像素子の色フィルター配列に対して，緑（Ｇ）の代わりに白（Ｗ＝全色透過）フィルターを配したものであり、Ｒ，Ｇ，Ｂ信号は以下の演算によって得る事ができる。

【００７１】

Ｒ＝Ｗ―Ｃｙ

Ｇ＝Ｙｅ＋Ｃｙ―Ｗ

Ｂ＝Ｗ―Ｙｅ

本色フィルター配列を用いた場合には、前述の実施例の色フィルター配列を用いた場合に比べてより高感度化が可能である。また、図１３（ｂ）は、補色の代わりに原色Ｒ，Ｇ，Ｂを透過する色フィルターを配したものであり、原色信号Ｒ，Ｇ，Ｂを直接得る事ができる。本色フィルター配列を用いた場合には、色純度、色Ｓ／Ｎの良好な撮像装置を得る事ができる。

【００７２】

以上説明したような色フィルター配列とすることにより、いかなる画素周期で垂直方向の混合または間引きを行っても、常に各ラインの信号から３種類の色フィルターに対応する色信号を得ることができるため、容易にテレビジョン方式の色信号を生成することが可能である。

【００７３】

【発明の効果】

以上説明したように、本発明によれば、垂直方向の画素数に上限がなくなるため、静止画に対しても十分な画素数をもつ多画素の撮像素子を用いて、高精細な静止画に加えて、良好な動画撮影を可能とした撮像装置を提供することができる。

【図面の簡単な説明】

【図１】

図１は、本発明による撮像装置の一実施形態の構成を示す構成図である。

【図２】

図２は、本発明による撮像装置の一実施形態における撮像素子の構成図である。

【図３】

図３は、本発明による撮像装置の一実施形態における駆動パルスタイミング図である。

【図４】

図４は、本発明による撮像装置の一実施形態における混合動作を説明する図である。

【図５】

図５は、本発明による撮像装置の一実施形態における読み出し領域を説明する図である。

【図６】

図６は、本発明による撮像装置の一実施形態における混合動作を説明する図である。

【図７】

図７は、本発明による撮像装置の一実施形態の構成を示す構成図である。

【図８】

図８は、本発明による撮像装置の一実施形態における混合動作を説明する図である。

【図９】

図９は、本発明による撮像装置の一実施形態における読み出し領域を説明する図である。

【図１０】

図１０は、本発明による撮像装置の一実施形態における撮像素子の構成図である。

【図１１】

図１１は、本発明による撮像装置の一実施形態における駆動パルスタイミング図である。

【図１２】

図１２は、本発明による撮像装置の一実施形態における補間動作を説明する図である。

【図１３】

図１３は、本発明による撮像装置の一実施形態における撮像素子の色フィルター配列を示す図である。

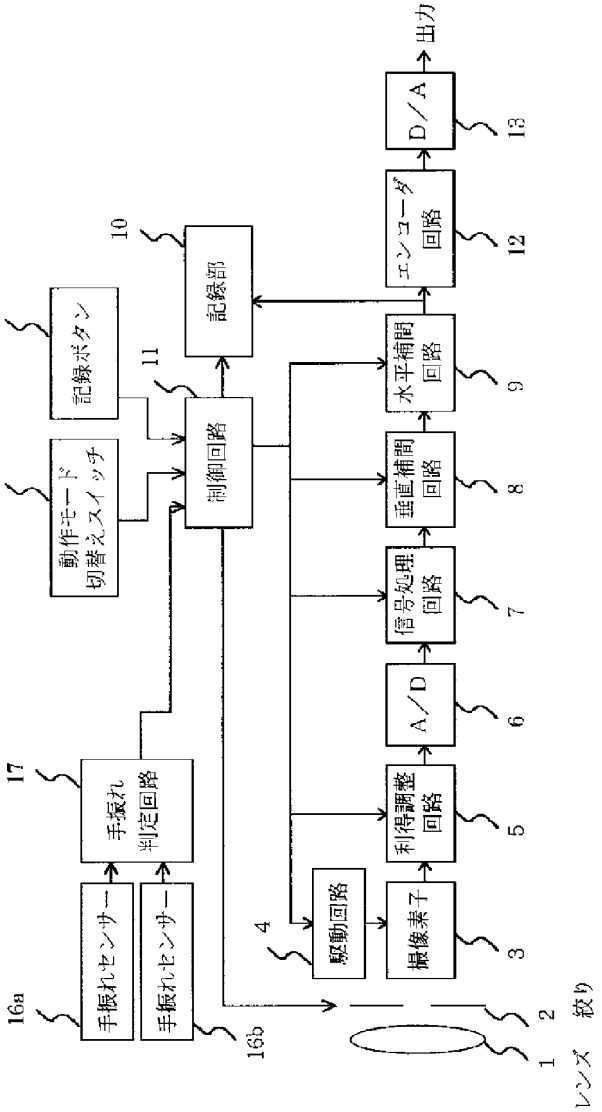
【符号の説明】

１…レンズ、２…絞り、３…撮像素子、４…駆動回路、５…利得調整回路、６…Ａ／Ｄ変換回路、７…信号処理回路、８…垂直補間回路、９…水平補間回路、１０…記録部、１１…制御回路、１２…エンコーダ回路、１３…Ｄ／Ａ変換回路、１４…モード切り替えスイッチ、１５…記録ボタン、１６ａ，１６ｂ…手振れセンサー、１７…手振れ判定回路、１８…画角変化指示スイッチ。

【書類名】　図面

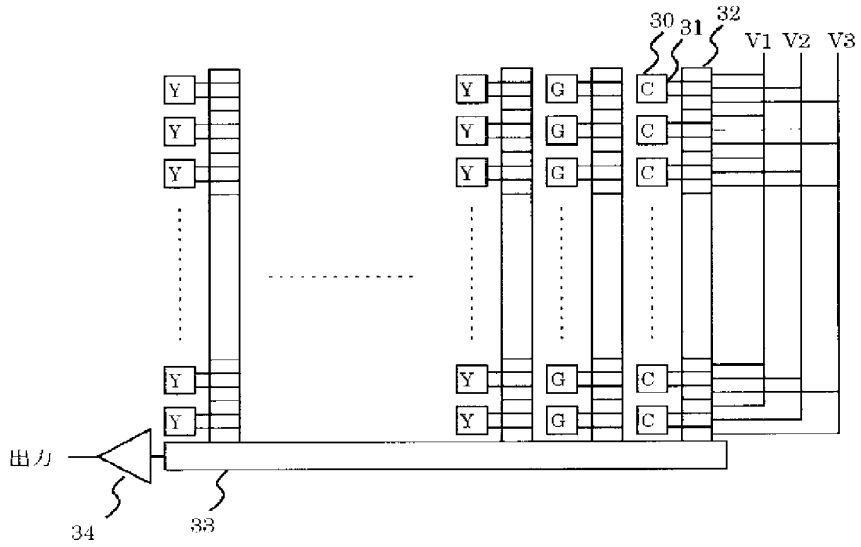
【図１】

【図１】


出力
D／A
エンコーダ回路
水平補間回路
垂直補間回路
信号処理回路
A／D
利得調整回路
撮像素子
駆動回路
制御回路
記録部
記録ボタン
動作モード切替えスイッチ
手振れ判定回路
手振れセンサー
手振れセンサー
絞り
レンズ
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16a
16b
17

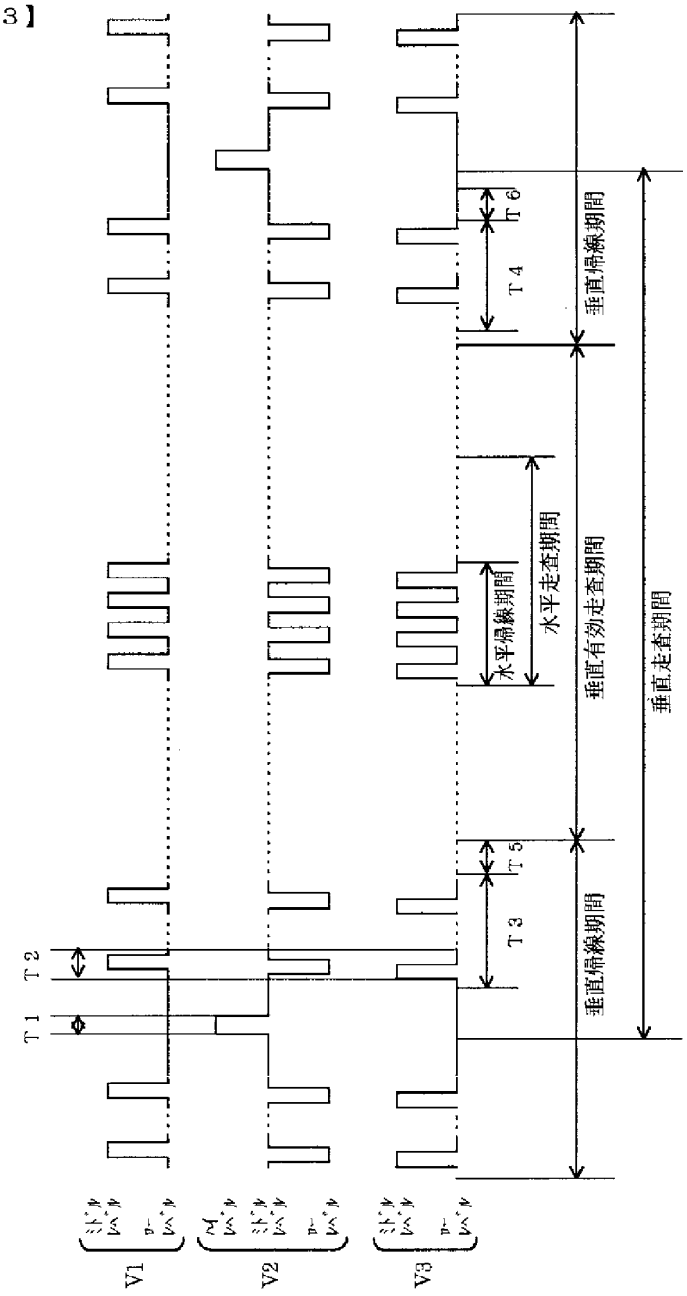
【図２】

【図２】



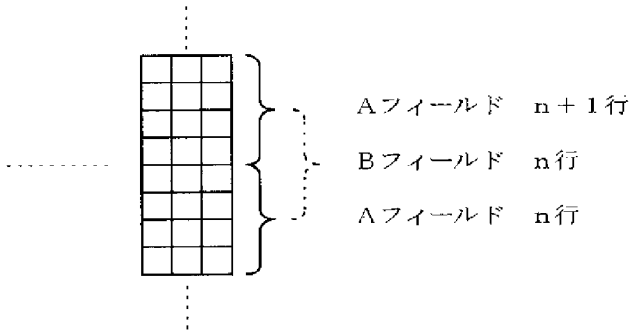
【図３】

【図３】


T1
T2
T3
T4
T5
T6
水平帰線期間
水平走査期間
垂直帰線期間
垂直有効走査期間
垂直走査期間
V1
V2
V3

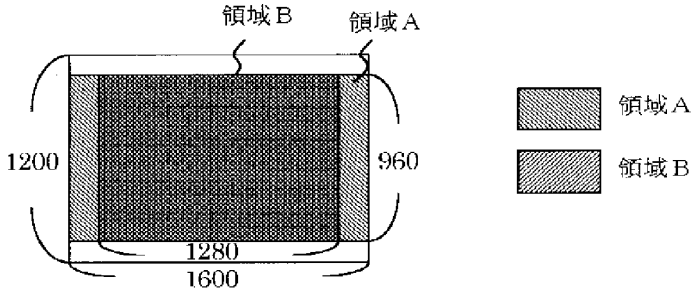
【図４】

【図４】


Ａフィールド　ｎ＋１行
Ｂフィールド　ｎ行
Ａフィールド　ｎ行

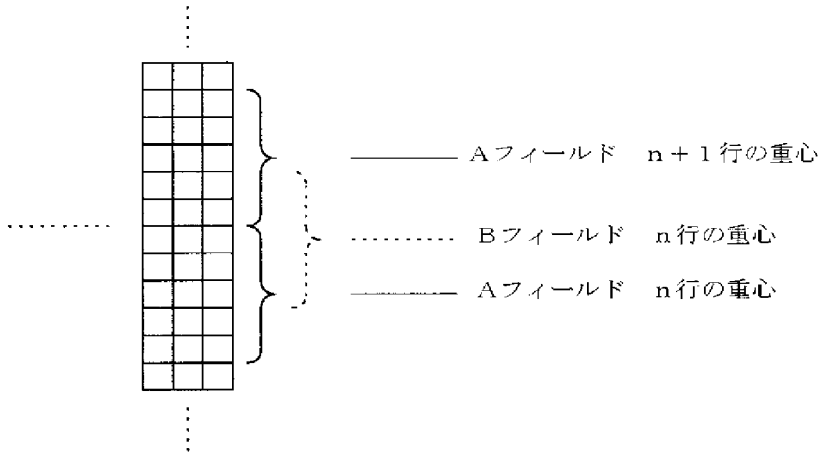
【図５】

【図５】


領域Ｂ
領域Ａ
1200
960
1280
1600
領域Ａ
領域Ｂ

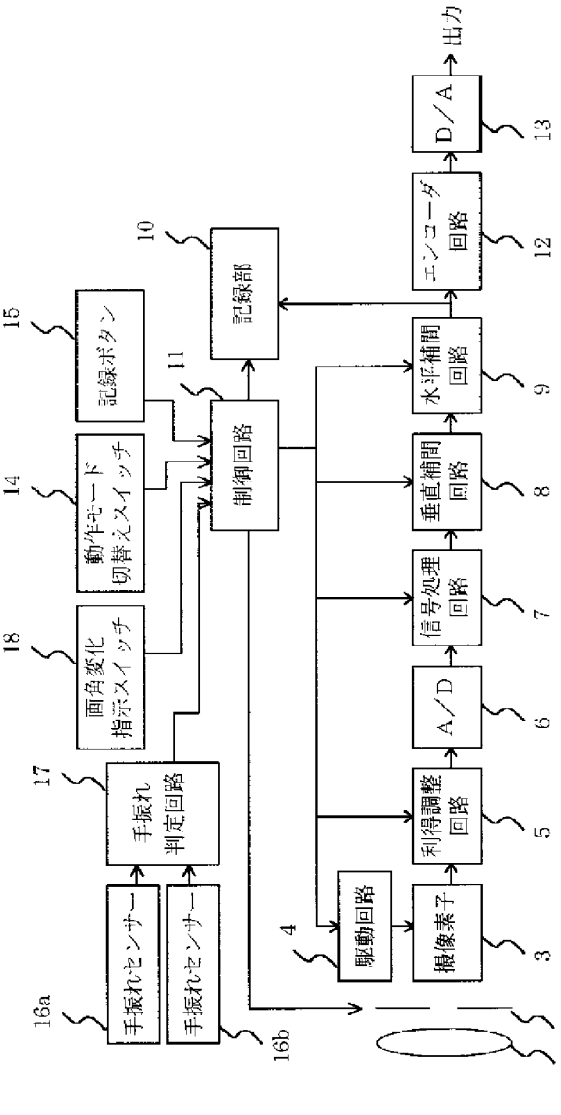
【図６】

【図６】



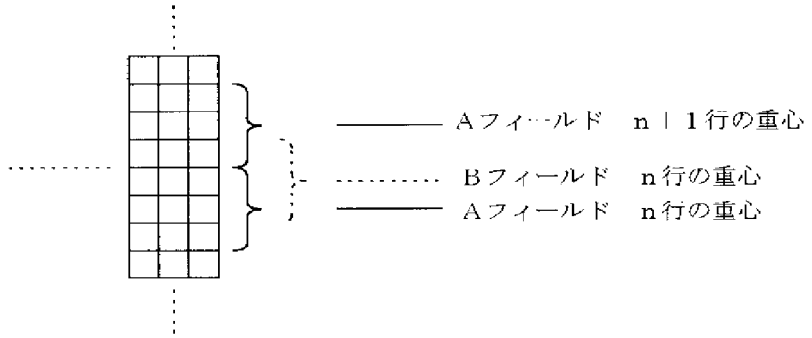
【図７】

【図７】


レンズ
絞り
1
2
撮像素子
3
駆動回路
4
利得調整回路
5
A／D
6
信号処理回路
7
垂直補間回路
8
水平補間回路
9
エンコーダ回路
12
D／A
13
出力
記録部
10
制御回路
11
動作モード切替えスイッチ
14
記録ボタン
15
画角変化指示スイッチ
18
手振れ判定回路
17
手振れセンサー
16a
手振れセンサー
16b

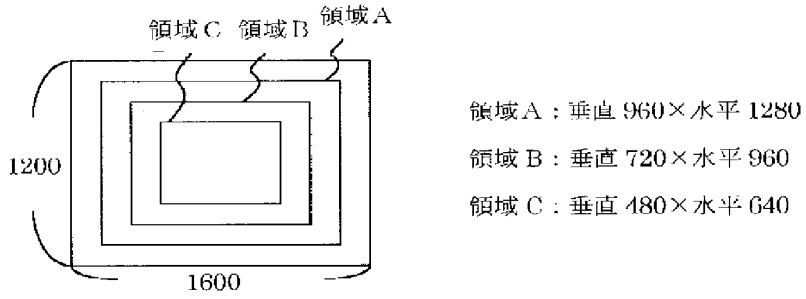
【図８】

【図８】


Aフィールド　n＋1行の重心
Bフィールド　n行の重心
Aフィールド　n行の重心

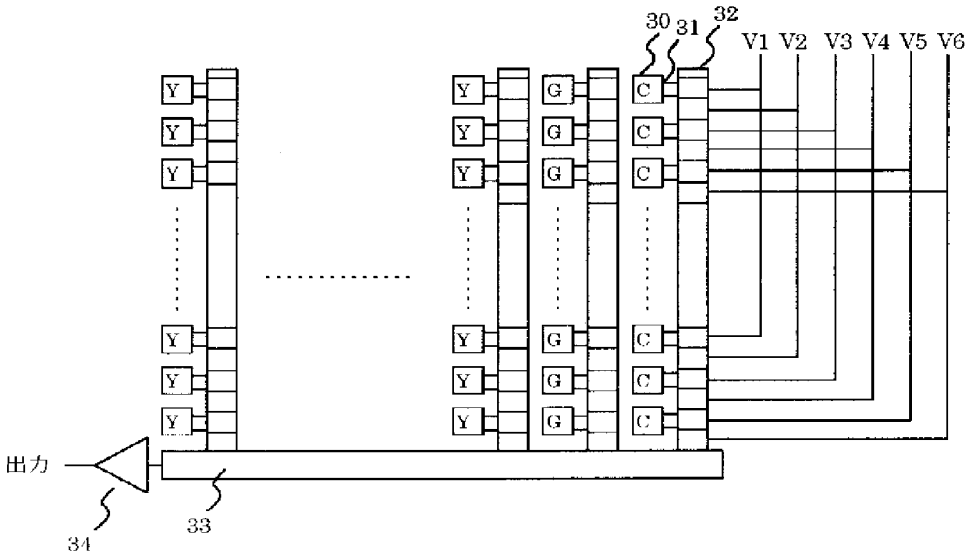
【図９】

【図９】

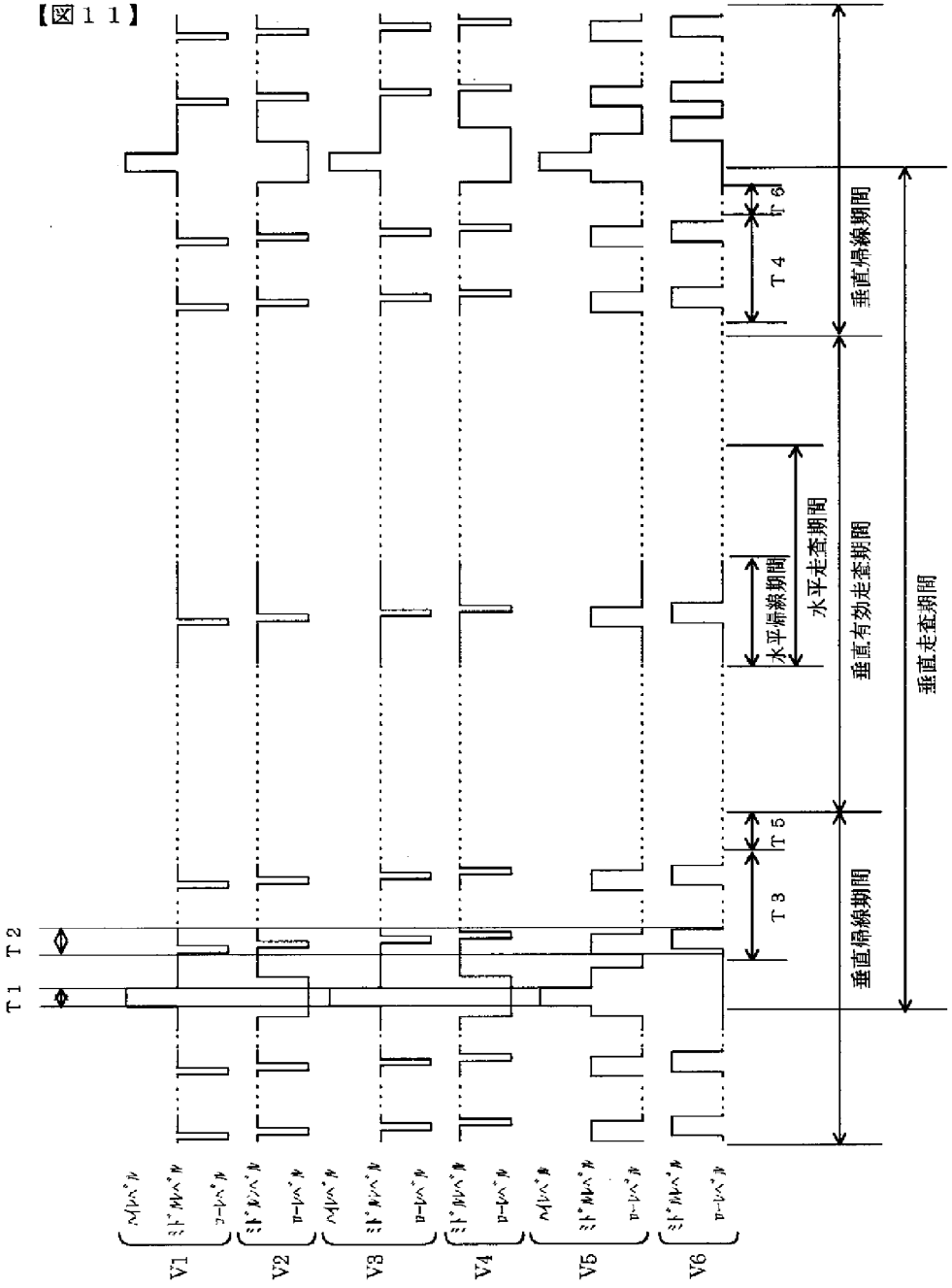

領域C
領域B
領域A
1200
1600
領域A：垂直960×水平1280
領域B：垂直720×水平960
領域C：垂直480×水平640

【図１０】

【図１０】

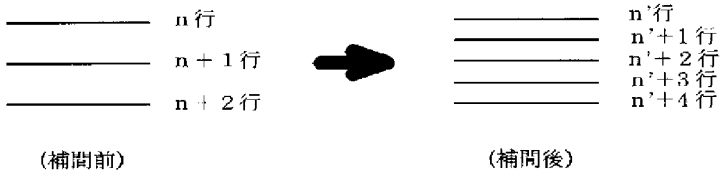


【図１１】


【図１１】
T1
T2
V1
V2
V3
V4
V5
V6
T3
T4
T5
T6
垂直帰線期間
水平帰線期間
水平走査期間
垂直有効走査期間
垂直走査期間

【図１２】

【図１２】



【図１３】

【図１３】

Ye	W	Cy
Ye	W	Cy
Ye	W	Cy
Ye	W	Cy
Ye	W	Cy

（a）

R	G	B
R	G	B
R	G	B
R	G	B
R	G	B

（b）

【書類名】　要約書

【要約】

【課題】

静止画撮影に対して十分な画素数を持つ多画素の撮像素子を用いて良好な動画撮影および静止画撮影中のモニタリングを可能とすることを目的とする。

【解決手段】

テレビジョン方式の有効走査線数の３倍以上の任意の垂直方向の画素数を持つ撮像素子を用いて、動画撮影時および静止画撮影中のモニタリング時には、画素混合または間引き、垂直帰線期間中の信号読み出し、補間処理によりテレビジョン信号を生成し、静止画記録時には全画素の信号を独立に読み出して記録する。

【選択図】　図１

【書類名】　手続補正書
【あて先】　特許庁長官　殿
【事件の表示】
　【出願番号】　特願2000-　6064
【補正をする者】
　【識別番号】　000005108
　【氏名又は名称】　株式会社日立製作所
【代理人】
　【識別番号】　100100310
　【弁理士】
　【氏名又は名称】　井上　学
【発送番号】　366136
【手続補正1】
　【補正対象書類名】　明細書
　【補正対象項目名】　特許請求の範囲
　【補正方法】　変更
　【補正の内容】
【特許請求の範囲】
　【請求項１】
　テレビジョン方式の一表示画面の有効走査線数Ｍの３倍以上の数Ｎの画素を垂直方向に、任意の数の画素を水平方向に配した受光面であって、該受光面を構成する画素配列の各画素に対して、水平方向に第一、第二、および第三の各色を各々透過する色フィルターを三画素周期で周期的に配し、垂直方向には同一種類の色を透過する色フィルターを配した受光面を備えた撮像素子と、
　該画素配列の各画素に蓄積された信号電荷を、ＮをＭで除した商の整数部またはそれ以下の整数の内少なくとも一つの整数であるところのＫ画素周期で、垂直方向に混合または間引きを行い、前記有効走査線数Ｍに相当するライン数の出力信号を得るように該撮像素子を駆動する駆動手段と、
　前記撮像素子の出力信号を用いて画像信号を生成する信号処理手段と、
　該画像信号を、テレビジョン方式の表示画面を備えた表示手段に出力する出力手段と、
　を備え、
　該駆動手段は、静止画モニタ時の画像信号を該表示手段が表示する場合には、Ｋ１画素周期で垂直方向に混合または間引きを行い、動画時の画像信号を該表示手段が表示する場合には、Ｋ２画素周期で垂直方向に混合または間引きを行うことを特徴とする撮像装置。
　【請求項２】
　前記駆動手段は、前記撮像素子の垂直方向の画素数Ｎから前記混合または間引き周期Ｋと前記有効走査線数Ｍとの積Ｋ・Ｍを減じた数の垂直画素に対応する画素領域の信号電荷を前記テレビジョン方式の垂直帰線期間内に読み出しまたは掃き捨てることにより、前記テレビジョン方式の有効垂直走査期間内に、前記撮像素子の画素の内Ｋ・Ｍの垂直画素に相当する画素領域の信号電荷を切り出して、前記有効走査線数Ｍに相当するライン数の出力信号を得るように前記撮像素子を駆動することを特徴とする請求項１記載の撮像装置。
　【請求項３】
　前記信号処理手段は、該撮像素子の該受光面の内、該切り出した垂直領域に対して該テレビジョン方式の縦横比と略等しくなる水平領域部分に相当する出力信号期間のみを切り出して該テレビジョン方式の有効水平走査期間全体にわたって出力する機能を有することを特徴とする請求項１または２記載の撮像装置。
　【請求項４】
　前記駆動手段は、該テレビジョン方式の表示周期毎に該混合または間引きの画素位置をずらすことによりインターレース信号を出力するように該撮像素子を駆動することを特徴とする請求項１～３のいずれか１項に記載の撮像装置。

【請求項５】
前記信号処理手段は、該混合または間引きによって得られるインターレース出力信号の垂直方向の重心位置が表示周期毎に１８０度の位相差となるように補間する機能を有することを特徴とする請求項４記載の撮像装置。
【請求項６】
前記撮像素子の該駆動手段は、装置内部または外部に設けたズームスイッチ等の画角変化を指示するスイッチ手段からの入力情報に対応して、該混合または間引きの画素周期を変化させることを特徴とする請求項１ないし５のいずれかに記載の撮像装置。
【請求項７】
前記撮像素子の出力信号の利得を調整する利得調整手段を有し、該撮像素子の混合の画素周期が変化した時にも、該利得調整手段の出力信号レベルが同一になるように、混合画素周期に対応して該利得調整手段の利得を変化させることを特徴とする請求項１ないし６のいずれかに記載の撮像装置。
【請求項８】
前記撮像装置の手振れを検出する手振れ検出手段を有し、該手振れ検出手段で検出した手振れ量に応じて、該受光面内における垂直方向及び水平方向の切り出し位置を、該手振れを補正するように変化させることを特徴とする請求項１～７のいずれか１項に記載の撮像装置。
【請求項９】
テレビジョン方式の一表示画面の有効走査線数Ｍの３倍以上の数Ｎの画素を垂直方向に、任意の数の画素を水平方向に配した受光面であって、該受光面を構成する画素配列の各画素に対して、水平方向に第一、第二、および第三の各色を各々透過する色フィルターを三画素周期で周期的に配し、垂直方向には同一種類の色を透過する色フィルターを配した受光面を備えた撮像素子と、
該画素配列の各画素に蓄積された信号電荷を、ＮをＭで除した商の整数部より大きな整数であるところのＫ画素周期で、垂直方向に混合または間引きを行い、前記テレビジョン方式の有効垂直走査期間内に、前記撮像素子の垂直画素数ＮのＫ分の一のライン数の出力信号を得るように前記撮像素子を駆動する駆動手段と、
前記撮像素子の出力信号を用いて画像信号を生成する機能を有する信号処理手段と、
該画像信号を、テレビジョン方式の表示画面を備えた表示手段に出力する出力手段と、
を備え、
該駆動手段は、第１の画像信号を該表示手段が表示する場合には、Ｋ１画素周期で垂直方向に混合または間引きを行い、第２の画像信号を該表示手段が表示する場合には、Ｋ２画素周期で垂直方向に混合または間引きを行うことを特徴とする撮像装置。
【請求項１０】
テレビジョン方式の一表示画面の有効走査線数Ｍの３倍以上の数Ｎの画素を垂直方向に、任意の数の画素を水平方向に配した受光面であって、該受光面を構成する画素配列の各画素に対して、水平方向に第一、第二、および第三の各色を各々透過する色フィルターを三画素周期で周期的に配し、垂直方向には同一種類の色を透過する色フィルターを配した受光面を備えた撮像素子と、
該画素配列の各画素に蓄積された信号電荷を、ＮをＭで除した商の整数部またはそれ以下の整数の内少なくとも一つの整数であるところのＫ画素周期で、垂直方向に混合または間引きを行い、前記有効走査線数Ｍに相当するライン数の出力信号を得るように該撮像素子を駆動する第１の駆動手段と、
該画素配列の各画素に蓄積された信号電荷を、ＮをＭで除した商の整数部より大きな整数であるところのＫ画素周期で、垂直方向に混合または間引きを行い、前記テレビジョン方式の有効垂直走査期間内に、前記撮像素子の垂直画素数ＮのＫ分の一のライン数の出力信号を得るように前記撮像素子を駆動する第２の駆動手段と、
前記撮像素子の出力信号を用いて画像信号を生成する信号処理手段と、
該画像信号を、テレビジョン方式の表示画面を備えた表示手段に出力する出力手段と、

を備え、
前記第１の駆動手段は、第１の画像信号を該表示手段が表示する場合には、Ｋ１画素周期で垂直方向に混合または間引きを行い、第２の画像信号を該表示手段が表示する場合には、Ｋ２画素周期で垂直方向に混合または間引きを行い、
前記第１の駆動手段による駆動と前記第２の駆動手段による駆動とを、装置内部または外部に設けたスイッチ手段からの入力情報に対応して選択、切り替えを行うことを特徴とする撮像装置。
【請求項１１】
シャッターボタン等のトリガー手段を有し、該トリガー手段によりトリガーが発生した時には、該撮像素子の各画素に蓄積した信号電荷を混合せずに全画素独立で読み出すことを特徴とする請求項１～１０のいずれか１項に記載の撮像装置。
【請求項１２】
前記第一、第二、および第三の各色は各々黄色、緑、シアンであることを特徴とする請求項１ないし１１のいずれかに記載の撮像装置。
【請求項１３】
前記第一、第二、および第三の各色は各々黄色、白色、シアンであることを特徴とする請求項１ないし１１のいずれかに記載の撮像装置。
【請求項１４】
前記第一、第二、および第三の各色は各々赤、緑、青であることを特徴とする請求項１ないし１１のいずれかに記載の撮像装置。
【請求項１５】
請求項１ないし１４のいずれかにおいて、
前記Ｋ１は前記Ｋ２よりも小さい値であることを特徴とする撮像装置。

【書類名】　手続補正書
【あて先】　特許庁長官　殿
【事件の表示】
　【出願番号】　特願2000-　6064
【補正をする者】
　【識別番号】　000005108
　【氏名又は名称】　株式会社日立製作所
【代理人】
　【識別番号】　100100310
　【弁理士】
　【氏名又は名称】　井上　学
【発送番号】　156904
【手続補正1】
　【補正対象書類名】　明細書
　【補正対象項目名】　特許請求の範囲
　【補正方法】　変更
　【補正の内容】
【特許請求の範囲】
　【請求項１】
　テレビジョン方式の一表示画面の有効走査線数Ｍの３倍以上の数Ｎの画素を垂直方向に、任意の数の画素を水平方向に配した受光面であって、該受光面を構成する画素配列の各画素に対して、水平方向に第一、第二、および第三の各色を各々透過する色フィルターを三画素周期で周期的に配し、垂直方向には同一種類の色を透過する色フィルターを配した受光面を備えた撮像素子と、
　該画素配列の各画素に蓄積された信号電荷を、ＮをＭで除した商の整数部またはそれ以下の整数の内少なくとも一つの整数であるところのＫ１画素周期で、垂直方向に混合または間引きを行い、または、該画素配列の各画素に蓄積された信号電荷の一部を、ＮをＭで除した商の整数部またはそれ以下の整数の内少なくとも一つの整数であるところのＫ２（Ｋ１＞Ｋ２）画素周期で、垂直方向に混合または間引きを行い、前記有効走査線数Ｍに相当するライン数の出力信号を得るように該撮像素子を駆動し、または、該画素配列の各画素に蓄積された信号電荷を混合または間引きを行わないで該撮像素子を駆動する駆動手段と、
　前記撮像素子の出力信号を用いて画像信号を生成する信号処理手段と、
　該画像信号を、テレビジョン方式の表示画面を備えた表示手段に出力する出力手段と、
　を備え、
　該駆動手段は、静止画モニタ時の画像信号を該表示手段が表示する場合には、該画素配列の各画素に蓄積された信号電荷をＫ１画素周期で垂直方向に混合または間引きを行い、動画時の画像信号を該表示手段が表示する場合には、該画素配列の各画素に蓄積された信号電荷の一部をＫ２画素周期で垂直方向に混合または間引きを行い、静止画を撮像する場合には、混合または間引きを行わないことを特徴とする撮像装置。
　【請求項２】
　前記駆動手段は、前記撮像素子の垂直方向の画素数Ｎから前記混合または間引き周期Ｋと前記有効走査線数Ｍとの積Ｋ・Ｍを減じた数の垂直画素に対応する画素領域の信号電荷を前記テレビジョン方式の垂直帰線期間内に読み出しまたは掃き捨てることにより、前記テレビジョン方式の有効垂直走査期間内に、前記撮像素子の画素の内Ｋ・Ｍの垂直画素に相当する画素領域の信号電荷を切り出して、前記有効走査線数Ｍに相当するライン数の出力信号を得るように前記撮像素子を駆動することを特徴とする請求項１記載の撮像装置。
　【請求項３】
　前記信号処理手段は、該撮像素子の該受光面の内、該切り出した垂直領域に対して該テレビジョン方式の縦横比と略等しくなる水平領域部分に相当する出力信号期間のみを切り

出して該テレビジョン方式の有効水平走査期間全体にわたって出力する機能を有することを特徴とする請求項１または２記載の撮像装置。

【請求項４】

前記駆動手段は、該テレビジョン方式の表示周期毎に該混合または間引きの画素位置をずらすことによりインターレース信号を出力するように該撮像素子を駆動することを特徴とする請求項１～３のいずれか１項に記載の撮像装置。

【請求項５】

前記信号処理手段は、該混合または間引きによって得られるインターレース出力信号の垂直方向の重心位置が表示周期毎に１８０度の位相差となるように補間する機能を有することを特徴とする請求項４記載の撮像装置。

【請求項６】

前記撮像素子の該駆動手段は、装置内部または外部に設けたズームスイッチ等の画角変化を指示するスイッチ手段からの入力情報に対応して、該混合または間引きの画素周期を変化させることを特徴とする請求項１ないし５のいずれかに記載の撮像装置。

【請求項７】

前記撮像素子の出力信号の利得を調整する利得調整手段を有し、該撮像素子の混合の画素周期が変化した時にも、該利得調整手段の出力信号レベルが同一になるように、混合画素周期に対応して該利得調整手段の利得を変化させることを特徴とする請求項１ないし６のいずれかに記載の撮像装置。

【請求項８】

前記撮像装置の手振れを検出する手振れ検出手段を有し、該手振れ検出手段で検出した手振れ量に応じて、該受光面内における垂直方向及び水平方向の切り出し位置を、該手振れを補正するように変化させることを特徴とする請求項１～７のいずれか１項に記載の撮像装置。

【請求項９】

テレビジョン方式の一表示画面の有効走査線数Ｍの３倍以上の数Ｎの画素を垂直方向に、任意の数の画素を水平方向に配した受光面であって、該受光面を構成する画素配列の各画素に対して、水平方向に第一、第二、および第三の各色を各々透過する色フィルターを二画素周期で周期的に配し、垂直方向には同一種類の色を透過する色フィルターを配した受光面を備えた撮像素子と、

該画素配列の各画素に蓄積された信号電荷を、ＮをＭで除した商の整数部より大きな整数であるところのＫ１画素周期で、垂直方向に混合または間引きを行い、または、該画素配列の各画素に蓄積された信号電荷の一部を、ＮをＭで除した商の整数部またはそれ以下の整数の内少なくとも一つの整数であるところのＫ２（Ｋ１＞Ｋ２）画素周期で、垂直方向に混合または間引きを行い、前記テレビジョン方式の有効垂直走査期間内に、前記撮像素子の垂直画素数ＮのＫ分の一のライン数の出力信号を得るように前記撮像素子を駆動し、または、該画素配列の各画素に蓄積された信号電荷を混合または間引きを行わないで該撮像素子を駆動する駆動手段と、

前記撮像素子の出力信号を用いて画像信号を生成する機能を有する信号処理手段と、

該画像信号を、テレビジョン方式の表示画面を備えた表示手段に出力する出力手段と、

を備え、

該駆動手段は、第１の画像信号を該表示手段が表示する場合には、該画素配列の各画素に蓄積された信号電荷をＫ１画素周期で垂直方向に混合または間引きを行い、第２の画像信号を該表示手段が表示する場合には、該画素配列の各画素に蓄積された信号電荷の一部をＫ２画素周期で垂直方向に混合または間引きを行い、第３の画像信号を撮像する場合には、混合または間引きを行わないことを特徴とする撮像装置。

【請求項１０】

テレビジョン方式の一表示画面の有効走査線数Ｍの３倍以上の数Ｎの画素を垂直方向に、任意の数の画素を水平方向に配した受光面であって、該受光面を構成する画素配列の各画素に対して、水平方向に第一、第二、および第三の各色を各々透過する色フィルターを

三画素周期で周期的に配し、垂直方向には同一種類の色を透過する色フィルターを配した受光面を備えた撮像素子と、
該画素配列の各画素に蓄積された信号電荷を、ＮをＭで除した商の整数部またはそれ以下の整数の内少なくとも一つの整数であるところのＫ１画素周期で、垂直方向に混合または間引きを行い、または、該画素配列の各画素に蓄積された信号電荷の一部を、ＮをＭで除した商の整数部またはそれ以下の整数の内少なくとも一つの整数であるところのＫ２（Ｋ１＞Ｋ２）画素周期で、垂直方向に混合または間引きを行い、前記有効走査線数Ｍに相当するライン数の出力信号を得るように該撮像素子を駆動し、または、該画素配列の各画素に蓄積された信号電荷を混合または間引きを行わないで該撮像素子を駆動する第１の駆動手段と、
該画素配列の各画素に蓄積された信号電荷を、ＮをＭで除した商の整数部より大きな整数であるところのＫ画素周期で、垂直方向に混合または間引きを行い、前記テレビジョン方式の有効垂直走査期間内に、前記撮像素子の垂直画素数ＮのＫ分の一のライン数の出力信号を得るように前記撮像素子を駆動する第２の駆動手段と、
前記撮像素子の出力信号を用いて画像信号を生成する信号処理手段と、
該画像信号を、テレビジョン方式の表示画面を備えた表示手段に出力する出力手段と、
を備え、
前記第１の駆動手段は、第１の画像信号を該表示手段が表示する場合には、該画素配列の各画素に蓄積された信号電荷をＫ１画素周期で垂直方向に混合または間引きを行い、第２の画像信号を該表示手段が表示する場合には、該画素配列の各画素に蓄積された信号電荷の一部をＫ２画素周期で垂直方向に混合または間引きを行い、第３の画像信号を撮像する場合には、混合または間引きを行わず、
前記第１の駆動手段による駆動と前記第２の駆動手段による駆動とを、装置内部または外部に設けたスイッチ手段からの入力情報に対応して選択、切り替えを行うことを特徴とする撮像装置。
【請求項１１】
シャッターボタン等のトリガー手段を有し、該トリガー手段によりトリガーが発生した時には、該撮像素子の各画素に蓄積した信号電荷を混合せずに全画素独立で読み出すことを特徴とする請求項１～１０のいずれか１項に記載の撮像装置。
【請求項１２】
前記第一、第二、および第三の各色は各々黄色、緑、シアンであることを特徴とする請求項１ないし１１のいずれかに記載の撮像装置。
【請求項１３】
前記第一、第二、および第三の各色は各々黄色、白色、シアンであることを特徴とする請求項１ないし１１のいずれかに記載の撮像装置。
【請求項１４】
前記第一、第二、および第三の各色は各々赤、緑、青であることを特徴とする請求項１ないし１１のいずれかに記載の撮像装置。

【手続補正2】
【補正対象書類名】　明細書
【補正対象項目名】　００１３
【補正方法】　変更
【補正の内容】
【００１３】
【課題を解決するための手段】
上記目的を達成するため、本発明では一例として、特許請求の範囲記載の構成を用いる。

出願人履歴

０００００５１０８

19900831

新規登録

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住所変更

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08

CONFIRMATION NO. 3687

24956
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

PUBLICATION NOTICE

OC000000090606499

Title:ELECTRIC CAMERA

Publication No.US-2017-0104945-A1
Publication Date:04/13/2017

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

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Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) : HITACHI MAXELL, LTD.

Confirmation No.: 3687

Serial No. : 15/386,656

Filed : December 21, 2016

For : ELECTRIC CAMERA

Group : 2663

Examiner : Luong TRUNG NGUYEN

Docket No. : ASA-9606-08

Customer No.: 24956

AMENDMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

August 4, 2017

Sir:

In response to the Office Action mailed February 8, 2017, please amend the above-identified patent application as follows. A fee for a 3-month Extension of Time accompanies this response.

Amendments to the Claims begin on page 2 of this paper.

Remarks begin on page 6 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (currently amended) An electric camera comprising:

an image sensing device with a light receiving surface having ~~N vertically arranged~~ an array of pixels ~~and an arbitrary number of pixels~~ arranged vertically and horizontally, ~~N being equal to or more than three times the number of effective scanning lines M of a display screen of a television system;~~ and configured to output signals accumulated in the pixels with an interval of a plurality of vertical pixels;

~~a driver to drive the image sensing device to vertically mix or cull signal charges accumulated in individual pixels of every K pixels to produce a number of lines of output signals which corresponds to the number of effective scanning lines M, K being at least one of integers equal to or less than an integral part of a quotient of N divided by M; and~~

a signal processing unit configured to generate image signals by using the ~~out put~~ signals ~~of the~~outputted by the image sensing device; and

a zoom operation unit configured to operate to continuously change a magnification factor;

wherein, as the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise.

2. (New) The electric camera according to claim 1,

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels including:

a first state in which the image signals are generated using signals based on a first area of the light receiving surface with a first magnification factor,

a second state in which the image signals are generated using signals based on a second area of the light receiving surface with a second magnification factor, and

a third state in which the image signals are generated using signals based on a third area, and

wherein, while the zoom operation unit is operated to continuously change the magnification factor, the image signals are generated as continuously magnified images while the states of the electric camera are changed stepwise from the first state to the third state via the second state.

3. (New) The electric camera according to claim 2,

wherein, while the state is between the first state and the second state when the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs signals with a first interval of vertical pixels,

wherein, while the state is between the second state and the third state when the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs signals with a second interval of vertical pixels which is different from the first interval.

4. (New) The electric camera according to claim 3,

wherein the image sensing device outputs the signals which are mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

5. (New) The electric camera according to claim 3,

wherein, as the zoom operation unit is operated to continuously change the magnification factor during recording of a moving video in a moving video mode, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise.

6. (New) The electric camera according to claim 3,

wherein the electric camera has a static image mode for taking a static image and, when in the static image mode, the signal processing unit generates the static

image by using all signals accumulated in all of an effective number of the vertical pixels.

REMARKS

Claims 1-6 are pending in this application. Claim 1 has been amended. New claims 2-6 have been added. No new matter has been added.

Claim for Priority

Applicant notes that a Request was submitted on February 9, 2017 to correct the foreign priority information. A corrected Official Filing Receipt was mailed from the Office on February 14, 2017 showing the correct foreign priority information.

Information Disclosure Statement

Applicant appreciates the Examiner's consideration of the references submitted in the Information Disclosure Statement filed December 21, 2016.

Claim Objections

Claim 1 has been amended to overcome the objection.

Rejections Under 35 U.S.C. §112

Claim 1 has been interpreted under 35 U.S.C. §112, sixth paragraph. Claim 1 has been amended to avoid any presumption that §112, sixth paragraph, is invoked.

Double Patenting Rejections

Claim 1 stands rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1, 4 and 13 of U.S. Patent Nos. 6,765,616, 7,403,226, 8,059,177, 9,100,604 and 9,544,517.

It is submitted that the amendments to claim 1 render the double patenting rejections moot.

Rejections Under 35 U.S.C. §§ 102 and 103

Claim 1 stands rejected under 35 U.S.C. §102(e) as being anticipated by Kijima et al. (U.S. 6,661,451).

Applicants request reconsideration of the rejections in view of the foregoing amendments and for the following reasons.

Claim 1 has been amended for clarification. *See* US 2017/0104945 at paras. [0071], for example, for support. New claims 2-6 depend on claim 1 as a base claim. According to claim 1, an electric camera includes:

> an image sensing device with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals accumulated in the pixels with an interval of a plurality of vertical pixels;
>
> a signal processing unit configured to generate image signals by using the signals outputted by the image sensing device; and
>
> a zoom operation unit configured to operate to continuously change a magnification factor;
>
> wherein, as the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise.

According to MPEP 2131, a claim is anticipated under 35 U.S.C. §102 only if each and every element as set forth in the claim is found in a single prior art reference. Further, the identical invention must be shown in as complete detail as is contained in the claim. As to the foregoing §102 rejection, it is submitted that each and every element set forth in claim 1 is not present in Kijima. In particular, Kijima is silent that "as the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise" as recited in claim 1. Moreover, it is submitted that Kijima and the remaining art of record fail to achieve the advantageous effects of the claimed invention as described at para. [0072] of US 2017/0104945.

In view of the foregoing, it is submitted that claim 1 is patentable over the art of record. Further, dependent claims 2-6 are patentable over the art of record at least for being dependent upon a base claim asserted to be allowable. As such, it is respectfully requested that the rejection under 35 U.S.C. §102 be withdrawn.

Conclusion

In view of the foregoing amendments and remarks, Applicants request reconsideration of the rejection and allowance of the claims.

The Commissioner is authorized to charge any shortage in the fees due, or credit any overpayment, to Deposit Account No. 50-1417 (referencing Attorney Docket No. ASA-9606-08).

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Registration No. 30,293
703-684-1120

Electronic Patent Application Fee Transmittal

Application Number:	15386656
Filing Date:	21-Dec-2016
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly/Krista Hargrove
Attorney Docket Number:	ASA-9606-08

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension - 3 months with $0 paid	1253	1	1400	1400
Miscellaneous:				
		Total in USD ($)		**1400**

Electronic Acknowledgement Receipt	
EFS ID:	29983939
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly
Filer Authorized By:	
Attorney Docket Number:	ASA-9606-08
Receipt Date:	04-AUG-2017
Filing Date:	21-DEC-2016
Time Stamp:	13:27:40
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1400
RAM confirmation Number	080417INTEFSW13290300
Deposit Account	501417
Authorized User	John Mattingly
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		9606-08-AMD01.pdf	40825 d8fe32f799bf2717807be409b4e398c58ed6a44a	yes	9

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	5
	Applicant Arguments/Remarks Made in an Amendment	6	9

Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30663 985370fc5f8d30b5256899196c69ee24029eb740	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	71488		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/386,656	Filing Date 12/21/2016	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)		
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	08/04/2017	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 6	Minus	** 20	= 0	X $80 =	0
	Independent (37 CFR 1.16(h))	* 1	Minus	***3	= 0	X $420 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
Frederick Briscoe

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08	3687

24956 7590 11/16/2017

MATTINGLY & MALUR, PC
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ALEXANDRIA, VA 22314

EXAMINER
NGUYEN, LUONG TRUNG

ART UNIT	PAPER NUMBER
2663	

NOTIFICATION DATE	DELIVERY MODE
11/16/2017	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

Office Action Summary	Application No. 15/386,656	Applicant(s) NAKANO ET AL.	
	Examiner LUONG T. NGUYEN	Art Unit 2663	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *08/04/2017*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-6* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-6* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☒ All b)☐ Some** c)☐ None of the:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

DETAILED ACTION

1. The present application is being examined under the pre-AIA first to invent provisions.

Priority

2. Receipt is acknowledged of certified copies of papers required by 37 CFR 1.55.

Response to Arguments

3. Applicant's arguments with respect to added claims 2-6 filed on 08/04/2017 have been considered but are moot because the arguments do not apply to any of the references being used in the current rejection.

4. Applicant's arguments, with respect to rejection of claim 1 on the ground of nonstatutory double patenting as being unpatentable over claims 1, 4 of U.S. Patent No. 9,544,517, filed on 08/04/2017 have been fully considered but they are not persuasive.

Since the Applicants fail to specifically point out the error in the rejection of claim 1 on the ground of nonstatutory double patenting as being unpatentable over claims 1, 4 of U.S. Patent No. 9,544,517; the Examiner considers that the patent claims 1, 4 still contain all the limitations of the amended claim 1 of the instant application as discussed below.

5. Applicant's arguments, with respect to limitation of claim 1 has been interpreted under 35 U.S.C. 112, sixth paragraph, filed 08/04/2017 have been fully considered but they are not persuasive.

The Applicants argued that the Applicant have amended the limitation "a signal processing unit to generate image signals ... " to "a signal processing unit configured to generate image signals ... " to avoid any presumption that § 112, sixth paragraph is invoked.

The Examiner considers that the limitation "**a signal processing unit** configured to generate image signals ... " as amended still being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because it meets three Prong Test, Prong (A): it uses a generic placeholder "unit," Prong (B): the term "unit" coupled with functional language "configured to generate image signals," Prong (C): the term "unit" is not modified by sufficient structure, material, or acts to perform the claimed function.

Therefore, the claim limitation "signal processing unit" as recited in claim 1 still being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

Claim Objections

6. Claims 3-6 are objected to because of the following informalities:

Claim 3 (line 2), "the state" should be changed to --a state--.

Claim 3 (line 5), "the state" should be changed to --a state--.

Claims 4-6 are objected as being dependent from claim 3.

Appropriate correction is required.

Claim Interpretation - 35 USC § 112

7. The following is a quotation of 35 U.S.C. 112(f):

> (f) Element in Claim for a Combination. – An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

The following is a quotation of pre-AIA 35 U.S.C. 112, sixth paragraph:

> An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

8. Use of the word "means" (or "step for") in a claim with functional language creates a rebuttable presumption that the claim element is to be treated in accordance with 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112, sixth paragraph). The presumption that 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112, sixth paragraph) is invoked is rebutted when the function is recited with sufficient structure, material, or acts within the claim itself to entirely perform the recited function.

Absence of the word "means" (or "step for") in a claim creates a rebuttable presumption that the claim element is not to be treated in accordance with 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112, sixth paragraph). The presumption that 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112, sixth paragraph) is not invoked is rebutted when the claim element recites function but fails to recite sufficiently definite structure, material or acts to perform that function.

Claim elements in this application that use the word "means" (or "step for") are presumed to invoke 35 U.S.C. 112(f) except as otherwise indicated in an Office action. Similarly, claim elements that do not use the word "means" (or "step for") are presumed not to invoke 35 U.S.C. 112(f) except as otherwise indicated in an Office action.

9. Claim limitation "signal processing unit, " "zoom operation unit, "as recited in claim 1 has been interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because it uses a generic placeholder "unit" coupled with functional language "configured to generate image signals," "configured to operate," without reciting sufficient structure to achieve the function. Furthermore, the generic placeholder is not preceded by a structural modifier. Note that "signal processing," "zoom operation," each is not a structural modifier.

Since the claim limitation invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, claim 1 has been interpreted to cover the corresponding structure described in the specification that achieves the claimed function, and equivalents thereof.

A review of the specification shows that the following appears to be the corresponding structure described in the specification for the 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph limitation:

"signal processing circuit 7" disclosed in Figures 1, 7, Specification, pages 9, 27 for claim limitation "signal processing circuit unit."

"view angle change switch 18" disclosed in Figure 7, Specification, pages 25-26 for claim limitation "zoom operation unit."

If applicant wishes to provide further explanation or dispute the examiner's interpretation of the corresponding structure, applicant must identify the corresponding structure with reference to the specification by page and line number, and to the drawing, if any, by reference characters in response to this Office action.

If applicant does not intend to have the claim limitation(s) treated under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112 , sixth paragraph, applicant may amend the claim(s) so that it/they will clearly not invoke 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, or present a sufficient showing that the claim recites/recite sufficient structure, material, or acts for performing the claimed function to preclude application of 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

For more information, see MPEP § 2173 *et seq.* and *Supplementary Examination Guidelines for Determining Compliance With 35 U.S.C. 112 and for Treatment of Related Issues in Patent Applications*, 76 FR 7162, 7167 (Feb. 9, 2011).

Claim Rejections - 35 USC § 112

10. The following is a quotation of 35 U.S.C. 112(b):

> (b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

11. Claims 2-6 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject

matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Claim 2 (line 13) recites the limitation "the" in "the states". There is insufficient antecedent basis for this limitation in the claim.

It should be noted that claim 2 (line 2) recites limitation "at least three states," claim 2 (line 4) recites limitation "a first state," claim 2 (line 6) recites limitation "a second state," claim 2 (line 9) recites limitation "a third state;" it is not known that the limitation "the states" as recited in claim 2 (line 13) corresponds to limitation "at least three states" as recited in claim 2 (line 2) or limitation "a first state" as recited in claim 2 (line 4) and limitation "a second state" as recited in claim 2 (line 6) and limitation "a third state" as recited in claim 2 (line 9).

Claims 3-6 are rejected as being dependent from claim 2.

Double Patenting

12. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the claims at issue are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); In re Vogel, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the reference application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under

the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/forms/. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to http://www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

13. Claim 1 is rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1, 4 of U.S. Patent No. 9,544,517. Although the conflicting claims are not identical, they are not patentably distinct from each other because of the following reasons.

Claim 1 of the instant application is anticipated by patent claim 1 in that claim 1 of the patent contains all the limitations of claim 1 of the instant application. Claim 1 of the instant application therefore is not patently distinct from the earlier patent claim and as such is unpatentable for obvious-type double patenting.

Claim 1 of the instant application is anticipated by patent claim 4 in that claim 4 of the patent contains all the limitations of claim 1 of the instant application. Claim 1 of the instant application therefore is not patently distinct from the earlier patent claim and as such is unpatentable for obvious-type double patenting.

The similar limitations of claims 1 and 4 of U.S. Patent No. 9,544,517 and limitations of claim 1 of the instant application are compared as shown in the table below.

US 9,544,517	**INSTANT APPLICATION**
1. **An electric camera** comprising: **an image sensing device** with a light receiving surface having **an array of vertically and horizontally arranged pixels** including N vertically arranged pixels, where N is an integer greater than or equal to three times an integer of M which is a number of effective scanning lines of a display screen of a television system; a driver configured to drive the image sensing device to vertically mix or cull signals accumulated in individual pixels, **at intervals of K pixels**, in order to produce a plurality of lines of output signals which correspond to the M effective scanning lines, where K is an integer less than or equal to a whole number portion of a quotient of N divided by M;	1. **An electric camera** comprising: **an image sensing device** with a light receiving surface having **an array of pixels** arranged vertically and horizontally, and configured to output signals accumulated in the pixels with **an interval of a plurality of vertical pixels**; **a signal processing unit** configured to **generate image signals** by using the signals outputted by the image sensing device; and
a zoom operation unit configured to receive a request **to continuously change a view angle** of a moving image; and **a signal processing unit** configured to **generate image signals** of the moving image by using the output signals of the image sensing device, wherein the display screen displays the moving image, wherein, when the request **to continuously change a magnification factor** to magnify the moving image is received by the zoom operation unit, the driver: *drives the image sensing device to vertically mix or cull signals at intervals of K1 pixels in a first area on the image sensing device corresponding to a first image of the moving image, when the first image is displayed on a display unit, and* *drives the image sensing device to vertically mix or cull signals at intervals of K2 pixels in a*	**a zoom operation unit** configured to operate **to continuously change a magnification factor**; wherein, as the *zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise*.

second area on the image sensing device corresponding to a second image of the moving image, when the second image is displayed on the display unit, *wherein the magnification factor of the first image is smaller than the magnification factor of the second image, and a value of K1 is larger than a value of K2,* and wherein M, K1, and K2 are positive integers greater than 1.	
US 9,544,517	**INSTANT APPLICATION**
4. **An electric camera** comprising: **an image sensing device** with a light receiving surface having **an array of vertically and horizontally arranged pixels** including N vertically arranged pixels, where N is an integer greater than or equal to three times an integer of M which is a number of effective scanning lines of a display screen of a television system; a driver configured to drive the image sensing device to vertically mix or cull signals accumulated in individual pixels, **at intervals of K pixels**, in order to produce a plurality of lines of output signals which correspond to the M effective scanning lines, where K is an integer less than or equal to a whole number portion of a quotient of N divided by M; **an input unit** configured to enable a user to input a request **to continuously change a magnification factor to magnify an output image**; and **a signal processing unit** configured to **generate image signals of the output image**	1. **An electric camera** comprising: **an image sensing device** with a light receiving surface having **an array of pixels** arranged vertically and horizontally, and configured to output signals accumulated in the pixels with **an interval of a plurality of vertical pixels**; **a signal processing unit** configured to **generate image signals by using the signals outputted by the image sensing device**; and **a zoom operation unit** configured to operate **to continuously change a magnification factor**; wherein, as *the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise.*

by using the output signals of the image sensing device, *wherein the display screen displays the output image, wherein the image sensing device is driven in:* *a first state in which intervals of K1 pixels in a first area on the image sensing device are vertically mixed or culled, and* *a second state in which intervals of K2 pixels in a second area on the image sensing device are vertically mixed or culled,* *where a value of K2 is smaller than a value of K1, wherein the first state switches to the second state in response to the request to continuously change the magnification factor,* and wherein M, K1, and K2 are positive integers greater than 1.	

Conclusion

14. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period

will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

15. Any inquiry concerning this communication or earlier communications from the examiner should be directed to LUONG T. NGUYEN whose telephone number is (571)272-7315. The examiner can normally be reached on 7:30AM - 5:00PM, MONDAY -THURSDAY.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, TWYLER HASKINS can be reached on (571) 272-7406. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2663
11/09/17

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15386656	NAKANO ET AL.
	Examiner	Art Unit
	LUONG T NGUYEN	2663

CPC- SEARCHED		
Symbol	Date	Examiner
H04N5/372; H04N5/23248; H04N5/3741; H04N5/23258; H04N9/045; H04N5/3454; H04N5/23274	2/1/2017	LTN
H04N5/372, H04N5/23248, H04N5/3741, H04N5/23258, H04N9/045	11/9/2017	LTN

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

SEARCH NOTES		
Search Notes	Date	Examiner
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	2/1/2017	LTN
Inventorship search	2/1/2017	LTN
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	11/9/2017	LTN

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S38	92	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (sensor$1 or CCD$1 or CMOS) same ratio same zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:26
S39	20	S38 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:27
S40	6	("4843475" | "4963981" | "4969044" | "5023722" | "5107334" | "5420632").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/11/09 20:28
S41	1339	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (sensor$1 or CCD$1 or CMOS) same zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:29
S42	44476	(H04N5/372 or H04N5/23248 or H04N5/3741 or H04N5/23258 or H04N9/045).CPC.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:30
S43	127	S41 and S42	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:30
S44	19	S43 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:30
S45	502	zoom$3 same (magnification near factor) same (chang$3 or varying)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	ON	2017/11/09 20:34

			DERWENT; IBM_TDB			
S46	135	S45 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:34
S47	3	("4974088" | "5526041" | "5808670").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/11/09 20:36
S48	787	zoom$3 and (magnification near factor) same (chang$3 or varying)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:37
S49	48	S48 and S42	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:37
S50	24	("4054915" | "5170249" | "5187569" | "5287192" | "5402173" | "5438365" | "5638132" | "5734424" | "5828406" | "5847758" | "5986698" | "6195125" | "6519000" | "6661451" | "6765616" | "6781634" | "6798448" | "6906746" | "6970191" | "7154539" | "7352391" | "7403226" | "8059177" | "9100604").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/11/09 20:38
S51	6	("3932775" | "4761689" | "4800435" | "4839735" | "4980776" | "5105264").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/11/09 20:39
S52	6	zoom$3 same (magnification near factor) same (chang$3 or varying) same pixel$1 same interval	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:43
S53	171	zoom$3 and (magnification near factor) and (pixel$1 same interval)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:44
S54	59	S53 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:44
S55	4446	(mix$3 or combin$3 or cull$3 or add$3)	US-PGPUB;	OR	ON	2017/11/09

		same (pixel$1 or charge$1 or signal$1) same zoom$3 and (sensor$1 or CCD$1 or CMOS or camera)	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			20:45
S56	281	S55 and S42	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:46
S57	53	S56 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:46
S58	5693	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:48
S59	63	S48 and S58	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:49
S60	11	zoom$3 same ratio same (chang$3 or varying) same pixel$1 same interval	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:51
S61	5	(zoom$3 near factor) same (chang$3 or varying) same pixel$1 same interval	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:52
S62	508	(magnification near factor) and (pixel$1 same interval)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:52
S63	18	S62 and S42	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	2017/11/09 20:53

			IBM_TDB			
S64	10	("4286291" | "4528585" | "4660081" | "4774581" | "4792856" | "4814860" | "4951125" | "4991022" | "5083208" | "5333055").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/11/09 20:53
S65	13216	(scan$4 with line) and (NTSC or standard) and (television or TV) and (mix$3 or combin$3 or cull$3 or add$3) and (pixel$1 or charge$1 or signal$1) and (sensor$1 or CCD$1 or CMOS)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:54
S66	29	S62 and S65	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:54
S67	584	S42 and S65	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:56
S68	340	S67 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 20:56
S69	10	("20030122941" | "5170249" | "5343243" | "5502483" | "5668597" | "5734427" | "5786852" | "5986698" | "6148031" | "6614477").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/11/09 21:06
S70	14	("4057830" | "4096530" | "4890165" | "5019906" | "5247367" | "5335013" | "5422670" | "5450129" | "5748234" | "5786851" | "6137920" | "6259478" | "6285399" | "6359654").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/11/09 21:06
S71	3081	(magnification near factor) same (area or region)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 21:11
S72	282	(magnification near factor) same (area or region) same zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 21:11
S73	76	S72 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2017/11/09 21:11

			JPO; DERWENT; IBM_TDB			
S74	4	("5083208" | "5307167" | "5371539" | "5493333").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2017/11/09 21:21
S75	19	S71 and S65	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 21:27
S76	381	(magnification near ratio) same (area or region) same zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 21:28
S77	82	S76 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/11/09 21:28

EAST Search History (Interference)

< This search history is empty>

11/9/2017 11:20:42 PM
C:\Users\lnguyen2\Documents\EAST\Workspaces\15386656.wsp

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15386656	NAKANO ET AL.
	Examiner	Art Unit
	LUONG T NGUYEN	2663

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	02/01/2017	11/09/2017							
	1	✓	✓							
	2		✓							
	3		✓							
	4		✓							
	5		✓							
	6		✓							

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

CORRECTED ADS FORM

Application Number	15386656
Title of Invention	ELECTRIC CAMERA

Inventor Information

****If no data is shown, no data has been corrected****

	Data of Record	Updated Data
Order Number		
Name		
Residence Information		
Residency		
City		
State		
Country of Residence		
Mailing Address of Inventor		
Address 1		
Address 2		
City,State/Province, Postal Code		
Country		

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

Application Information

	Data of Record	Updated Data
Title of Invention	ELECTRIC CAMERA	
Attorney Docket Number	ASA-9606-08	
Entity Type	Regular Undiscounted	

Domestic Benefit/National Stage Information

****If no data is shown, no data has been corrected****

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121,365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S. C. 119(e) or 120, and 37 CFR 1.78(a).

		Data of Record	Updated Data
	Prior Application Status		
	Application Number		
	Continuity Type		
	Prior Application Number		
	Filing Date (YYYY-MM-DD)		
	Patent Number		
	Issue Date (YYYY-MM-DD)		

Foreign Priority Information

Document Description: Application Data Sheet to update/correct info
Doc Code: ADS.CORR

****If no data is shown, no data has been corrected****

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

		Data of Record	Updated Data
	Application Number		
	Country		
	Filing Date		
	Access Code		

Applicant Information

****If no data is shown, no data has been corrected****
Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

	Data of Record	Updated Data
Applicant Type	ASG	
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is		
Name of the Deceased or Legally Incapacitated Inventor		
Applicant is an Organization	Yes	
Name		
Organization Name	~~Hitachi Maxell, Ltd.~~	Maxell, Ltd.
Address 1		1, Koizumi, Oyamazaki, Oyamazaki-cho Otokuni-gun
Address 2		

Corrected ADS 1.0

City,State/Province,Postal Code	~~Osaka~~	Kyoto 618-8525
Country	JP	
Phone Number		
Fax Number		
Email Address		

Assignee Information including Non-Applicant Assignee Information

****If no data is shown, no data has been corrected****
Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office

	Data of Record	Updated Data
Order		
Applicant is an Organization		
Name		
Organization Name		
Mailing Address		
Address 1		
Address 2		
City,State/Province,Postal Code		
Country		
Phone Number		
Fax Number		
Email Address		

Signature

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b).

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/John R. Mattingly/	Registration Number	30293
First Name	John	Last Name	Mattingly

PTO/AIA/80 (07-12)
Approved for use through 11/30/2014. OMB 0651-0035
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

■ Practitioners associated with Customer Number: 24956

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

■ The address associated with Customer Number: 24956

OR

☐	Firm or Individual Name		
	Address		
	City	State	Zip
	Country		
	Telephone	Email	

Assignee Name and Address:

Maxell, Ltd.
1, Koizumi, Oyamazaki, Oyamazaki-cho Otokuni-gun, Kyoto 618-8525, Japan

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	Kazuhiro Kaizaki	Date	Oct. 17. 2017
Name	Kazuhiro Kaizaki	Telephone	
Title	Vice President		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc Code: R46C.REQ
Document Description: Request under 37 CFR 1.46(c) to correct, update or change the applicant.

PTO/AIA/41 (04-15)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

REQUEST TO CORRECT OR UPDATE THE NAME OF THE APPLICANT UNDER 37 CFR 1.46(c)(1), OR CHANGE THE APPLICANT UNDER 37 CFR 1.46(c)(2)

(FOR USE ONLY IN APPLICATIONS FILED ON OR AFTER SEPTEMBER 16, 2012)

Application Number	15/386,656
Filing Date	12/21/2016
First Named Inventor	Takahiro NAKANO
Art Unit	2663
Examiner Name	NGUYEN, LUONG TRUNG
Practitioner Docket Number	ASA-9606-08

To: Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Applicant hereby **requests that the name of the applicant be corrected or updated under 37 CFR 1.46(c)(1), or that the applicant be changed under 37 CFR 1.46(c)(2),** in the above-identified application. **Requests under 37 CFR 1.46(c)(1) or (c)(2) cannot be submitted after payment of the issue fee or if the application has been patented.**

Please check the applicable box(es) below.

☐ 1. This request is to **correct or update the name of the applicant** (**under 37 CFR 1.46(c)(1)**) and includes:

☐ An application data sheet (ADS) in accordance with 37 CFR 1.76(c) with the corrected or updated information shown with markings (*e.g.*, underlining for insertions, strikethrough for deletions). A Corrected Web-based ADS may be used.

Note: Requests under 37 CFR 1.46(c)(1) may be filed to correct typographical errors in the name of the § 1.46 applicant, or for updating the name of the § 1.46 applicant (*i.e.*, where there is no change in the applicant itself but just in the applicant's name). See the Manual of Patent Examining Procedure (MPEP) section 605.01.

☒ 2. This request is to **change the applicant** (**under 37 CFR 1.46(c)(2)**) and includes:

☒ An application data sheet (ADS) in accordance with 37 CFR 1.76(c) that identifies the changes with proper markings (underlining for insertions and strikethrough for deletions). A Corrected Web-based ADS may be used.

☒ A Statement Under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent). See MPEP 325.

I am the

☐ applicant* ☒ attorney or agent of record Registration number 30,293 ☐ attorney or agent acting under 37 CFR 1.34 Registration number _____

Signature /John R. Mattingly/

Typed or printed name John R. Mattingly

Date _____

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. *Juristic entities must be represented by a patent practitioner (See 37 CFR 1.31, applicable to any paper filed on or after September 16, 2012 that is presented on behalf of a juristic entity, regardless of application filing date). Submit multiple forms if more than one signature is required, see below**.

☒ ** Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.36. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/386,656	12/21/2016	2663	1600	ASA-9606-08	1	1

CONFIRMATION NO. 3687

CORRECTED FILING RECEIPT

24956
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

OC000000089199527

Date Mailed: 02/14/2017

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Takahiro NAKANO, Tokyo, JAPAN;
Ryuji NISHIMURA, Tokyo, JAPAN;
Toshiro KINUGASA, Tokyo, JAPAN;

Applicant(s)

~~Hitachi Maxell, Ltd., Osaka, JAPAN;~~ Maxell, Ltd., Kyoto, JAPAN;

Power of Attorney: The patent practitioners associated with Customer Number 24956

Domestic Priority data as claimed by applicant

This application is a CON of 14/661,227 03/18/2015 PAT 9544517
which is a CON of 14/264,243 04/29/2014 PAT 9100604
which is a CON of 13/681,495 11/20/2012 PAT 8736729
which is a CON of 12/845,266 07/28/2010 PAT 8339493
which is a CON of 10/660,710 09/12/2003 PAT 8059177
which is a DIV of 09/520,836 03/08/2000 PAT 6765616

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
JAPAN 2000-006064 01/11/2000

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Maxell, Ltd.

Application No./Patent No.: 15/386,656 Filed/Issue Date: December 21, 2016

Titled: Electric Camera

Maxell, Ltd., a Corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

B. ☑ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Nakano, T. et al. To: HITACHI, LTD.

   The document was recorded in the United States Patent and Trademark Office at
   Reel 010631, Frame 0900, or for which a copy thereof is attached.

2. From: Hitachi, Ltd. To: HITACHI CONSUMER ELECTRONICS CO., LTD.

   The document was recorded in the United States Patent and Trademark Office at
   Reel 030648, Frame 0217, or for which a copy thereof is attached.

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: HITACHI CONSUMER ELECTRONICS CO., LTD. To: HITACHI MAXELL, LTD.

The document was recorded in the United States Patent and Trademark Office at
Reel 033694, Frame 0745, or for which a copy thereof is attached.

4. From: HITACHI MAXELL, LTD. To: Maxell, Ltd.

The document was recorded in the United States Patent and Trademark Office at
Reel 045142, Frame 0208, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/John R. Mattingly/	2018-04-16
Signature	Date
John R. Mattingly	30,293
Printed or Typed Name	Title or Registration Number

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	32349462
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-08
Receipt Date:	16-APR-2018
Filing Date:	21-DEC-2016
Time Stamp:	15:43:28
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet to update/ correct info	CorrectedADS.pdf	64694 fd120db76a4a867036156d9a819f4b0d0208bfdc	no	5

Warnings:

Information:					
2	Assignee showing of ownership per 37 CFR 3.73	9606-08-POA-Maxell-80.pdf	196018 17ace2c46a7465b9c8269bf0d6e24520854 3e416	no	2
Warnings:					
Information:					
3	Miscellaneous Incoming Letter	9606-08-ReqChgApplicant.pdf	194799 7f60fb8b14b097b465769b74d98460ec178 80ba0	no	2
Warnings:					
Information:					
4	Request for Corrected Filing Receipt	9606-08-MarkedUpOFR.pdf	961217 4bdec858152be2957bd94a5ad94f7b29baf 731a1	no	1
Warnings:					
Information:					
5	Assignee showing of ownership per 37 CFR 3.73	9606-08-POA-Maxell-373c.pdf	122596 c65debd86b203ced48331cae023d907ca60 8d10c	no	3
Warnings:					
Information:					
		Total Files Size (in bytes):	1539324		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Doc Code: DIST.E.FILE **Document Description: Electronic Terminal Disclaimer - Filed**	PTO/SB/26 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT**
Application Number	15386656
Filing Date	21-Dec-2016
First Named Inventor	Takahiro NAKANO
Attorney Docket Number	ASA-9606-08
Title of Invention	ELECTRIC CAMERA

☒ Filing of terminal disclaimer does not obviate requirement for response under 37 CFR 1.111 to outstanding Office Action

☒ This electronic Terminal Disclaimer is not being used for a Joint Research Agreement.

Owner	Percent Interest
MAXELL, LTD.	100%

The owner(s) with percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of prior patent number(s)

9544517

as the term of said prior patent is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the prior patent, "as the term of said prior patent is presently shortened by any terminal disclaimer," in the event that said prior patent later:
- expires for failure to pay a maintenance fee;
- is held unenforceable;
- is found invalid by a court of competent jurisdiction;
- is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
- has all claims canceled by a reexamination certificate;
- is reissued; or
- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

◉ Terminal disclaimer fee under 37 CFR 1.20(d) is included with Electronic Terminal Disclaimer request.

○ I certify, in accordance with 37 CFR 1.4(d)(4), that the terminal disclaimer fee under 37 CFR 1.20(d) required for this terminal disclaimer has already been paid in the above-identified application.	
Applicant claims the following fee status: ○ Small Entity ○ Micro Entity ◉ Regular Undiscounted I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.	
THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES I certify, in accordance with 37 CFR 1.4(d)(4) that I am: ◉ An attorney or agent registered to practice before the Patent and Trademark Office who is of record in this application Registration Number 30293 ○ A sole inventor ○ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application ○ A joint inventor; all of whom are signing this request	
Signature	/John R. Mattingly/
Name	John R. Mattingly

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

Electronic Patent Application Fee Transmittal

Application Number:	15386656
Filing Date:	21-Dec-2016
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-08

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
STATUTORY OR TERMINAL DISCLAIMER	1814	1	160	160
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**160**

Doc Code: DISQ.E.FILE
Document Description: Electronic Terminal Disclaimer – Approved

Application No.: 15386656

Filing Date: 21-Dec-2016

Applicant/Patent under Reexamination: NAKANO

Electronic Terminal Disclaimer filed on April 16, 2018

☒ APPROVED

This patent is subject to a terminal disclaimer

☐ DISAPPROVED

Approved/Disapproved by: Electronic Terminal Disclaimer automatically approved by EFS-Web

U.S. Patent and Trademark Office

Electronic Acknowledgement Receipt	
EFS ID:	32349309
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly
Filer Authorized By:	
Attorney Docket Number:	ASA-9606-08
Receipt Date:	16-APR-2018
Filing Date:	21-DEC-2016
Time Stamp:	16:21:29
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$160
RAM confirmation Number	041718INTEFSW16212700
Deposit Account	501417
Authorized User	Krista Hargrove
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Terminal Disclaimer-Filed (Electronic)	eTerminal-Disclaimer.pdf	33451 97979246674a0061c669b85bbb40ee279e306919	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30126 ea8081bcd2628252a8c9e5ee5eebff9337c5f528	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	63577		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	15386656
Filing Date	2016-12-21
First Named Inventor	NAKANO, T.
Art Unit	2663
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-08

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4958915	A	1990-09-25	OKADA et al.	
	2	5060074	A	1991-10-22	KINUGASA et al.	
	3	5440343	A	1995-08-08	PARULSKI et al.	
	4	5493335	A	1996-02-20	PARULSKI et al.	
	5	5497191	A	1996-03-05	YOO et al.	
	6	5497192	A	1996-03-05	ISHIZUKA	
	7	5054052	A	1991-10-01	NONAMI	
	8	5793923	A	1998-08-11	SAWANOBORI	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

	9	5828406	A	1998-10-27	PARULSKI et al.	
	10	6512541	B2	2003-01-28	DUNTON et al.	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	ZTE (USA) Inc.'s Provisional Preliminary Invalidity Contentions which were filed in the following litigation: HITACHI MAXELL, LTD. v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-00179 RWS (E.D. Tex.), filed November 18, 2016	
	2	ZTE (USA) Inc.'s Invalidity Contentions which were filed in the following litigation: HITACHI MAXELL, LTD. v. HUAWEI DEVICE USA INC. and HUAWEI DEVICE CO., LTD., Civil Action No. 5:16-cv-00178 RWS (E.D. Tex.) and v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-00179 RWS (E.D. Tex.), filed November 18, 2016	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

	3	Asustek Computer Inc. and Asus Computer International's Invalidity Contentions which were filed in the following litigation: MAXELL, LTD. v. ASUSTEK COMPUTER INC. AND ASUS COMPUTER INTERNATIONAL, Civil Action No. 2:17-cv-7528-R-MRW (C.D. CA), filed October 13, 2017

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2018-04-16
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Atty. Docket No. ASA-9606-08

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: 15/386,656	Confirmation No.	: 3687
Applicant	: Maxell, Ltd.	TC/GAU	: 2663
Filed	: December 21, 2016	Examiner	: NGUYEN, L. T.
Title	: ELECTRIC CAMERA		

Customer No.: 24956

NOTICE OF RELATED PATENTS INVOLVED IN *INTER PARTES* REVIEW

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

April 16, 2018

Sir:

Applicant notifies the Office that two related patents, U.S. Patent Nos. 8,339,493 and 8,736,729, which matured from applications 12/845,266 and 13/681,495, respectively, and from which the above-identified application claims priority under 35 U.S.C. 120, are involved in the following *Inter Partes* Review proceedings:

ZTE CORPORATION and ZTE (USA) Inc. v. Hitachi Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,736,729, *Inter Partes* Review No. IPR2018-00238; and

ZTE CORPORATION and ZTE (USA) Inc. v. Hitachi Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,339,493, Inter Partes Review No. IPR2018-00236.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly, Reg. No. 30,293
(703) 684-1120

Electronic Acknowledgement Receipt

EFS ID:	32349088
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly
Filer Authorized By:	
Attorney Docket Number:	ASA-9606-08
Receipt Date:	16-APR-2018
Filing Date:	21-DEC-2016
Time Stamp:	16:25:24
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	9606-08-NoticeofLitigation.pdf	20147 46f27d71fca5d1cbe0f09539035a0f38f61051f2	no	2
Warnings:					

Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	9606-08-SB08A-litigation.pdf	1035292 e43a9f4fd158b7a6c381d7514e617785b1954aa1	no	5
Warnings:					
Information:					
3	Non Patent Literature	ZTE-ProvisionalPreliminaryInvalidityContentions.pdf	576028 2e73f613a9039d3aa213e4a35047d1dd85032c89	no	83
Warnings:					
Information:					
4	Non Patent Literature	ZTE-SupplementalInvalidityContentions.pdf	615623 8e6ad98de9cddc47d88a879028d805eff0e625a2	no	93
Warnings:					
Information:					
5	Non Patent Literature	ExhibitC-1-Nakano493.pdf	259882 7dd221d4ed476416f07e3824d3e6ecbcfc83acfa	no	9
Warnings:					
Information:					
6	Non Patent Literature	ExhibitC-2-Nakano493.pdf	288247 a58d6aab6e89617a4679123e45f0ca7f922ceb28	no	12
Warnings:					
Information:					
7	Non Patent Literature	ExhibitC-3-Nakano493.pdf	235788 65b0b32a67cf129187894db64aad1944f372c321	no	7
Warnings:					
Information:					
8	Non Patent Literature	ExhibitC-4-Nakano493.pdf	237594 f28a3acbb462fde1907fdda4f46065adbc76d514	no	7
Warnings:					
Information:					

9	Non Patent Literature	ExhibitC-5-Nakano493.pdf	320405 576220680415b42370954 3d78bd22224528182ad	no	10
Warnings:					
Information:					
10	Non Patent Literature	ExhibitC-6-Nakano493.pdf	163349 9bc112968e1d0d4c67b1dbe93eb02494137a1b04	no	3
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Information:					
11	Non Patent Literature	ExhibitC-7-Nakano493.pdf	157232 951bfe4672c8404d6298c53f24924b9994c4987e	no	3
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Information:					
12	Non Patent Literature	ExhibitC-8-Nakano493.pdf	164833 d288cf0e5dca678b00e707a653803c9d608d25cb	no	3
Warnings:					
Information:					
13	Non Patent Literature	ExhibitC-9-Nakano493.pdf	179562 dd81c51deaacde73b11e643cb8b4394a95a4fdc0	no	4
Warnings:					
Information:					
14	Non Patent Literature	ExhibitD-1-Nakano729.pdf	248026 784fea86fd90dd04ee3c05f12c3e2bd14f68a2ca	no	8
Warnings:					
Information:					
15	Non Patent Literature	ExhibitD-2-Nakano729.pdf	296081 10e62f91113693429b9f9ff15056c2f35d8821b3	no	13
Warnings:					
Information:					

16	Non Patent Literature	ExhibitD-3-Nakano729.pdf	251774 501b15a0a05a954b6b919819d6a01e0ce9c4f6ce	no	9
Warnings:					
Information:					
17	Non Patent Literature	ExhibitD-4-Nakano729.pdf	255383 68a609d7d5631e28378bb76c07d309e8e273ceb1	no	9
Warnings:					
Information:					
18	Non Patent Literature	ExhibitD-5-Nakano729.pdf	316814 66d882b9923692a94d32dc01c9995ac2fb190236	no	10
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Information:					
19	Non Patent Literature	ExhibitD-6-Nakano729.pdf	179395 d540c90f5b756f1a5f7340aa1cda749b6bec478a	no	4
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Information:					
20	Non Patent Literature	ExhibitD-7-Nakano729.pdf	161358 13ca5981fe4b57163e722f0b7a526c929c6c02fa	no	3
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Information:					
21	Non Patent Literature	ExhibitD-8-Nakano729.pdf	166571 845bdd1c524865cdc5e6fddfd91fbac058d89a3d	no	3
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Information:					
22	Non Patent Literature	ExhibitD-9-Nakano729.pdf	215080 983d213c8567009e93427e453e2283c50f35b070	no	7
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Information:					

23	Non Patent Literature	ExhibitD-10-Nakano729.pdf	160090 09eded8f9c7d188a95a020ded3c1b88dcf19bfd1	no	3
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24	Non Patent Literature	Asustek-InvalidityContentions.pdf	1314145 9428faa80e821377c63a0309fd695b1e579090be	no	105
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25	Non Patent Literature	AsustekExhibitA-1.pdf	2850775 6129194f090d1e4906131760fa44251302a1ccda	no	62
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Information:					
26	Non Patent Literature	AsustekExhibitA-2.pdf	5531433 81496a2f50f4c1c0ddb18ced22f70e1625c9ca73	no	77
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Information:					
27	Non Patent Literature	AsustekExhibitA-3.pdf	1476679 f9e9116d7efab9d02d29540a3b6d4fd26928ab9b	no	41
Warnings:					
Information:					
28	Non Patent Literature	AsustekExhibitA-4.pdf	847208 ad3a769c31f0f5cd10f4278b22366b3f59f55cee	no	43
Warnings:					
Information:					
29	Non Patent Literature	AsustekExhibitA-5.pdf	2215371 ea8116f5311bae183e0f7343d998e63685db0909	no	47
Warnings:					
Information:					

30	Non Patent Literature	AsustekExhibitA-6.pdf	802077 46911208ea7d945cb8b12b1662b3c47c848575e9	no	34
Warnings:					
Information:					
31	Non Patent Literature	AsustekExhibitA-7.pdf	287162 6cf7a0045f36ab655f37047c879dfc276052afbc	no	31
Warnings:					
Information:					
32	Non Patent Literature	AsustekExhibitA-8.pdf	336161 ac385b5e76165480307be1a50e373f1b83a32ce9	no	32
Warnings:					
Information:					
33	Non Patent Literature	AsustekExhibitA-9.pdf	400858 44000fc81c6b83228444e07847d74eea0be7e089	no	33
Warnings:					
Information:					
34	Miscellaneous Incoming Letter	9606-08-NoticeofIPR.pdf	19194 d52c6aa8059bc2c00581f7d9825df60f7a5673c9	no	1
Warnings:					
Information:					
		Total Files Size (in bytes):	22585617		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Atty. Docket No. ASA-9606-08

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: 15/386,656	Confirmation No.	: 3687
Applicant	: Maxell, Ltd.	TC/GAU	: 2663
Filed	: December 21, 2016	Examiner	: NGUYEN, L. T.
Title	: ELECTRIC CAMERA		

Customer No.: 24956

NOTICE OF RELATED PATENTS INVOLVED IN LITIGATION

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

April 16, 2018

Sir:

Applicant notifies the Office that three related patents, U.S. Patent Nos. 7,403,226, 8,339,493, 8,736,729 and 9,544,517 which matured from applications 10/660,711, 12/845,266, 13/681,495 and 14/661,227, respectively, and from which the above-identified application claims priority under 35 U.S.C. 120, are involved in the following litigation:

Hitachi Maxell, Ltd. v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-179 RWS (E.D. Tex.), filed November 18, 2016.

Hitachi Maxell, Ltd. v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-178 RWS (E.D. Tex.), filed November 18, 2016.

Maxell, Ltd. v. Asustek Computer Inc. and Asus Computer International, Civil Action No. 2:17-cv-7528-R-MRW (C.D. CA), filed October 13, 2017.

Maxell, Ltd. v. BlackBerry Corporation and BlackBerry Ltd., Civil Action No. 1:17-cv-01446-JFB-SRF (DE), filed October 13, 2017.

Maxell, Ltd. v. Blue Products, Inc., Civil Action No. 1:18-cv-21231-CMA (S.D. FL), filed April 3, 2018.

Maxell, Ltd. v. Huawei Device USA, Inc. Huawei Device Co., Ltd., Civil Action No. 5:18-cv-0033-RWS (E.D. Tex), filed March 2, 2018.

Maxell, Ltd. v. ZTE Corporation and ZTE USA, Inc., Civil Action No. 5:18-cv-0034-RWS (E.D. Tex), filed March 2, 2018.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly, Reg. No. 30,293
(703) 684-1120

PTO/SB/30EFS (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	15/386,656	Filing Date	2016-12-21	Docket Number (if applicable)	ASA-9606-08	Art Unit	2663
First Named Inventor	T. NAKANO			Examiner Name	Luong TRUNG NGUYEN		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☒ Amendment/Reply
- ☒ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____ (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 501417

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

Applicant Signature

PTO/SB/30EFS (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Signature of Registered U.S. Patent Practitioner			
Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2018-04-16
Name	John R. Mattingly	Registration Number	30293

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	15386656
Filing Date:	21-Dec-2016
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly/Krista Hargrove
Attorney Docket Number:	ASA-9606-08

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
INDEPENDENT CLAIMS IN EXCESS OF 3	1201	1	460	460
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Extension - 2 months with $0 paid	1252	1	600	600
Miscellaneous:				
RCE- 1ST REQUEST	1801	1	1300	1300
		Total in USD ($)		**2360**

Electronic Acknowledgement Receipt

EFS ID:	32349184
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly
Filer Authorized By:	
Attorney Docket Number:	ASA-9606-08
Receipt Date:	16-APR-2018
Filing Date:	21-DEC-2016
Time Stamp:	16:30:10
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$2360
RAM confirmation Number	041718INTEFSW16401800
Deposit Account	501417
Authorized User	Krista Hargrove
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		9606-08-AMD02-revised_04-16-2018.pdf	42186 66519cc8a06c78057a1c75843db427b58ae87ebe	yes	9

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment Submitted/Entered with Filing of CPA/RCE	1	1
	Claims	2	7
	Applicant Arguments/Remarks Made in an Amendment	8	9

Warnings:					
Information:					
2	Request for Continued Examination (RCE)	9606-08_RCE.pdf	1350123 cde38ea32206172a17d3aec58cfe68e6453609e6	no	3
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	34169 edf9de2f8aa7da1a97e02c611c3ce54e668d64e7	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1426478		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) : MAXELL, LTD.

Confirmation No.: 3687

Serial No. : 15/386,656

Filed : December 21, 2016

For : ELECTRIC CAMERA

Group : 2663

Examiner : Luong TRUNG NGUYEN

Docket No. : ASA-9606-08

Customer No.: 24956

AMENDMENT

Mail Stop: AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

April 16, 2018

Sir:

In response to the Final Office Action mailed November 16, 2017, please amend the above-identified patent application as follows. A fee for a 2-month Extension of Time accompanies this response.

Amendments to the Claims begin on page 2 of this paper.

Remarks begin on page 8 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently amended) An electric camera comprising:

an image sensing device with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals accumulated in the pixels with an interval of a plurality of vertical pixels;

a signal processing unit configured to generate image signals by using the signals outputted by the image sensing device; and

a zoom operation unit configured to operate to continuously change a magnification factor;

wherein, as the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise.

2. (Canceled).

3. (Currently amended) The electric camera according to ~~claim 2~~claim 1,

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels including:

a first state of the at least three states in which the image signals are generated using signals based on a first area of the light receiving surface with a first magnification factor,

a second state of the at least three states in which the image signals are generated using signals based on a second area of the light receiving surface with a second magnification factor, and

a third state of the at least three states in which the image signals are generated using signals based on a third area of the light receiving surface with a third magnification factor, and

wherein, while a ~~the~~ state is between the first state and the second state when the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs signals with a first interval of vertical pixels,

wherein, while ~~the~~ a state is between the second state and the third state when the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs signals with a second interval of vertical pixels which is different from the first interval.

4. (Previously presented) The electric camera according to claim 3,

wherein the image sensing device outputs the signals which are mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

5. (Previously presented) The electric camera according to claim 3,

wherein, as the zoom operation unit is operated to continuously change the magnification factor during recording of a moving video in a moving video mode, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise.

6. (Previously presented) The electric camera according to claim 3,

wherein the electric camera has a static image mode for taking a static image and, when in the static image mode, the signal processing unit generates the static image by using all signals accumulated in all of an effective number of the vertical pixels.

7. (New) An electric camera comprising:

an image sensing device with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals accumulated in the pixels with an interval of a plurality of vertical pixels;

a processor circuitry configured to control generating image signals by using the signals outputted by the image sensing device and to continuously change a magnification factor in accordance with a zoom operation;

wherein, as the processor circuitry controls to continuously change the magnification factor in accordance with a zoom operation, the image sensing device outputs signals while changing the interval of the plurality of vertical pixels stepwise.

8. (New) An operating method for an electric camera comprising:

receiving light with an image sensing device having a light receiving surface including an array of pixels arranged vertically and horizontally, and outputting signals accumulated in the pixels with an interval of a plurality of vertical pixels;

generating image signals by using the signals outputted by the image sensing device;

continuously changing a magnification factor of a zoom operation; and

wherein, as the zoom operation continuously changes the magnification factor, the outputting of the signals of the image sensing device includes outputting the signals while changing the interval of the plurality of vertical pixels stepwise.

9. (New) The method according to claim 8,

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels, and wherein:

the generating of the image signals includes, in a first state of the at least three states, generating the image signals using signals output by the image sensing device based on a first area of the light receiving surface with a first magnification factor,

the generating of the image signals includes, in a second state of the at least three states, generating the image signals using signals output by the image sensing

device based on a second area of the light receiving surface with a second magnification factor, and

the generating of the image signals includes, in a third state of the at least three states, generating the image signals using signals output by the image sensing device based on a third area of the light receiving surface with a third magnification factor,

wherein, while a state is between the first state and the second state when the zoom operation is continuously changing the magnification factor, outputting with the image sensing device signals with a first interval of vertical pixels, and

wherein, while a state is between the second state and the third state when the zoom operation continuously changes the magnification factor, outputting with the image sensing device signals with a second interval of vertical pixels which is different from the first interval.

10. (New) The method according to claim 9,

wherein the outputting of the signals with the image sensing device includes outputting mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

11. (New) The method according to claim 9,

wherein, as the zoom operation continuously changes the magnification factor during recording of a moving video in a moving video mode, the outputting of the

signals with the image sensing device includes outputting the signals while changing the interval of the plurality of vertical pixels stepwise.

12. (New) The method according to claim 9,

wherein the electric camera has a static image mode for taking a static image and, wherein, in the static image mode, the generating of the image signals includes generating the static image by using all signals accumulated in all of an effective number of the vertical pixels.

13. (New) An operating method for an electric camera comprising:

receiving light with an image sensing device having a light receiving surface having an array of pixels arranged vertically and horizontally, and outputting signals accumulated in the pixels with an interval of a plurality of vertical pixels;

controlling with processor circuitry generating image signals by using the signals outputted by the image sensing device and controlling to continuously change a magnification factor in accordance with a zoom operation;

wherein, as the zoom operation is controlled with the processor circuitry to continuously change the magnification factor, the outputting of the signals of the image sensing device includes outputting the signals while changing the interval of the plurality of vertical pixels stepwise.

REMARKS

Claims 1 and 3-13 are pending in this application. Claim 2 has been canceled without prejudice and without disclaimer. Claim 3 has been amended. New claims 7-13 have been added. No new matter has been added.

Claim Objections

Claims 3-6 are objected to for informalities. The amendments to claim 3 overcome the objection.

Rejections Under 35 U.S.C. §112

The Examiner has rejected claims 2-6 under 35 U.S.C. § 112(b) or 35 U.S.C. § 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

It is submitted that claim 3, which incorporates the language of claim 2 upon which the rejection is based, has been amended to overcome the rejection under 35 U.S.C. §112. Additionally, Applicant has cancelled claim 2 without prejudice and without disclaimer. Accordingly, the rejection under 35 U.S.C. §112 should be withdrawn.

Double Patenting Rejections

Claim 1 stands rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1, 4 and 13 of U.S. Patent No. 9,544,517.

It is submitted that the amendments to claim 1 render the double patenting rejections moot.

Request for Continued Examination

Applicants submit a Request for Continued Examination to ensure entry and consideration of the foregoing amendments to the claims.

Conclusion

In view of the foregoing amendments and remarks, Applicants request reconsideration of the rejection and allowance of the claims.

The Commissioner is authorized to charge any shortage in the fees due, or credit any overpayment, to Deposit Account No. 50-1417 (referencing Attorney Docket No. ASA-9606-08).

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Registration No. 30,293
703-684-1120

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/386,656	Filing Date 12/21/2016	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $80 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $420 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	04/16/2018	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 12	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 3	= 1		x $460 =	460
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	460

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	SLIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	juliet mcmillan
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08

CONFIRMATION NO. 3687

24956
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

POA ACCEPTANCE LETTER

OC000000098871054

Date Mailed: 04/19/2018

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 04/16/2018.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/ylueng/

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/386,656	12/21/2016	2663	2060	ASA-9606-08	1	1

CONFIRMATION NO. 3687

CORRECTED FILING RECEIPT

24956
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

OC000000098871053

Date Mailed: 04/19/2018

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Takahiro NAKANO, Tokyo, JAPAN;
Ryuji NISHIMURA, Tokyo, JAPAN;
Toshiro KINUGASA, Tokyo, JAPAN;

Applicant(s)

Maxell, Ltd., Kyoto, JAPAN;

Power of Attorney: The patent practitioners associated with Customer Number 24956

Domestic Priority data as claimed by applicant

This application is a CON of 14/661,227 03/18/2015 PAT 9544517
which is a CON of 14/264,243 04/29/2014 PAT 9100604
which is a CON of 13/681,495 11/20/2012 PAT 8736729
which is a CON of 12/845,266 07/28/2010 PAT 8339493
which is a CON of 10/660,710 09/12/2003 PAT 8059177
which is a DIV of 09/520,836 03/08/2000 PAT 6765616

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
JAPAN 2000-006064 01/11/2000 No Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

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Request to Retrieve - This application either claims priority to one or more applications filed in an intellectual property Office that participates in the Priority Document Exchange (PDX) program or contains a proper **Request to Retrieve Electronic Priority Application(s)** (PTO/SB/38 or its equivalent). Consequently, the USPTO will attempt to electronically retrieve these priority documents.

If Required, Foreign Filing License Granted: 02/13/2017

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 15/386,656**

Projected Publication Date: Not Applicable

Non-Publication Request: No

Early Publication Request: No

Title

ELECTRIC CAMERA

Preliminary Class

348

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

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Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08	3687

24956 7590 06/15/2018

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314
UNITED STATES OF AMERICA

EXAMINER	
ART UNIT	PAPER NUMBER

DATE MAILED: 06/15/2018

Please find below and/or attached an Office communication concerning this application or proceeding.

Notice of Non-Compliant Amendment (37 CFR 1.121)	Application No.	Applicant(s)
	15/386,656	NAKANO ET AL.
	Examiner	Art Unit
	LUONG T. NGUYEN	2663

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

The amendment document filed on *16 April 2018* is considered non-compliant because it has failed to meet the requirements of 37 CFR 1.121 or 1.4. In order for the amendment document to be compliant, correction of the following item(s) is required.

THE FOLLOWING MARKED (X) ITEM(S) CAUSE THE AMENDMENT DOCUMENT TO BE NON-COMPLIANT:

- ☐ 1. Amendments to the specification:
  - ☐ A. Amended paragraph(s) do not include markings.
  - ☐ B. New paragraph(s) should not be underlined.
  - ☐ C. Other _____.
- ☐ 2. Abstract:
  - ☐ A. Not presented on a separate sheet. 37 CFR 1.72.
  - ☐ B. Other _____.
- ☐ 3. Amendments to the drawings:
  - ☐ A. The drawings are not properly identified in the top margin as "Replacement Sheet," "New Sheet," or "Annotated Sheet" as required by 37 CFR 1.121(d).
  - ☐ B. The practice of submitting proposed drawing correction has been eliminated. Replacement drawings showing amended figures, without markings, in compliance with 37 CFR 1.84 are required.
  - ☐ C. Other _____.
- ☒ 4. Amendments to the claims:
  - ☐ A. A complete listing of all of the claims is not present.
  - ☐ B. The listing of claims does not include the text of all pending claims (including withdrawn claims)
  - ☐ C. Each claim has not been provided with the proper status identifier, and as such, the individual status of each claim cannot be identified. Note: the status of every claim must be indicated after its claim number by using one of the following status identifiers: (Original), (Currently amended), (Canceled), (Previously presented), (New), (Not entered), (Withdrawn) and (Withdrawn-currently amended).
  - ☐ D. The claims of this amendment paper have not been presented in ascending numerical order.
  - ☒ E. Other: *See Continuation Sheet*.
- ☐ 5. Other (e.g., the amendment is unsigned or not signed in accordance with 37 CFR 1.4):

_____

For further explanation of the amendment format required by 37 CFR 1.121, see MPEP § 714.

TIME PERIODS FOR FILING A REPLY TO THIS NOTICE:

1. Applicant is given **no new time period** if the non-compliant amendment is an after-final amendment or an amendment filed after allowance. If applicant wishes to resubmit the non-compliant after-final amendment with corrections, the **entire corrected amendment** must be resubmitted.

2. Applicant is given **two months** from the mail date of this notice to supply the correction, if the non-compliant amendment is one of the following: a preliminary amendment, a non-final amendment (including a submission for a request for continued examination (RCE) under 37 CFR 1.114), a supplemental amendment filed within a suspension period under 37 CFR 1.103(a) or (c), and an amendment filed in response to a *Quayle* action. If any of above boxes 1. to 4. are checked, the correction required is only the **corrected section** of the non-compliant amendment in compliance with 37 CFR 1.121.

   Extensions of time are available under 37 CFR 1.136(a) only if the non-compliant amendment is a non-final amendment or an amendment filed in response to a *Quayle* action.

   Failure to timely respond to this notice will result in:
   Abandonment of the application if the non-compliant amendment is a non-final amendment or an amendment filed in response to a *Quayle* action; or
   Non-entry of the amendment if the non-compliant amendment is a preliminary amendment or supplemental amendment.

/LUONG T NGUYEN/ Primary Examiner, Art Unit 2663	

Continuation of 4(e) Other:

The status identifier of claim 1, which is indicated as "Currently amended", is improper, since there is no indication of line through for deleted limitation or underline for newly added limitation in claim 1. Claim 1 is not amended.

Applicant is requested to submit a proper amendment based on the claims filed on 08/04/2017, in which the proper status identifier of claim 1 should be indicated as "Previously presented" .

Notice of Non-Compliant Amendment (37 CFR 1.121)	Application No.	Applicant(s)
	15/386,656	NAKANO ET AL.
	Examiner	Art Unit
	LUONG T. NGUYEN	2663

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

The amendment document filed on *16 April 2018* is considered non-compliant because it has failed to meet the requirements of 37 CFR 1.121 or 1.4. In order for the amendment document to be compliant, correction of the following item(s) is required.

THE FOLLOWING MARKED (X) ITEM(S) CAUSE THE AMENDMENT DOCUMENT TO BE NON-COMPLIANT:

- ☐ 1. Amendments to the specification:
  - ☐ A. Amended paragraph(s) do not include markings.
  - ☐ B. New paragraph(s) should not be underlined.
  - ☐ C. Other _____.
- ☐ 2. Abstract:
  - ☐ A. Not presented on a separate sheet. 37 CFR 1.72.
  - ☐ B. Other _____.
- ☐ 3. Amendments to the drawings:
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  - ☐ B. The practice of submitting proposed drawing correction has been eliminated. Replacement drawings showing amended figures, without markings, in compliance with 37 CFR 1.84 are required.
  - ☐ C. Other _____.
- ☒ 4. Amendments to the claims:
  - ☐ A. A complete listing of all of the claims is not present.
  - ☐ B. The listing of claims does not include the text of all pending claims (including withdrawn claims)
  - ☐ C. Each claim has not been provided with the proper status identifier, and as such, the individual status of each claim cannot be identified. Note: the status of every claim must be indicated after its claim number by using one of the following status identifiers: (Original), (Currently amended), (Canceled), (Previously presented), (New), (Not entered), (Withdrawn) and (Withdrawn-currently amended).
  - ☐ D. The claims of this amendment paper have not been presented in ascending numerical order.
  - ☒ E. Other: *See Continuation Sheet*.
- ☐ 5. Other (e.g., the amendment is unsigned or not signed in accordance with 37 CFR 1.4):

_____

For further explanation of the amendment format required by 37 CFR 1.121, see MPEP § 714.

TIME PERIODS FOR FILING A REPLY TO THIS NOTICE:

1. Applicant is given **no new time period** if the non-compliant amendment is an after-final amendment or an amendment filed after allowance. If applicant wishes to resubmit the non-compliant after-final amendment with corrections, the **entire corrected amendment** must be resubmitted.

2. Applicant is given **two months** from the mail date of this notice to supply the correction, if the non-compliant amendment is one of the following: a preliminary amendment, a non-final amendment (including a submission for a request for continued examination (RCE) under 37 CFR 1.114), a supplemental amendment filed within a suspension period under 37 CFR 1.103(a) or (c), and an amendment filed in response to a *Quayle* action. If any of above boxes 1. to 4. are checked, the correction required is only the **corrected section** of the non-compliant amendment in compliance with 37 CFR 1.121.

   Extensions of time are available under 37 CFR 1.136(a) only if the non-compliant amendment is a non-final amendment or an amendment filed in response to a *Quayle* action.

   Failure to timely respond to this notice will result in:
   Abandonment of the application if the non-compliant amendment is a non-final amendment or an amendment filed in response to a *Quayle* action; or
   Non-entry of the amendment if the non-compliant amendment is a preliminary amendment or supplemental amendment.

/LUONG T NGUYEN/ Primary Examiner, Art Unit 2663	

Continuation of 4(e) Other:

The status identifier of claim 1, which is indicated as "Currently amended", is improper, since there is no indication of line through for deleted limitation or underline for newly added limitation in claim 1. Claim 1 is not amended.

Applicant is requested to submit a proper amendment based on the claims filed on 08/04/2017, in which the proper status identifier of claim 1 should be indicated as "Previously presented" .

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) : MAXELL, LTD.

Confirmation No.: 3687

Serial No. : 15/386,656

Filed : December 21, 2016

For : ELECTRIC CAMERA

Group : 2663

Examiner : Luong TRUNG NGUYEN

Docket No. : ASA-9606-08

Customer No.: 24956

AMENDMENT

Mail Stop: AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

July 5, 2018

Sir:

In response to the Notice of Non-Compliant Amendment mailed June 15, 2018, reconsideration and withdrawal of the outstanding rejections and allowance of the present application are respectfully requested in view of the following amendments and remarks.

Amendments to the Claims begin on page 2 of this paper.

Remarks begin on page 8 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Previously presented) An electric camera comprising:

an image sensing device with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals accumulated in the pixels with an interval of a plurality of vertical pixels;

a signal processing unit configured to generate image signals by using the signals outputted by the image sensing device; and

a zoom operation unit configured to operate to continuously change a magnification factor;

wherein, as the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise.

2. (Canceled).

3. (Currently amended) The electric camera according to ~~claim 2~~claim 1,

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels including:

a first state of the at least three states in which the image signals are generated using signals based on a first area of the light receiving surface with a first magnification factor,

a second state of the at least three states in which the image signals are generated using signals based on a second area of the light receiving surface with a second magnification factor, and

a third state of the at least three states in which the image signals are generated using signals based on a third area of the light receiving surface with a third magnification factor, and

wherein, while a ~~the~~ state is between the first state and the second state when the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs signals with a first interval of vertical pixels,

wherein, while ~~the~~ a state is between the second state and the third state when the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs signals with a second interval of vertical pixels which is different from the first interval.

4. (Previously presented) The electric camera according to claim 3,

wherein the image sensing device outputs the signals which are mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

5. (Previously presented) The electric camera according to claim 3,

wherein, as the zoom operation unit is operated to continuously change the magnification factor during recording of a moving video in a moving video mode, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise.

6. (Previously presented) The electric camera according to claim 3,

wherein the electric camera has a static image mode for taking a static image and, when in the static image mode, the signal processing unit generates the static image by using all signals accumulated in all of an effective number of the vertical pixels.

7. (New) An electric camera comprising:

an image sensing device with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals accumulated in the pixels with an interval of a plurality of vertical pixels;

a processor circuitry configured to control generating image signals by using the signals outputted by the image sensing device and to continuously change a magnification factor in accordance with a zoom operation;

wherein, as the processor circuitry controls to continuously change the magnification factor in accordance with a zoom operation, the image sensing device outputs signals while changing the interval of the plurality of vertical pixels stepwise.

8. (New) An operating method for an electric camera comprising:

receiving light with an image sensing device having a light receiving surface including an array of pixels arranged vertically and horizontally, and outputting signals accumulated in the pixels with an interval of a plurality of vertical pixels;

generating image signals by using the signals outputted by the image sensing device;

continuously changing a magnification factor of a zoom operation; and

wherein, as the zoom operation continuously changes the magnification factor, the outputting of the signals of the image sensing device includes outputting the signals while changing the interval of the plurality of vertical pixels stepwise.

9. (New) The method according to claim 8,

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels, and wherein:

the generating of the image signals includes, in a first state of the at least three states, generating the image signals using signals output by the image sensing device based on a first area of the light receiving surface with a first magnification factor,

the generating of the image signals includes, in a second state of the at least three states, generating the image signals using signals output by the image sensing

device based on a second area of the light receiving surface with a second magnification factor, and

the generating of the image signals includes, in a third state of the at least three states, generating the image signals using signals output by the image sensing device based on a third area of the light receiving surface with a third magnification factor,

wherein, while a state is between the first state and the second state when the zoom operation is continuously changing the magnification factor, outputting with the image sensing device signals with a first interval of vertical pixels, and

wherein, while a state is between the second state and the third state when the zoom operation continuously changes the magnification factor, outputting with the image sensing device signals with a second interval of vertical pixels which is different from the first interval.

10. (New) The method according to claim 9,

wherein the outputting of the signals with the image sensing device includes outputting mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

11. (New) The method according to claim 9,

wherein, as the zoom operation continuously changes the magnification factor during recording of a moving video in a moving video mode, the outputting of the

signals with the image sensing device includes outputting the signals while changing the interval of the plurality of vertical pixels stepwise.

12. (New) The method according to claim 9,

wherein the electric camera has a static image mode for taking a static image and, wherein, in the static image mode, the generating of the image signals includes generating the static image by using all signals accumulated in all of an effective number of the vertical pixels.

13. (New) An operating method for an electric camera comprising:

receiving light with an image sensing device having a light receiving surface having an array of pixels arranged vertically and horizontally, and outputting signals accumulated in the pixels with an interval of a plurality of vertical pixels;

controlling with processor circuitry generating image signals by using the signals outputted by the image sensing device and controlling to continuously change a magnification factor in accordance with a zoom operation;

wherein, as the zoom operation is controlled with the processor circuitry to continuously change the magnification factor, the outputting of the signals of the image sensing device includes outputting the signals while changing the interval of the plurality of vertical pixels stepwise.

REMARKS

Claims 1 and 3-13 are pending in this application. Claim 2 has been canceled without prejudice and without disclaimer. Claim 3 has been amended. New claims 7-13 have been added. No new matter has been added.

Claim Objections

Claims 3-6 are objected to for informalities. The amendments to claim 3 overcome the objection.

Rejections Under 35 U.S.C. §112

The Examiner has rejected claims 2-6 under 35 U.S.C. § 112(b) or 35 U.S.C. § 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

It is submitted that claim 3, which incorporates the language of claim 2 upon which the rejection is based, has been amended to overcome the rejection under 35 U.S.C. §112. Additionally, Applicant has cancelled claim 2 without prejudice and without disclaimer. Accordingly, the rejection under 35 U.S.C. §112 should be withdrawn.

Double Patenting Rejections

Claim 1 stands rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1, 4 and 13 of U.S. Patent No. 9,544,517.

It is submitted that the amendments to claim 1 render the double patenting rejections moot.

Request for Continued Examination

Applicants submit a Request for Continued Examination to ensure entry and consideration of the foregoing amendments to the claims.

Conclusion

In view of the foregoing amendments and remarks, Applicants request reconsideration of the rejection and allowance of the claims.

The Commissioner is authorized to charge any shortage in the fees due, or credit any overpayment, to Deposit Account No. 50-1417 (referencing Attorney Docket No. ASA-9606-08).

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Registration No. 30,293
703-684-1120

Electronic Acknowledgement Receipt

EFS ID:	33092309
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Krista Hargrove
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-08
Receipt Date:	05-JUL-2018
Filing Date:	21-DEC-2016
Time Stamp:	12:33:30
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		9606-08-AMD03.pdf	42231 d7a0202922fe96428c81e52b9d0709c536c99199	yes	9

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment Submitted/Entered with Filing of CPA/RCE	1	1
	Claims	2	7
	Applicant Arguments/Remarks Made in an Amendment	8	9
Warnings:			
Information:			
	Total Files Size (in bytes):	42231	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08	3687

24956 7590 08/27/2018

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
NGUYEN, LUONG TRUNG	

ART UNIT	PAPER NUMBER
2663	

NOTIFICATION DATE	DELIVERY MODE
08/27/2018	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

Office Action Summary	**Application No.** 15/386,656	**Applicant(s)** NAKANO et al.	
	Examiner LUONG T NGUYEN	**Art Unit** 2663	**AIA Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 07/05/2018.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1 and 3-13 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1,7-8 and 13 is/are rejected.

8) ☑ Claim(s) 3-6 and 9-12 is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application is being examined under the pre-AIA first to invent provisions.

Continued Examination Under 37 CFR 1.114

2. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 04/16/2018 has been entered.

Response to Arguments

3. Applicant's arguments with respect to claim 1 and newly added claims 7-13 filed on 07/05/2018 have been considered but are moot because the arguments do not apply to any of the references being used in the current rejection.

Information Disclosure Statement

4. The information disclosure statement (IDS) submitted on 04/16/2018 is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner.

Terminal Disclaimer

5. The terminal disclaimer filed on 04/16/2018 disclaiming the terminal portion of any patent granted on this application which would extend beyond the expiration date of the full statutory term of

prior U. S. patent number 9,544,517 has been reviewed and is accepted. The terminal disclaimer has been recorded.

Claim Interpretation

6. The following is a quotation of 35 U.S.C. 112(f):

> (f) Element in Claim for a Combination. – An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

The following is a quotation of pre-AIA 35 U.S.C. 112, sixth paragraph:

> An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

7. Use of the word "means" (or "step for") in a claim with functional language creates a rebuttable presumption that the claim element is to be treated in accordance with 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112, sixth paragraph). The presumption that 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112, sixth paragraph) is invoked is rebutted when the function is recited with sufficient structure, material, or acts within the claim itself to entirely perform the recited function.

Absence of the word "means" (or "step for") in a claim creates a rebuttable presumption that the claim element is not to be treated in accordance with 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112, sixth paragraph). The presumption that 35 U.S.C. 112(f) (pre-AIA 35 U.S.C. 112, sixth paragraph) is not invoked is rebutted when the claim element recites function but fails to recite sufficiently definite structure, material or acts to perform that function.

Claim elements in this application that use the word "means" (or "step for") are presumed to invoke 35 U.S.C. 112(f) except as otherwise indicated in an Office action. Similarly, claim elements that do not use the word "means" (or "step for") are presumed not to invoke 35 U.S.C. 112(f) except as otherwise indicated in an Office action.

8. Claim limitation "signal processing unit, " "zoom operation unit, "as recited in claim 1 has been interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because it uses a generic placeholder "unit" coupled with functional language "configured to generate image signals," "configured to operate," without reciting sufficient structure to achieve the function. Furthermore, the generic placeholder is not preceded by a structural modifier. Note that "signal processing," "zoom operation," each is not a structural modifier.

Since the claim limitation invokes 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, claim 1 has been interpreted to cover the corresponding structure described in the specification that achieves the claimed function, and equivalents thereof.

A review of the specification shows that the following appears to be the corresponding structure described in the specification for the 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph limitation:

"signal processing circuit 7" disclosed in Figures 1, 7, Specification, pages 9, 27 for claim limitation "signal processing circuit unit."

"view angle change switch 18" disclosed in Figure 7, Specification, pages 25-26 for claim limitation "zoom operation unit."

If applicant wishes to provide further explanation or dispute the examiner's interpretation of the corresponding structure, applicant must identify the corresponding structure with reference to the

specification by page and line number, and to the drawing, if any, by reference characters in response to this Office action.

If applicant does not intend to have the claim limitation(s) treated under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112 , sixth paragraph, applicant may amend the claim(s) so that it/they will clearly not invoke 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, or present a sufficient showing that the claim recites/recite sufficient structure, material, or acts for performing the claimed function to preclude application of 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

For more information, see MPEP § 2173 *et seq.* and *Supplementary Examination Guidelines for Determining Compliance With 35 U.S.C. 112 and for Treatment of Related Issues in Patent Applications*, 76 FR 7162, 7167 (Feb. 9, 2011).

Claim Rejections - 35 USC § 103

9. In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

10. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

11. Claims 1, 7, 8, 13 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Kijima et al. (US 6,661,451) in view of Tamura et al. (US 5,959,670).

Regarding claim 1, Kijima et al. discloses an electric camera comprising: an image sensing device (CCD 12, figure 1, column 3, lines 25-34; column 4, line 57 -column 5, line 42) with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals accumulated in the pixels with an interval of a plurality of vertical pixels;

a signal processing unit (image processing portion 26, figure 1, column 2, lines 62-67) having a function of generating image signals by using the output signals of the image sensing device.

Kijima et al. fails to disclose a zoom operation unit configured to operate to continuously change a magnification factor; wherein, as the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise.

However, Tamura et al. discloses a zoom operation unit (electronic-zoom magnification control part 16b, figure 1, column 5, line 33 - column 6, line 32; column 24, lines 32-67) configured to operate to continuously change a magnification factor; wherein, as the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals while changing the interval of the plurality of vertical pixels stepwise (an angle of view set by the zooming always coincides with a read-out area of the image pickup surface of the image pickup element. If the electronic-zoom function is operated, the angle of view of an optical image to be actually made incident on the image pickup surface differs from the read-out area of the image pickup element, column 1, lines 30-55; column 3, lines 4-31).

Therefore, it would have been obvious to one of ordinary skill in the art before the effective filing date of the claimed invention to modify the device in Kijima et al. by the teaching of Tamura et al. in order to obtain an electronic camera having capability of electronically enlarging the image magnification of a subject (column 1, lines 10-14).

Regarding claim 7, see Examiner's comments regarding claim 1.

Regarding claim 8, claim 8 is a method claim of apparatus claim 1, therefore, claim 8 is rejected for the same reasons given in claim 1.

Regarding claim 13, claim 13 is a method claim of apparatus claim 7, therefore, claim 13 is rejected for the same reasons given in claim 7.

Allowable Subject Matter

12. Claims 3-6, 9-12 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

13. Any inquiry concerning this communication or earlier communications from the examiner should be directed to LUONG TRUNG NGUYEN whose telephone number is (571)272-7315. The examiner can normally be reached on 7:30AM-5:00PM, MONDAY - THURSDAY.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, TWYLER HASKINS can be reached on 571-272-7406. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2663
08/21/2018

Notice of References Cited	Application/Control No. 15/386,656	Applicant(s)/Patent Under Reexamination NAKANO et al.	
	Examiner LUONG T NGUYEN	Art Unit 2663	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-5959670-A	09-1999	Tamura; Kyoji	G06T3/40	348/229.1
	B					
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	Art Unit
	LUONG T NGUYEN	2663

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04N5/372; H04N5/23248; H04N5/3741; H04N5/23258; H04N9/045; H04N5/3454; H04N5/23274	2/1/2017	LTN
H04N5/372, H04N5/23248, H04N5/3741, H04N5/23258, H04N9/045	11/9/2017	LTN
H04N5/372, H04N5/23248, H04N5/3741, H04N5/23258, H04N9/045	08/18/2018	LTN

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	Art Unit
	LUONG T NGUYEN	2663

Search Notes		
Search Notes	**Date**	**Examiner**
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	2/1/2017	LTN
Inventorship search	2/1/2017	LTN
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	11/9/2017	LTN
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	08/18/2018	LTN
IPR2018-00236 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,339,493	08/18/2018	LTN
IPR2018-00238 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,736,729	08/18/2018	LTN
IPR2018-00904 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,339,493	08/18/2018	LTN
IPR2018-00908 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,100,604	08/18/2018	LTN
IPR2018-00909 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,100,604	08/18/2018	LTN
IPR2018-00910 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,059,177	08/18/2018	LTN

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	**Art Unit**
	LUONG T NGUYEN	2663

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	02/01/2017	11/09/2017	08/21/2018						
	1	✓	✓	✓						
	2		✓	-						
	3		✓	O						
	4		✓	O						
	5		✓	O						
	6		✓	O						
	7			✓						
	8			✓						
	9			O						
	10			O						
	11			O						
	12			O						
	13			✓						

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S81	1	15/386656	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 15:26
S82	177	(magnification near factor) and (pixel$1 same interval) and zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 15:28
S83	60	S82 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 15:29
S85	4	(magnification near factor) same (vertical near pixels$1) same zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 16:00
S86	248	((magnification near factor) or zoom$3) same (vertical near pixels$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 16:02
S87	31	S86 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 16:02
S88	0	(magnification near factor) same (vertical near pixels$1) same (zoom$3 near (button or switch))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 18:04
S89	0	(zoom near ratio) same (vertical near	US-PGPUB;	OR	ON	2018/08/18

		pixels$1) same (zoom$3 near (button or switch))	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			18:04
S90	2	(vertical near pixels$1) same (zoom$3 near (button or switch))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 18:04
S91	7	("4589029" | "4791308" | "5034804" | "6411361" | "6542201" | "6593963" | "6614474").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2018/08/18 18:06
S93	141	pixels$1 same (zoom$3 near (button or switch))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 18:15
S94	12	S93 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 18:15
S95	5	("5986698").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 19:29
S96	4	("5828406").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 19:32
S97	2	("6661451").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 19:40
S98	90	(pixels$1 near (mix$3 or combin$4 or cull$3)) same zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 19:50
S99	6	S98 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR;	OR	ON	2018/08/18 19:50

			FPRS; EPO; JPO; DERWENT; IBM_TDB			
S101	1320	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (sensor$1 or CCD$1 or CMOS) same vertical$2 and zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 19:52
S102	170	S101 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 19:53
S103	16	("4426664" | "4492980" | "4884144" | "4975777" | "5196939" | "5272535" | "5412422" | "5450129" | "5486859" | "5510836" | "5572256" | "5612739" | "5652622" | "5719625" | "5784103" | "5801850").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2018/08/18 20:00
S104	1	S101 and (view adj angle adj switch)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:11
S105	2	(view adj angle adj switch) same zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:12
S106	2	("6396538").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:19
S107	2	("4231066" | "4843475").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2018/08/18 20:19
S108	0	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (view adj angle adj switch) same vertical$2 and zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:41
S109	0	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (view adj angle adj switch) and zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	2018/08/18 20:42

			IBM_TDB			
S110	1	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) and (view adj angle adj switch) and zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:43
S111	2	14/661227	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:44
S112	177	(magnification near factor) and (pixel$1 same interval) and zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:45
S113	60	S112 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:45
S114	5696	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same vertical$2 and zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:47
S116	1665	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same vertical$2 and zoom$3 and magnification	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:48
S117	440	S116 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:48
S118	2529	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same vertical$2 and (zoom$3 near button or switch) and magnification	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/18 20:50
S120	49	S117 and (zoom$3 near (button or switch))	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2018/08/18 20:51

			JPO; DERWENT; IBM_TDB			
S121	18	("4479145" | "4517599" | "4704632" | "4779142" | "4783840" | "4891697" | "4933758" | "4937676" | "4963981" | "4969043" | "5031036" | "5032928" | "5083208" | "5311328" | "5374995" | "5384581" | "5428391" | "5457546").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2018/08/18 20:59
S122	14	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same vertical$2 same (optical near zoom$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 11:20
S123	20	(mix$3 or combin$3 or cull$3 or add$3) same inter$lock$3 same (optical near zoom$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 11:22
S124	49124	(H04N5/372 or H04N5/23248 or H04N5/3741 or H04N5/23258 or H04N9/045).CPC.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 11:26
S125	13967	(scan$4 with line) and (NTSC or standard) and (television or TV) and (mix$3 or combin$3 or cull$3 or add$3) and (pixel$1 or charge$1 or signal$1) and (sensor$1 or CCD$1 or CMOS)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 11:26
S126	600	S124 and S125	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 11:27
S127	4762	S125 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 11:27
S128	5	S127 and (inter$lock$3 same (optical near zoom$3))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 11:28
S129	39	S127 and (optical near zoom$3)	US-PGPUB; USPAT;	OR	ON	2018/08/19 11:30

			USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			
S130	1665	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same vertical$2 and zoom$3 and magnification	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 11:35
S131	170	S124 and S130	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 11:36
S132	25	S131 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 11:36
S133	4	"4774581".PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 12:17
S134	71	(magnification near (ratio or factor)) same pixel$1 same interval	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 12:27
S135	24	S134 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 12:27
S136	6108	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same vertical$2 same (magnification near ratio or factor)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 12:32
S137	162	S124 and S136	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 12:33

S138	39	S137 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 12:33
S139	46	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (view adj angle) same zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 13:51
S140	5959	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 13:55
S141	49124	(H04N5/372 or H04N5/23248 or H04N5/3741 or H04N5/23258 or H04N9/045).CPC.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 13:55
S142	316	S140 and S141	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 13:55
S143	66	S142 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 13:56
S144	3	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same zoom$3 same stepwise	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 14:14
S145	4	"5828406".PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 14:22
S146	59	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same vertical$2 same (electronic near zoom$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;			

			DERWENT; IBM_TDB			
S149	1505	(vary or various or varying or chang$3) same (magnification near (factor or ratio)) same zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 14:53
S150	81	S141 and S149	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 14:53
S152	184	(vary or various or varying or chang$3) same (magnification near (factor or ratio)) same ((electronic near zoom$3) or (optical near zoom$3))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 14:54
S153	14	S152 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 14:55
S154	91	S140 and S149	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 14:57
S155	16	("20020109782" | "4876590" | "5420632" | "5477264" | "5557328" | "5684532" | "5701157" | "5867217" | "5970261" | "5982429" | "6041195" | "6172707" | "6204880" | "6396538" | "6441854" | "6559888").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2018/08/19 15:04
S156	0	(thin$4) same (pixel$1 or charge$1 or signal$1) same (vary or various or varying or chang$3) same (magnification near (factor or ratio)) same ((electronic near zoom$3) or (optical near zoom$3))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 16:37
S157	1	(thin$4) same (pixel$1 or charge$1 or signal$1) same (magnification near (factor or ratio)) same ((electronic near zoom$3) or (optical near zoom$3))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 16:37
S158	4	(thin$4) same (magnification near (factor or ratio)) same ((electronic near zoom$3) or (optical near zoom$3))	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2018/08/19 16:45

			JPO; DERWENT; IBM_TDB			
S159	766	(thin$4) same (magnification near (factor or ratio))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 16:46
S160	201	S159 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 16:47
S161	1	("5715013").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2018/08/19 16:52
S162	611	(thin$4) same ((electronic near zoom$3) or (optical near zoom$3))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 16:53
S163	47	S162 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2018/08/19 16:53

EAST Search History (Interference)

< This search history is empty>

8/ 21/ 2018 10:01:35 PM
C:\ Users\ lnguyen2\ Documents\ EAST\ Workspaces\ 15386656.wsp

Receipt date: 04/16/2018

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	15386656
Filing Date	2016-12-21
First Named Inventor	NAKANO, T.
Art Unit	2663
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-08

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4958915	A	1990-09-25	OKADA et al.	
	2	5060074	A	1991-10-22	KINUGASA et al.	
	3	5440343	A	1995-08-08	PARULSKI et al.	
	4	5493335	A	1996-02-20	PARULSKI et al.	
	5	5497191	A	1996-03-05	YOO et al.	
	6	5497192	A	1996-03-05	ISHIZUKA	
	7	5054052	A	1991-10-01	NONAMI	
	8	5793923	A	1998-08-11	SAWANOBORI	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

Receipt date: 04/16/2018

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	9	5828406	A	1998-10-27	PARULSKI et al.	
	10	6512541	B2	2003-01-28	DUNTON et al.	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	ZTE (USA) Inc.'s Provisional Preliminary Invalidity Contentions which were filed in the following litigation: HITACHI MAXELL, LTD. v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-00179 RWS (E.D. Tex.), filed ~~November 18, 2016~~ April 17, 2017	
	2	ZTE (USA) Inc.'s Invalidity Contentions which were filed in the following litigation: HITACHI MAXELL, LTD. v. HUAWEI DEVICE USA INC. and HUAWEI DEVICE CO., LTD., Civil Action No. 5:16-cv-00178 RWS (E.D. Tex.) and v. ZTE CORP. and ZTE USA INC., Civil Action No. 5:16-cv-00179 RWS (E.D. Tex.), filed ~~November 18, 2016~~ June 30, 2017	

EFS Web 2.1.18

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Receipt date: 04/16/2018

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	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

	3	Asustek Computer Inc. and Asus Computer International's Invalidity Contentions which were filed in the following litigation: MAXELL, LTD. v. ASUSTEK COMPUTER INC. AND ASUS COMPUTER INTERNATIONAL, Civil Action No. 2:17-cv-7528-R-MRW (C.D. CA), filed ~~October 13, 2017~~ March 26, 2018

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EXAMINER SIGNATURE

Examiner Signature	/LUONG T NGUYEN/	Date Considered	08/21/2018

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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Receipt date: 04/16/2018

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	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2663
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2018-04-16
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) : MAXELL, LTD.

Confirmation No.: 3687

Serial No. : 15/386,656

Filed : December 21, 2016

For : ELECTRIC CAMERA

Group : 2663

Examiner : Luong TRUNG NGUYEN

Docket No. : ASA-9606-08

Customer No.: 24956

AMENDMENT

Mail Stop: Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

February 27, 2019

Sir:

In response to the Non-Final Office Action mailed August 27, 2018, please amend the above-identified patent application as follows. A fee for a 3-month Extension of Time accompanies this response.

Amendments to the Claims begin on page 2 of this paper.

Remarks begin on page 12 of this paper.

Electronic Patent Application Fee Transmittal

Application Number:	15386656
Filing Date:	21-Dec-2016
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly/Krista Hargrove
Attorney Docket Number:	ASA-9606-08

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension - 3 months with $0 paid	1253	1	1400	1400
Miscellaneous:				
		Total in USD ($)		**1400**

Electronic Acknowledgement Receipt	
EFS ID:	35263835
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Krista Hargrove
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-08
Receipt Date:	27-FEB-2019
Filing Date:	21-DEC-2016
Time Stamp:	11:59:50
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1400
RAM confirmation Number	022719INTEFSW12020100
Deposit Account	501417
Authorized User	Krista Hargrove
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		9606-08-AMD04-revised.pdf	59092 107d6a90bbd6d2a65fe670d2c739bd4c0f19d480	yes	14

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Claims	2	11
Applicant Arguments/Remarks Made in an Amendment	12	14

Warnings:

Information:

2	Fee Worksheet (SB06)	fee-info.pdf	30664 4261d21fb5727211b51da40c9646badd0ae996a3	no	2

Warnings:

Information:

Total Files Size (in bytes):	89756

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-08

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

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	Attorney Docket Number	ASA-9606-08

	1	ZTE Corporation and ZTE (USA), Inc. v. Hitachi Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,339,493, Inter Partes Review No. IPR2018-00236 filed November 22, 2017	
	2	ZTE Corporation and ZTE (USA), Inc. v. Hitachi Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,736,729, Inter Partes Review No. IPR2018-00238 filed November 22, 2017	
	3	Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,339,493, Inter Partes Review No. IPR2018-00904 dated June 20, 2018	
	4	Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2018-00908 dated June 20, 2018	
	5	Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2018-00909 dated June 20, 2018	
	6	Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,059,177, Inter Partes Review No. IPR2018-00910 dated June 20, 2018	
	7	Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 7,403,226, Inter Partes Review No. IPR2019-00068 dated October 16, 2018	
	8	Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,544,517, Inter Partes Review No. IPR2019-00069 dated October 16, 2018	
	9	BlackBerry Corporation v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 6,765,616, Inter Partes Review No. IPR2019-00087 dated October 15, 2018	
	10	BlackBerry Corporation v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2019-00097 dated October 16, 2018	
	11	Huawei Technologies Co., Ltd. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,544,517, Inter Partes Review No. IPR2019-00656 dated February 6, 2019	

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	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

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EXAMINER SIGNATURE			
Examiner Signature		Date Considered	

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

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OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-02-27
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Electronic Patent Application Fee Transmittal

Application Number:	15386656
Filing Date:	21-Dec-2016
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly/Emily Scotti
Attorney Docket Number:	ASA-9606-08

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	240	240
		Total in USD ($)		**240**

Electronic Acknowledgement Receipt	
EFS ID:	35262362
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Krista Hargrove
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-08
Receipt Date:	27-FEB-2019
Filing Date:	21-DEC-2016
Time Stamp:	12:16:25
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$240
RAM confirmation Number	022719INTEFSW12165900
Deposit Account	501417
Authorized User	Krista Hargrove
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	9606-08-NoticeofIPR-2.pdf	22706 0b281e692387a3fe7f1c30c423ed74f44ede8273	no	2
Warnings:					
Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	9606-08-SB08A-IPR-2.pdf	1034839 cd9dbb27168fad889022e1d0a09ef1416a9b389c	no	5
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
3	Non Patent Literature	Petition_IPR2018-00236.pdf	1423680 87376f0c978c62b5bb76a07e209ef734fe4eb294	no	56
Warnings:					
Information:					
4	Non Patent Literature	Petition_IPR2018-00238.pdf	728579 a9a8ee1aa7a6ae4bc57b185a9d4711039dfaebfc	no	60
Warnings:					
Information:					
5	Non Patent Literature	Petition_IPR2018-00904.pdf	1022243 d43e215f5d270e422ff05299e1899fc40874ad74	no	86
Warnings:					
Information:					

6	Non Patent Literature	Petition_IPR2018-00908.pdf	695774 80f0c35c71b1af17ca27ddbb5a713c58aa921690	no	78
Warnings:					
Information:					
7	Non Patent Literature	Petition_IPR2018-00909.pdf	2421861 1b2aaed83544e1f9a0871236744fa8b21553c5a6	no	83
Warnings:					
Information:					
8	Non Patent Literature	Petition_IPR2018-00910.pdf	2564451 d3f6abadda63425ccad88c64ea57e4618d105eef	no	82
Warnings:					
Information:					
9	Non Patent Literature	Petition_IPR2019-00068.pdf	2325088 8cb6efb9f33b3fd1a2d9017daea348c291a950f1	no	91
Warnings:					
Information:					
10	Non Patent Literature	Petition_IPR2019-00069.pdf	2431802 2bcc4ae47495ba3fdb1b89aadbb977ffd84c297e	no	97
Warnings:					
Information:					
11	Non Patent Literature	Petition_IPR2019-00087.pdf	2733159 d3ede703efeeedb1af22c807ca0db2c54055065e	no	63
Warnings:					
Information:					
12	Non Patent Literature	Petition_IPR2019-00097.pdf	732431 1230bec37b2807a0107ac43d869819d82d638c8e	no	73
Warnings:					
Information:					

13	Non Patent Literature	Petition_IPR2019-00656.pdf	3018069 1f718ca703d3bd78d8b8a098970808b7f7f36529	no	67
Warnings:					
Information:					
14	Fee Worksheet (SB06)	fee-info.pdf	30360 6db8f6706907eb1c45e166ea0068d54d247414cc	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	21185042		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Atty. Docket No. ASA-9606-08

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: 15/386,656	Confirmation No.	: 3687
Applicant	: Maxell, Ltd.	TC/GAU	: 2698
Filed	: December 21, 2016	Examiner	: NGUYEN, L. T.
Title	: ELECTRIC CAMERA		

Customer No.: 24956

NOTICE OF RELATED PATENTS INVOLVED IN *INTER PARTES* REVIEW

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

February 27, 2019

Sir:

Applicant notifies the Office of seven related U.S. Patent Nos. which claim priority under 35 U.S.C. 120 and are involved in the following *Inter Partes* Review proceedings:

1. 6,765,616 which which is the parent of patent nos. 7,403,226 and 8,059,177
2. 7,403,226 which matured from application 09/250,836
3. 8,059,177 which matured from application 09/250,836
4. 8,339,493 which matured from application 10/660,710
5. 8,736,729 which matured from application 12/845,266
6. 9,100,604 which matured from application 13/681,495
7. 9,544,517 which matured from application 14/264,243

ZTE Corporation and ZTE (USA), Inc. v. Hitachi Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 8,339,493, *Inter Partes* Review No. IPR2018-00236.

ZTE Corporation and ZTE (USA), Inc. v. Hitachi Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 8,736,729, *Inter Partes* Review No. IPR2018-00238.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 8,339,493, *Inter Partes* Review No. IPR2018-00904.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 9,100,604, *Inter Partes* Review No. IPR2018-00908.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 9,100,604, *Inter Partes* Review No. IPR2018-00909.

Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 8,059,177, *Inter Partes* Review No. IPR2018-00910.

Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 7,403,226, *Inter Partes* Review No. IPR2019-00068.

Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 9,544,517, *Inter Partes* Review No. IPR2019-00069.

BlackBerry Corporation v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 6,765,616, *Inter Partes* Review No. IPR2019-00087.

BlackBerry Corporation v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 9,100,604, *Inter Partes* Review No. IPR2019-00097.

Huawei Technologies Co., Ltd. v. Maxell, Ltd., Petition for *Inter Partes* Review of U.S. Patent No. 9,544,517, *Inter Partes* Review No. IPR2019-00656.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/_____
John R. Mattingly, Reg. No. 30,293
(703) 684-1120

REMARKS

Claims 1, 4-8 and 10-19 are pending in this application. Claim 2 was previously canceled without prejudice and without disclaimer. Claims 3 and 9 have been canceled without prejudice and without disclaimer. Claims 1, 4-8 and 10-13 have been amended. New claims 14-19 have been added. No new matter has been added.

Information Disclosure Statement

Applicants appreciate the Examiner's consideration of the references submitted in the Information Disclosure Statement filed April 16, 2018.

Rejections Under 35 U.S.C. § 103

Claims 1, 7, 8 and 13 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Kijima et al. (U.S. 6,661,451) in view of Tamura et al. (U.S. 5,959,670).

Without admitting to the propriety of the rejection under 35 U.S.C. §103, it is submitted that amended claims 1, 7, 8 and 13 render the rejection moot.

Allowable Subject Matter

The Examiner has objected to claims 3-6 and 9-12 as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Claim 1 has been amended to incorporate allowable claim 3. Claims 4-6 have been amended to depend on claim 1.

Claim 7 has been amended to incorporate subject matter similar to allowable claim 3. New claims 14-16 depend on claim 7.

Claim 8 has been amended to incorporate allowable claim 9. Claims 10-12 have been amended to depend on claim 8.

Claim 13 has been amended to incorporate subject matter similar to allowable claim 9. New claims 17-19 depend on claim 13.

As such, it is submitted that claims 1, 4-8 and 10-19 are in condition for allowance.

Conclusion

In view of the foregoing amendments and remarks, Applicants request reconsideration of the rejection and allowance of the claims.

The Commissioner is authorized to charge any shortage in the fees due, or credit any overpayment, to Deposit Account No. 50-1417 (referencing Attorney Docket No. ASA-9606-08).

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Registration No. 30,293
703-684-1120

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently amended) An electric camera comprising:

an image sensing device with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

a signal processing unit configured to generate image signals by using the signals outputted by the image sensing device; and

a zoom operation unit configured to operate to continuously change a magnification factor;

wherein, as the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals to generate image signals based on signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels including:

a first state of the at least three states in which the image signals are generated using signals based on a first area of the light receiving surface with a first magnification factor,

a second state of the at least three states in which the image signals are generated using signals based on a second area of the light receiving surface with a second magnification factor, and

a third state of the at least three states in which the image signals are generated using signals based on a third area of the light receiving surface with a third magnification factor, and

wherein, while a state is between the first state and the second state when the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs signals to generate image signals based on signal charges accumulated with a first interval of vertical pixels,

wherein, while a state is between the second state and the third state when the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs signals to generate image signals based on signal charges accumulated with a second interval of vertical pixels which is different from the first interval.

2.-3. (Canceled).

4. (Currently amended) The electric camera according to ~~claim 3~~claim 1,

wherein the image sensing device outputs the signals which are mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

5. (Currently amended) The electric camera according to ~~claim 3~~claim 1,

wherein, as the zoom operation unit is operated to continuously change the magnification factor during recording of a moving video in a moving video mode, the image sensing device outputs the signals to generate image signals based on signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

6. (Currently amended) The electric camera according to ~~claim 3~~claim 1,

wherein the electric camera has a static image mode for taking a static image and, when in the static image mode, the signal processing unit generates the static image by using all signals accumulated in all of an effective number of the vertical pixels.

7. (Currently amended) An electric camera comprising:

an image sensing device with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

a processor circuitry configured to control generating image signals by using the signals outputted by the image sensing device and to continuously change a magnification factor in accordance with a zoom operation;

wherein, as the processor circuitry controls to continuously change the magnification factor in accordance with a zoom operation, the image sensing device outputs signals to generate image signals based on signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels including:

a first state of the at least three states in which the image signals are generated using signals based on a first area of the light receiving surface with a first magnification factor,

a second state of the at least three states in which the image signals are generated using signals based on a second area of the light receiving surface with a second magnification factor, and

a third state of the at least three states in which the image signals are generated using signals based on a third area of the light receiving surface with a third magnification factor, and

wherein, while a state is between the first state and the second state when continuously changing the magnification factor in accordance with the zoom operation, the image sensing device outputs signals to generate image signals based on signal charges accumulated with a first interval of vertical pixels,

wherein, while a state is between the second state and the third state when continuously changing the magnification factor in accordance with the zoom operation, the image sensing device outputs signals to generate image signals based on signal charges accumulated with a second interval of vertical pixels which is different from the first interval.

8. (Currently amended) An operating method for an electric camera comprising:

receiving light with an image sensing device having a light receiving surface including an array of pixels arranged vertically and horizontally, and outputting signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

generating image signals by using the signals outputted by the image sensing device;

continuously changing a magnification factor of a zoom operation; and

wherein, as the zoom operation continuously changes the magnification factor, the outputting of the signals of the image sensing device includes outputting the signals to generate image signals based on signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels, and

wherein:

the generating of the image signals includes, in a first state of the at least three states, generating the image signals using signals output by the image sensing device based on a first area of the light receiving surface with a first magnification factor,

the generating of the image signals includes, in a second state of the at least three states, generating the image signals using signals output by the image sensing device based on a second area of the light receiving surface with a second magnification factor, and

the generating of the image signals includes, in a third state of the at least three states, generating the image signals using signals output by the image sensing device based on a third area of the light receiving surface with a third magnification factor,

wherein, while a state is between the first state and the second state when the zoom operation continuously changes the magnification factor, outputting with the image sensing device signals to generate image signals based on signal charges accumulated with a first interval of vertical pixels, and

wherein, while a state is between the second state and the third state when the zoom operation continuously changes the magnification factor, outputting with the image sensing device signals to generate image signals based on signal charges accumulated with a second interval of vertical pixels which is different from the first interval.

9. (Canceled).

10. (Currently amended) The operating method according to ~~claim 9~~claim 8,

wherein the outputting of the signals with the image sensing device includes outputting mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

11. (Currently amended) The operating method according to ~~claim 9~~claim 8,

wherein, as the zoom operation continuously changes the magnification factor during recording of a moving video in a moving video mode, the outputting of the signals with the image sensing device includes outputting the signals to generate image signals based on signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

12. (Currently amended) The operating method according to ~~claim 9~~claim 8,

wherein the electric camera has a static image mode for taking a static image and, wherein, in the static image mode, the generating of the image signals includes generating the static image by using all signals accumulated in all of an effective number of the vertical pixels.

13. (Currently amended) An operating method for an electric camera comprising:

receiving light with an image sensing device having a light receiving surface having an array of pixels arranged vertically and horizontally, and outputting signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

controlling with processor circuitry generating image signals by using the signals outputted by the image sensing device and controlling to continuously change a magnification factor in accordance with a zoom operation;

wherein, as the zoom operation is controlled with the processor circuitry to continuously change the magnification factor, the outputting of the signals of the image sensing device includes outputting the signals to generate image signals based on signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels, and

wherein:

the generating of the image signals includes, in a first state of the at least three states, generating the image signals using signals output by the image sensing device based on a first area of the light receiving surface with a first magnification factor,

the generating of the image signals includes, in a second state of the at least three states, generating the image signals using signals output by the image sensing device based on a second area of the light receiving surface with a second magnification factor, and

the generating of the image signals includes, in a third state of the at least three states, generating the image signals using signals output by the image sensing device based on a third area of the light receiving surface with a third magnification factor,

wherein, while a state is between the first state and the second state when the zoom operation continuously changes the magnification factor, outputting with the image sensing device signals to generate image signals based on signal charges accumulated with a first interval of vertical pixels, and

wherein, while a state is between the second state and the third state when the zoom operation continuously changes the magnification factor, outputting with the image sensing device signals to generate image signals based on signal charges accumulated with a second interval of vertical pixels which is different from the first interval.

14. (New) The electric camera according to claim 7,

wherein the image sensing device outputs the signals which are mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

15. (New) The electric camera according to claim 7,

wherein, as the processor circuitry controls to continuously change the magnification factor during recording of a moving video in a moving video mode, the image sensing device outputs the signals to generate image signals based on signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

16. (New) The electric camera according to claim 7,

wherein the electric camera has a static image mode for taking a static image and, when in the static image mode, the processor circuitry controls to generate the static image by using all signals accumulated in all of an effective number of the vertical pixels.

17. (New) The operating method according to claim 13,

wherein the outputting of the signals with the image sensing device includes outputting mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

18. (New) The operating method according to claim 13,

wherein, as the zoom operation continuously changes the magnification factor during recording of a moving video in a moving video mode, the outputting of the

signals with the image sensing device includes outputting the signals to generate image signals based on signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

19. (New) The operating method according to claim 13,

wherein the electric camera has a static image mode for taking a static image and, wherein, in the static image mode, the generating of the image signals includes generating the static image by using all signals accumulated in all of an effective number of the vertical pixels.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/386,656	Filing Date 12/21/2016	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $80 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $420 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	02/27/2019	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 16	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 4	= 0		x $460 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/TRINA RIDDICK/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08	3687

24956 7590 05/15/2019

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
NGUYEN, LUONG TRUNG	

ART UNIT	PAPER NUMBER
2698	

NOTIFICATION DATE	DELIVERY MODE
05/15/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

Office Action Summary	**Application No.** 15/386,656	**Applicant(s)** NAKANO et al.	
	Examiner LUONG T NGUYEN	**Art Unit** 2698	**AIA (FITF) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 02/27/2019.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☑ This action is **FINAL.** 2b) ☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1,4-8 and 10-19 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1,4-8 and 10-19 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application is being examined under the pre-AIA first to invent provisions.

Information Disclosure Statement

2. The information disclosure statement (IDS) submitted on 02/27/2019 is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner.

Response to Arguments

3. Applicant's arguments with respect to claims 1, 4-8, 10-13 and newly added claims 14-19 filed on 02/27/2019 have been considered but are moot because the arguments do not apply to any of the references being used in the current rejection.

Claim Rejections - 35 USC § 112

4. The following is a quotation of 35 U.S.C. 112(b):

> (b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

5. Claims 1, 4-8, 10-19 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Claim 1 (line 6) recites limitation “image signals;” it is unclear that limitation “image signals” as recited in claim 1 (line 6) is the same or different from newly added limitation “image signals” as amended in claim 1 (line 4).

Claim 1 (lines 11-12) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 1 (lines 11-12) corresponds to limitation “image signals” as amended in claim 1 (line 4) or corresponds to limitation “image signals” as recited in claim 1 (line 6).

Claim 1 (line 12) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 1 (line 12) is the same or different from newly added limitation “signal charges” as amended in claim 1 (line 4).

Claim 1 (line 16) amended with limitation “the image signals;” it is unclear that limitation “the image signals” as amended in claim 1 (line 16) corresponds to limitation “image signals” as amended in claim 1 (line 4) or corresponds to limitation “image signals” as recited in claim 1 (line 6) or corresponds to limitation “image signals” as amended in claim 1 (lines 11-12).

Claim 1 (line 19) amended with limitation “the image signals;” it is unclear that limitation “the image signals” as amended in claim 1 (line 19) corresponds to limitation “image signals” as amended in claim 1 (line 4) or corresponds to limitation “image signals” as recited in claim 1 (line 6) or corresponds to limitation “image signals” as amended in claim 1 (lines 11-12).

Claim 1 (line 22) amended with limitation “the image signals;” it is unclear that limitation “the image signals” as amended in claim 1 (line 22) corresponds to limitation “image signals” as amended in claim 1 (line 4) or corresponds to limitation “image signals” as recited in claim 1 (line 6) or corresponds to limitation “image signals” as amended in claim 1 (lines 11-12).

Claim 1 (line 27) amended with limitation “signals;” it is unclear that limitation “signals” as amended in claim 1 (line 27) corresponds to limitation “signals” as recited in claim 1 (line 3) or

corresponds to limitation “the signals” as recited in claim 1 (lines 6-7) or corresponds to limitation “signals” as amended in claim 1 (line 17).

Claim 1 (line 27) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 1 (line 27) corresponds to limitation “image signals” as amended in claim 1 (line 4) or corresponds to limitation “image signals” as recited in claim 1 (line 6) or corresponds to limitation “image signals” as amended in claim 1 (lines 11-12) or corresponds to limitation “the image signals” as amended in claim 1 (line 16).

Claim 1 (lines 27-28) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 1 (lines 27-28) corresponds to limitation “signal charges” as amended in claim 1 (line 4) or corresponds to limitation “signal charges” as amended in claim 1 (line 12).

Claim 1 (line 31) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 1 (line 31) corresponds to limitation “image signals” as amended in claim 1 (line 4) or corresponds to limitation “image signals” as recited in claim 1 (line 6) or corresponds to limitation “image signals” as amended in claim 1 (lines 11-12) or corresponds to limitation “the image signals” as amended in claim 1 (line 19).

Claim 1 (line 31) amended with limitation “signals;” it is unclear that limitation “signals” as amended in claim 1 (line 31) corresponds to limitation “signals” as recited in claim 1 (line 3) or corresponds to limitation “the signals” as recited in claim 1 (lines 6-7) or corresponds to limitation “signals” as amended in claim 1 (line 20).

Claim 1 (lines 31-32) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 1 (lines 31-32) corresponds to limitation “signal charges” as amended in claim 1 (line 4) or corresponds to limitation “signal charges” as amended in claim 1 (line 12).

Claim 5 (line 4) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 5 (line 4) corresponds to limitation “image signals” as amended in claim 1

(line 4) or corresponds to limitation "image signals" as recited in claim 1 (line 6) or corresponds to limitation "image signals" as amended in claim 1 (lines 11-12).

Claim 5 (lines 4-5) amended with limitation "signal charges;" it is unclear that limitation "signal charges" as amended in claim 5 (lines 4-5) corresponds to limitation "signal charges" as amended in claim 1 (line 4) or corresponds to limitation "signal charges" as amended in claim 1 (line 12).

Claim 7 (line 6) recites limitation "image signals;" it is unclear that limitation "image signals" as recited in claim 7 (line 6) is the same or different from newly added limitation "image signals" as amended in claim 7 (line 4).

Claim 7 (line 11) amended with limitation "image signals;" it is unclear that limitation "image signals" as amended in claim 7 (line 11) corresponds to limitation "image signals" as amended in claim 7 (line 4) or corresponds to limitation "image signals" as recited in claim 7 (line 6).

Claim 7 (line 11) amended with limitation "signal charges;" it is unclear that limitation "signal charges" as amended in claim 7 (line 11) is the same or different from newly added limitation "signal charges" as amended in claim 7 (line 4).

Claim 7 (line 11) amended with limitation "signals;" it is unclear that limitation "signals" as amended in claim 7 (line 11) is the same or different from newly added limitation "signals" as recited in claim 7 (line 3).

Claim 7 (line 15) amended with limitation "the image signals;" it is unclear that limitation "the image signals" as amended in claim 7 (line 15) corresponds to limitation "image signals" as amended in claim 7 (line 4) or corresponds to limitation "image signals" as recited in claim 7 (line 6) or corresponds to limitation "image signals" as amended in claim 7 (lines 11).

Claim 7 (line 18) amended with limitation "the image signals;" it is unclear that limitation "the image signals" as amended in claim 7 (line 18) corresponds to limitation "image signals" as amended in

claim 7 (line 4) or corresponds to limitation “image signals” as recited in claim 7 (line 6) or corresponds to limitation “image signals” as amended in claim 7 (line 11).

Claim 7 (line 21) amended with limitation “the image signals;” it is unclear that limitation “the image signals” as amended in claim 7 (line 21) corresponds to limitation “image signals” as amended in claim 7 (line 4) or corresponds to limitation “image signals” as recited in claim 7 (line 6) or corresponds to limitation “image signals” as amended in claim 7 (line 11).

Claim 7 (line 16) amended with limitation “signals;” it is unclear that limitation “signals” as amended in claim 7 (line 16) corresponds to limitation “signals” as recited in claim 7 (line 3) or corresponds to limitation “the signals” as recited in claim 7 (line 7) or corresponds to limitation “signals” as amended in claim 7 (line 11).

Claim 7 (line 18) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 7 (line 18) corresponds to limitation “image signals” as amended in claim 7 (line 4) or corresponds to limitation “image signals” as recited in claim 7 (line 6) or corresponds to limitation “image signals” as amended in claim 7 (line 11) or corresponds to limitation “the image signals” as amended in claim 7 (line 15).

Claim 7 (line 27) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 7 (line 27) corresponds to limitation “signal charges” as amended in claim 7 (line 4) or corresponds to limitation “signal charges” as amended in claim 7 (line 11).

Claim 7 (line 30) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 7 (line 30) corresponds to limitation “image signals” as amended in claim 7 (line 4) or corresponds to limitation “image signals” as recited in claim 7 (line 6) or corresponds to limitation “image signals” as amended in claim 7 (line 11) or corresponds to limitation “the image signals” as amended in claim 7 (line 18).

Claim 7 (line 30) amended with limitation “signals;” it is unclear that limitation “signals” as amended in claim 7 (line 30) corresponds to limitation “signals” as recited in claim 1 (line 3) or corresponds to limitation “the signals” as recited in claim 7 (line 7) or corresponds to limitation “signals” as recited in claim 7 (line 11).

Claim 7 (line 31) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 7 (line 31) corresponds to limitation “signal charges” as amended in claim 7 (line 4) or corresponds to limitation “signal charges” as amended in claim 17 (line 11).

Claim 8 (line 7) recites limitation “image signals;” it is unclear that limitation “image signals” as recited in claim 8 (line 7) is the same or different from newly added limitation “image signals” as amended in claim 8 (line 5).

Claim 8 (line 12) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 8 (line 12) corresponds to limitation “image signals” as amended in claim 8 (line 5) or corresponds to limitation “image signals” as recited in claim 8 (line 7).

Claim 8 (line 12) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 8 (line 12) is the same or different from newly added limitation “signal charges” as amended in claim 8 (line 5).

Claim 8 (line 17) amended with limitation “the image signals;” it is unclear that limitation “the image signals” as amended in claim 8 (line 17) corresponds to limitation “image signals” as amended in claim 8 (line 5) or corresponds to limitation “image signals” as recited in claim 8 (line 7) or corresponds to limitation “image signals” as amended in claim 8 (line 12).

Claim 8 (line 21) amended with limitation “the image signals;” it is unclear that limitation “the image signals” as amended in claim 8 (line 21) corresponds to limitation “image signals” as amended in claim 8 (line 5) or corresponds to limitation “image signals” as recited in claim 8 (line 7) or corresponds to limitation “image signals” as amended in claim 1 (line 12).

Claim 8 (line 25) amended with limitation "the image signals;" it is unclear that limitation "the image signals" as amended in claim 8 (line 25) corresponds to limitation "image signals" as amended in claim 8 (line 5) or corresponds to limitation "image signals" as recited in claim 8 (line 7) or corresponds to limitation "image signals" as amended in claim 8 (line 12).

Claim 8 (line 31) amended with limitation "signals;" it is unclear that limitation "signals" as amended in claim 8 (line 31) corresponds to limitation "signals" as recited in claim 8 (line 5) or corresponds to limitation "the signals" as recited in claim 8 (line 12) or corresponds to limitation "signals" as amended in claim 8 (line 18).

Claim 8 (line 31) amended with limitation "image signals;" it is unclear that limitation "image signals" as amended in claim 8 (line 31) corresponds to limitation "image signals" as amended in claim 8 (line 5) or corresponds to limitation "image signals" as recited in claim 8 (line 7) or corresponds to limitation "image signals" as amended in claim 8 (line 12) or corresponds to limitation "the image signals" as amended in claim 8 (line 17).

Claim 8 (line 31) amended with limitation "signal charges;" it is unclear that limitation "signal charges" as amended in claim 8 (line 31) corresponds to limitation "signal charges" as amended in claim 8 (line 5) or corresponds to limitation "signal charges" as amended in claim 8 (line 12).

Claim 8 (line 31) amended with limitation "image signals;" it is unclear that limitation "image signals" as amended in claim 8 (line 31) corresponds to limitation "image signals" as amended in claim 8 (line 5) or corresponds to limitation "image signals" as recited in claim 8 (line 7) or corresponds to limitation "image signals" as amended in claim 8 (line 12) or corresponds to limitation "the image signals" as amended in claim 8 (line 17).

Claim 8 (line 31) amended with limitation "signals;" it is unclear that limitation "signals" as amended in claim 8 (line 31) corresponds to limitation "signals" as recited in claim 8 (line 5) or

corresponds to limitation “the signals” as recited in claim 8 (line 7) or corresponds to limitation “the signals” as recited in claim 8 (line 12).

Claim 8 (line 31) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 8 (line 31) corresponds to limitation “signal charges” as amended in claim 8 (line 5) or corresponds to limitation “signal charges” as amended in claim 8 (line 12).

Claim 11 (line 6) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 11 (line 6) corresponds to limitation “image signals” as amended in claim 8 (line 5) or corresponds to limitation “image signals” as recited in claim 8 (line 7) or corresponds to limitation “image signals” as amended in claim 8 (line 12).

Claim 11 (line 6) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 11 (line 6) corresponds to limitation “signal charges” as amended in claim 8 (line 5) or corresponds to limitation “signal charges” as amended in claim 8 (line 12).

Claim 13 (line 7) recites limitation “image signals;” it is unclear that limitation “image signals” as recited in claim 13 (line 7) is the same or different from newly added limitation “image signals” as amended in claim 13 (line 5).

Claim 13 (line 12) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 13 (line 12) corresponds to limitation “image signals” as amended in claim 13 (line 5) or corresponds to limitation “image signals” as recited in claim 13 (line 7).

Claim 13 (line 13) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 13 (line 13) is the same or different from newly added limitation “signal charges” as amended in claim 8 (line 5).

Claim 13 (line 18) amended with limitation “the image signals;” it is unclear that limitation “the image signals” as amended in claim 13 (line 18) corresponds to limitation “image signals” as amended in

claim 13 (line 5) or corresponds to limitation “image signals” as recited in claim 13 (line 7) or corresponds to limitation “image signals” as amended in claim 13 (line 12).

Claim 13 (line 22) amended with limitation “the image signals;” it is unclear that limitation “the image signals” as amended in claim 13 (line 22) corresponds to limitation “image signals” as amended in claim 13 (line 5) or corresponds to limitation “image signals” as recited in claim 13 (line 7) or corresponds to limitation “image signals” as amended in claim 13 (line 12).

Claim 13 (line 27) amended with limitation “the image signals;” it is unclear that limitation “the image signals” as amended in claim 13 (line 27) corresponds to limitation “image signals” as amended in claim 13 (line 5) or corresponds to limitation “image signals” as recited in claim 13 (line 7) or corresponds to limitation “image signals” as amended in claim 13 (line 12).

Claim 13 (line 32) amended with limitation “signals;” it is unclear that limitation “signals” as amended in claim 13 (line 32) corresponds to limitation “signals” as recited in claim 13 (line 4) or corresponds to limitation “the signals” as recited in claim 13 (line 12) or corresponds to limitation “signals” as amended in claim 13 (line 19).

Claim 13 (line 32) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 13 (line 32) corresponds to limitation “image signals” as amended in claim 13 (line 5) or corresponds to limitation “image signals” as recited in claim 13 (line 7) or corresponds to limitation “image signals” as amended in claim 13 (line 12) or corresponds to limitation “the image signals” as amended in claim 13 (line 18).

Claim 13 (line 32) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 13 (line 32) corresponds to limitation “signal charges” as amended in claim 13 (line 5) or corresponds to limitation “signal charges” as amended in claim 13 (line 13).

Claim 13 (line 32) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 3 (line 32) corresponds to limitation “image signals” as amended in claim

13 (line 5) or corresponds to limitation “image signals” as recited in claim 13 (line 7) or corresponds to limitation “image signals” as amended in claim 13 (line 12) or corresponds to limitation “the image signals” as amended in claim 13 (line 18).

Claim 13 (line 32) amended with limitation “signals;” it is unclear that limitation “signals” as amended in claim 13 (line 32) corresponds to limitation “signals” as recited in claim 13 (line 4) or corresponds to limitation “the signals” as recited in claim 13 (lines 6-7) or corresponds to limitation “the signals” as recited in claim 13 (line 12).

Claim 13 (line 32) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 13 (line 32) corresponds to limitation “signal charges” as amended in claim 13 (line 5) or corresponds to limitation “signal charges” as amended in claim 13 (line 13).

Claim 15 (line 4) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 15 (line 4) corresponds to limitation “image signals” as amended in claim 7 (line 4) or corresponds to limitation “image signals” as recited in claim 7 (line 6) or corresponds to limitation “image signals” as amended in claim 7 (line 11).

Claim 15 (lines 4-5) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 15 (lines 4-5) corresponds to limitation “signal charges” as amended in claim 7 (line 4) or corresponds to limitation “signal charges” as amended in claim 7 (line 11).

Claim 18 (line 5) amended with limitation “image signals;” it is unclear that limitation “image signals” as amended in claim 18 (line 5) corresponds to limitation “image signals” as amended in claim 13 (line 5) or corresponds to limitation “image signals” as recited in claim 13 (line 7) or corresponds to limitation “image signals” as amended in claim 13 (line 12).

Claim 18 (line 5) amended with limitation “signal charges;” it is unclear that limitation “signal charges” as amended in claim 18 (line 5) corresponds to limitation “signal charges” as amended in claim 13 (line 5) or corresponds to limitation “signal charges” as amended in claim 13 (line 13).

Claims 4-6 are rejected as being dependent from claim 1.

Claims 10-12 are rejected as being dependent from claim 8.

Claims 14-16 are rejected as being dependent from claim 7.

Claims 17-19 are rejected as being dependent from claim 13.

Conclusion

6. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to LUONG TRUNG NGUYEN whose telephone number is (571)272-7315. The examiner can normally be reached on 7:30AM-5:00PM, MONDAY - THURSDAY.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, TWYLER HASKINS can be reached on (571) 272-7406. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2698
05/10/2019

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	**Art Unit**
	LUONG T NGUYEN	2698

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	02/01/2017	11/09/2017	08/21/2018	05/10/2019					
	1	✓	✓	✓	✓					
	2		✓	-	-					
	3		✓	O	-					
	4		✓	O	✓					
	5		✓	O	✓					
	6		✓	O	✓					
	7			✓	✓					
	8			✓	✓					
	9			O	-					
	10			O	✓					
	11			O	✓					
	12			O	✓					
	13			✓	✓					
	14				✓					
	15				✓					
	16				✓					
	17				✓					
	18				✓					
	19				✓					

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	Art Unit
	LUONG T NGUYEN	2698

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04N5/372; H04N5/23248; H04N5/3741; H04N5/23258; H04N9/045; H04N5/3454; H04N5/23274	2/1/2017	LTN
H04N5/372, H04N5/23248, H04N5/3741, H04N5/23258, H04N9/045	11/9/2017	LTN
H04N5/372, H04N5/23248, H04N5/3741, H04N5/23258, H04N9/045	08/18/2018	LTN
H04N5/372, H04N5/23248, H04N5/23258, H04N5/23274, H04N5/3741, H04N2209/045, H04N9/045	05/06/2019	LTN

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	Art Unit
	LUONG T NGUYEN	2698

Search Notes		
Search Notes	**Date**	**Examiner**
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	2/1/2017	LTN
Inventorship search	2/1/2017	LTN
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	11/9/2017	LTN
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	08/18/2018	LTN
IPR2018-00236 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,339,493	08/18/2018	LTN
IPR2018-00238 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,736,729	08/18/2018	LTN
IPR2018-00904 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,339,493	08/18/2018	LTN
IPR2018-00908 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,100,604	08/18/2018	LTN
IPR2018-00909 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,100,604	08/18/2018	LTN
IPR2018-00910 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,059,177	08/18/2018	LTN
IPR2019-00068 Reviewed Petition for Inter Partes Review of U.S. Patent No. 7,403,226	05/06/2019	LTN
IPR2019-00069 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,544,517	05/06/2019	LTN
IPR2019-00087 Reviewed Petition for Inter Partes Review of U.S. Patent No. 6,765,616	05/06/2019	LTN
IPR2019-00097 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,100,604	05/06/2019	LTN
IPR2019-00656 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,544,517	05/06/2019	LTN

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	Art Unit
	LUONG T NGUYEN	2698

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

Receipt date: 02/27/2019

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)		
	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							

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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

EFS Web 2.1.18

Receipt date: 02/27/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

	1	ZTE Corporation and ZTE (USA), Inc. v. Hitachi Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,339,493, Inter Partes Review ~~No. IPR2018-00236~~ filed November 22, 2017 Not shown on submitted copy.	
	2	ZTE Corporation and ZTE (USA), Inc. v. Hitachi Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,736,729, Inter Partes Review ~~No. IPR2018-00238~~ filed November 22, 2017 Not shown on submitted copy.	
	3	Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,339,493, Inter Partes Review No. IPR2018-00904 dated June 20, 2018	
	4	Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2018-00908 dated June 20, 2018	
	5	Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2018-00909 dated June 20, 2018	
	6	Olympus Corporation, Olympus Corporation of the Americas and Olympus America inc. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 8,059,177, Inter Partes Review No. IPR2018-00910 dated June 20, 2018	
	7	Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 7,403,226, Inter Partes Review No. IPR2019-00068 dated October 16, 2018	
	8	Asustek Computer Inc. and Asus Computer International v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,544,517, Inter Partes Review No. IPR2019-00069 dated October 16, 2018	
	9	BlackBerry Corporation v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 6,765,616, Inter Partes Review No. IPR2019-00087 dated October 15, 2018	
	10	BlackBerry Corporation v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,100,604, Inter Partes Review No. IPR2019-00097 dated October 16, 2018	
	11	Huawei Technologies Co., Ltd. v. Maxell, Ltd., Petition for Inter Partes Review of U.S. Patent No. 9,544,517, Inter Partes Review No. IPR2019-00656 dated February 6, 2019	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

Receipt date: 02/27/2019

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	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

If you wish to add additional non-patent literature document citation information please click the Add button [Add]

EXAMINER SIGNATURE

Examiner Signature	/LUONG T NGUYEN/	Date Considered	05/01/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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Receipt date: 02/27/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-02-27
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S167	1	15/386656	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 13:30
S168	294	((("NAKANO") near3 ("Takahiro"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/05/06 13:31
S169	43	((("NISHIMURA") near3 ("Ryuji"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/05/06 13:33
S170	10	("20030122941" | "5170249" | "5343243" | "5502483" | "5668597" | "5734427" | "5786852" | "5986698" | "6148031" | "6614477").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/05/06 13:34
S171	43	((("KINUGASA") near3 ("Toshiro"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/05/06 13:45
S172	6	("4638362" | "4689686" | "4858020" | "4942473" | "4963981" | "5019912").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/05/06 13:47
S173	2	"6661451".pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 14:05
S174	4	"5959670".pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 14:21
S175	644	(thin$4) same ((electronic near zoom$3) or (optical near zoom$3))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 14:59
S176	47	S175 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	2019/05/06 14:59

			IBM_TDB			
S177	785	(thin$4) same (magnification near (factor or ratio))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:01
S179	201	S177 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:02
S180	23	(vary or various or varying or chang$3) same (magnification near (factor or ratio)) same ((electronic near zoom$3) or (optical near zoom$3)) same area	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:12
S181	502	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same ((electronic near zoom$3) or (optical near zoom$3))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:17
S182	101	S181 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:18
S183	54	(scan$4 with line) same (NTSC or standard) same (television or TV) and (mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) and((electronic near zoom$3) or (optical near zoom$3))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:40
S184	52700	(H04N5/372 or H04N5/23248 or H04N5/23258 or H04N5/23274 or H04N5/3741 or H04N2209/045 or H04N9/045).CPC.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:47
S185	19553	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (sensor$1 or CCD$1 or CMOS) same ratio	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:47
S186	690	S184 and S185	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2019/05/06 15:47

			JPO; DERWENT; IBM_TDB			
S187	102	S186 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:48
S188	6	("4281339" | "4907089" | "5144444" | "5523786" | "5572155" | "5625414").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/05/06 15:49
S189	2591	(magnification or magnif$4) and (pixel$1 same interval) and zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:54
S190	298	S184 and S189	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:55
S191	93	S190 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 15:55
S192	12	("20050083430" | "4691253" | "5040068" | "5070405" | "5382974" | "5396290" | "5412424" | "5589879" | "5650819" | "5751348" | "5929906" | "6072526").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/05/06 16:01
S193	2	("4843475" | "5420632").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/05/06 16:04
S194	8978	(magnification or magnif$4) and (pixel$1 same interval)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 16:11
S195	425	S184 and S194	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 16:12
S196	118	S195 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2019/05/06 16:12

			JPO; DERWENT; IBM_TDB			
S197	225	S185 and S194	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 16:15
S198	20	S197 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 16:15
S199	180	(pixel$1 same interval) same zoom$3 same area	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 16:17
S200	12	S199 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 16:17
S201	2123	(magnification or magnif$4) and (pixel$1 same interval) and (charge$1 or signal$1) and (sensor$1 or CCD$1 or CMOS) and zoom$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 16:21
S202	289	S184 and S201	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 16:21
S203	93	S202 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/05/06 16:22

EAST Search History (Interference)

< This search history is empty>

5/10/2019 11:06:29 PM
C:\Users\lnguyen2\Documents\EAST\Workspaces\15386656.wsp

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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08	3687

24956 7590 07/16/2019

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
NGUYEN, LUONG TRUNG	

ART UNIT	PAPER NUMBER
2698	

NOTIFICATION DATE	DELIVERY MODE
07/16/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

Applicant-Initiated Interview Summary	**Application No.** 15/386,656	**Applicant(s)** NAKANO et al.	
	Examiner LUONG T NGUYEN	**Art Unit** 2698	**AIA (FITF) Status** No

All participants (applicant, applicants representative, PTO personnel):

(1) LUONG TRUNG. NGUYEN. (3) _____.

(2) JAMIE NGUYEN (Reg. No. 64,687). (4) _____.

Date of Interview: 11 July 2019.

Type: ☑ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☑ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☑112 ☐102 ☐103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: 1,5,7-8 and 13.

Identification of prior art discussed: _____.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Mr. Jamie Nguyen explained the claimed invention. The parties discussed the claim language and the rejection under 35 USC 112 with respect to claims 1, 5, 7-8, 13 (see attached Interview Agenda). No agreement was reach.

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☑ Attachment

/LUONG T NGUYEN/ Primary Examiner, Art Unit 2698	

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiners responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicants correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,-
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
(The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicants record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiners version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, Interview Record OK on the paper recording the substance of the interview along with the date and the examiners initials.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) : MAXELL, LTD.

Confirmation No.: 3687

Serial No. : 15/386,656

Filed : December 21, 2016

For : ELECTRIC CAMERA

Group : 2663

Examiner : Luong TRUNG NGUYEN

Docket No. : ASA-9606-08

Customer No.: 24956

INTERVIEW AGENDA

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In advance of the telephone interview on July 11, 2019, please refer to the following proposed amendments and remarks.

Proposed Amendments to the Claims begin on page 2 of this paper.

Remarks begin on page 12 of this paper.

Serial No. 15/386,656
Interview Agenda
Regarding the Office Action of May 15, 2019

Proposed Amendments to the Claims:

1. (Currently amended - proposed) An electric camera comprising:

an image sensing device with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

a signal processing unit configured to generate the image signals by using the signals outputted by the image sensing device; and

a zoom operation unit configured to operate to continuously change a magnification factor;

wherein, as the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels including:

a first state of the at least three states in which the image signals are generated using the signals based on a first area of the light receiving surface with a first magnification factor,

a second state of the at least three states in which the image signals are generated using the signals based on a second area of the light receiving surface with a second magnification factor, and

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a third state of the at least three states in which the image signals are generated using the signals based on a third area of the light receiving surface with a third magnification factor, and

wherein, while a state is between the first state and the second state when the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals to generate the image signals based on first signal charges accumulated with a first interval of vertical pixels,

wherein, while a state is between the second state and the third state when the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals to generate the image signals based on second signal charges accumulated with a second interval of vertical pixels which is different from the first interval.

2.-3. (Canceled).

4. (Previously presented) The electric camera according to claim 1,

wherein the image sensing device outputs the signals which are mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

5. (Previously presented) The electric camera according to claim 1,

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wherein, as the zoom operation unit is operated to continuously change the magnification factor during recording of a moving video in a moving video mode, the image sensing device outputs the signals to generate image signals based on signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

6. (Previously presented) The electric camera according to claim 1,

wherein the electric camera has a static image mode for taking a static image and, when in the static image mode, the signal processing unit generates the static image by using all signals accumulated in all of an effective number of the vertical pixels.

7. (Currently amended - proposed) An electric camera comprising:

an image sensing device with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

a processor circuitry configured to control generating the image signals by using the signals outputted by the image sensing device and to continuously change a magnification factor in accordance with a zoom operation;

wherein, as the processor circuitry controls to continuously change the magnification factor in accordance ~~with a~~ with the zoom operation, the image

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sensing device outputs the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels including:

a first state of the at least three states in which the image signals are generated using the signals based on a first area of the light receiving surface with a first magnification factor,

a second state of the at least three states in which the image signals are generated using the signals based on a second area of the light receiving surface with a second magnification factor, and

a third state of the at least three states in which the image signals are generated using the signals based on a third area of the light receiving surface with a third magnification factor, and

wherein, while a state is between the first state and the second state when continuously changing the magnification factor in accordance with the zoom operation, the image sensing device outputs the signals to generate the image signals based on first signal charges accumulated with a first interval of vertical pixels,

wherein, while a state is between the second state and the third state when continuously changing the magnification factor in accordance with the zoom operation, the image sensing device outputs the signals to generate the image

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signals based on second signal charges accumulated with a second interval of vertical pixels which is different from the first interval.

8. (Currently amended - proposed) An operating method for an electric camera comprising:

receiving light with an image sensing device having a light receiving surface including an array of pixels arranged vertically and horizontally, and outputting signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

generating the image signals by using the signals outputted by the image sensing device;

continuously changing a magnification factor of a zoom operation; and

wherein, as the zoom operation continuously changes the magnification factor, the outputting of the signals of the image sensing device includes outputting the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels, and

wherein:

the generating of the image signals includes, in a first state of the at least three states, generating the image signals using the signals output by the image

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sensing device based on a first area of the light receiving surface with a first magnification factor,

the generating of the image signals includes, in a second state of the at least three states, generating the image signals using the signals output by the image sensing device based on a second area of the light receiving surface with a second magnification factor, and

the generating of the image signals includes, in a third state of the at least three states, generating the image signals using the signals output by the image sensing device based on a third area of the light receiving surface with a third magnification factor,

wherein, while a state is between the first state and the second state when the zoom operation continuously changes the magnification factor, outputting with the image sensing device the signals to generate the image signals based on first signal charges accumulated with a first interval of vertical pixels, and

wherein, while a state is between the second state and the third state when the zoom operation continuously changes the magnification factor, outputting with the image sensing device the signals to generate the image signals based on second signal charges accumulated with a second interval of vertical pixels which is different from the first interval.

9. (Canceled).

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10. (Previously presented) The operating method according to claim 8, wherein the outputting of the signals with the image sensing device includes outputting mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

11. (Currently amended - proposed) The operating method according to claim 8,

wherein, as the zoom operation continuously changes the magnification factor during recording of a moving video in a moving video mode, the outputting of the signals with the image sensing device includes outputting the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

12. (Previously presented) The operating method according to claim 8, wherein the electric camera has a static image mode for taking a static image and, wherein, in the static image mode, the generating of the image signals includes generating the static image by using all signals accumulated in all of an effective number of the vertical pixels.

13. (Currently amended - proposed) An operating method for an electric camera comprising:

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receiving light with an image sensing device having a light receiving surface having an array of pixels arranged vertically and horizontally, and outputting signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

controlling with processor circuitry generating the image signals by using the signals outputted by the image sensing device and controlling to continuously change a magnification factor in accordance with a zoom operation;

wherein, as the zoom operation is controlled with the processor circuitry to continuously change the magnification factor, the outputting of the signals of the image sensing device includes outputting the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels, and

wherein:

the generating of the image signals includes, in a first state of the at least three states, generating the image signals using the signals output by the image sensing device based on a first area of the light receiving surface with a first magnification factor,

the generating of the image signals includes, in a second state of the at least three states, generating the image signals using the signals output by the image

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sensing device based on a second area of the light receiving surface with a second magnification factor, and

the generating of the image signals includes, in a third state of the at least three states, generating the image signals using the signals output by the image sensing device based on a third area of the light receiving surface with a third magnification factor,

wherein, while a state is between the first state and the second state when the zoom operation continuously changes the magnification factor, outputting with the image sensing device the signals to generate the image signals based on first signal charges accumulated with a first interval of vertical pixels, and

wherein, while a state is between the second state and the third state when the zoom operation continuously changes the magnification factor, outputting with the image sensing device the signals to generate the image signals based on second signal charges accumulated with a second interval of vertical pixels which is different from the first interval.

14. (Previously presented) The electric camera according to claim 7,

wherein the image sensing device outputs the signals which are mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

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15. (Currently amended - proposed) The electric camera according to claim 7,

wherein, as the processor circuitry controls to continuously change the magnification factor during recording of a moving video in a moving video mode, the image sensing device outputs the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

16. (Previously presented) The electric camera according to claim 7,

wherein the electric camera has a static image mode for taking a static image and, when in the static image mode, the processor circuitry controls to generate the static image by using all signals accumulated in all of an effective number of the vertical pixels.

17. (Previously presented) The operating method according to claim 13,

wherein the outputting of the signals with the image sensing device includes outputting mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

18. (Currently amended - proposed) The operating method according to claim 13,

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wherein, as the zoom operation continuously changes the magnification factor during recording of a moving video in a moving video mode, the outputting of the signals with the image sensing device includes outputting the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

19. (Previously presented) The operating method according to claim 13, wherein the electric camera has a static image mode for taking a static image and, wherein, in the static image mode, the generating of the image signals includes generating the static image by using all signals accumulated in all of an effective number of the vertical pixels.

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Serial No. 15/386,656
Interview Agenda
Regarding the Office Action of May 15, 2019

REMARKS

Discussion of the foregoing proposed amendments is respectfully requested during the telephone interview with respect to the outstanding rejection(s) under 35 U.S.C. §112 in the Office Action of May 15, 2019.

Respectfully submitted,

MATTINGLY & MALUR, PC

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Doc code: RCEX
Doc description: Request for Continued Examination (RCE)

PTO/SB/30EFS (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	15386656	Filing Date	2016-12-21	Docket Number (if applicable)	ASA-9606-08	Art Unit	
First Named Inventor	NAKANO, T.			Examiner Name	NGUYEN, L. T.		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☒ Amendment/Reply
- ☐ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____
(Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 501417

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

Applicant Signature

PTO/SB/30EFS (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Signature of Registered U.S. Patent Practitioner			
Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-08-07
Name	John R. Mattingly	Registration Number	30293

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	15386656
Filing Date:	21-Dec-2016
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly/Krista Hargrove
Attorney Docket Number:	ASA-9606-08

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
RCE- 2ND AND SUBSEQUENT REQUEST	1820	1	1900	1900
		Total in USD ($)		**1900**

Electronic Acknowledgement Receipt	
EFS ID:	36803931
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Krista Hargrove
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-08
Receipt Date:	07-AUG-2019
Filing Date:	21-DEC-2016
Time Stamp:	12:49:16
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1900
RAM confirmation Number	E201987C49434995
Deposit Account	501417
Authorized User	Krista Hargrove
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		9606-08-AMD05-revised.pdf	65721 4eb7175f81467f63205fef3f3f7b5496b3375daa	yes	15
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Amendment Submitted/Entered with Filing of CPA/RCE		1	1	
	Claims		2	13	
	Applicant Arguments/Remarks Made in an Amendment		14	15	
Warnings:					
Information:					
2	Request for Continued Examination (RCE)	9606-08-RCE-2.pdf	1350097 ce5d37eecd7640ec3e7d8ffee3b7497d57a9e97a	no	3
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	30358 e4e5ee930dd4ad5214703c59fc04e86782e7243e	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1446176		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) : MAXELL, LTD.

Confirmation No.: 3687

Serial No. : 15/386,656

Filed : December 21, 2016

For : ELECTRIC CAMERA

Group : 2663

Examiner : Luong TRUNG NGUYEN

Docket No. : ASA-9606-08

Customer No.: 24956

AMENDMENT AFTER FINAL REJECTION

Mail Stop: AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

August 7, 2019

Sir:

In response to the Final Office Action mailed May 15, 2019, please amend the above-identified patent application as follows.

Amendments to the Claims begin on page 2 of this paper.

Remarks begin on page 14 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently amended) An electric camera comprising:

an image sensing device with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

a signal processing unit configured to generate the image signals by using the signals outputted by the image sensing device; and

a zoom operation unit configured to operate to continuously change a magnification factor;

wherein, as the zoom operation unit is operated to continuously change the magnification factor, the image sensing device outputs the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states, which have different intervals of the plurality of vertical pixels, including:

a first state having a first interval of the plurality of vertical pixels ~~of the at least three states~~ in which ~~the~~ first image signals are generated using first signals based

on first signal charges accumulated in a first area of the light receiving surface with a first magnification factor,

a second state having a second interval of the plurality of vertical pixels ~~of the at least three states~~ in which ~~the~~ second image signals are generated using second signals based on second signal charges accumulated in a second area of the light receiving surface with a second magnification factor, and

a third state having a third interval of the plurality of vertical pixels ~~of the at least three states~~ in which ~~the~~ third image signals are generated using third signals based on third signal charges accumulated in a third area of the light receiving surface with a third magnification factor, ~~and~~

wherein, while a state is between the first state and the second state when the zoom operation unit is operated to continuously change the magnification factor, the electric camera is configured to change areas of the light receiving surface to be used in accordance with changing the magnification factor between the first magnification factor and the second magnification factor and keep the first interval constant~~the image sensing device outputs signals to generate image signals based on signal charges accumulated with a first interval of vertical pixels~~, and

wherein, while a state is between the second state and the third state when the zoom operation unit is operated to continuously change the magnification factor, the electric camera is configured to change areas of the light receiving surface to be used in accordance with changing the magnification factor between the second magnification factor and the third magnification factor and keep the second interval

constant~~the image sensing device outputs signals to generate image signals based on signal charges accumulated with a second interval of vertical pixels which is different from the first interval~~.

2.-3. (Canceled).

4. (Previously presented) The electric camera according to claim 1, wherein the image sensing device outputs the signals which are mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

5. (Currently amended) The electric camera according to claim 1, wherein, as the zoom operation unit is operated to continuously change the magnification factor during recording of a moving video in a moving video mode, the image sensing device outputs the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

6. (Previously presented) The electric camera according to claim 1, wherein the electric camera has a static image mode for taking a static image and, when in the static image mode, the signal processing unit generates the static

image by using all signals accumulated in all of an effective number of the vertical pixels.

7. (Currently amended) An electric camera comprising:

an image sensing device with a light receiving surface having an array of pixels arranged vertically and horizontally, and configured to output signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

a processor circuitry configured to control generating the image signals by using the signals outputted by the image sensing device and to continuously change a magnification factor in accordance with a zoom operation;

wherein, as the processor circuitry controls to continuously change the magnification factor in accordance ~~with a~~ with the zoom operation, the image sensing device outputs the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states, which have different intervals of the plurality of vertical pixels, including:

a first state having a first interval of the plurality of vertical pixels ~~of the at least three states~~ in which ~~the~~ first image signals are generated using first signals based on first signal charges accumulated in a first area of the light receiving surface with a first magnification factor,

a second state having a second interval of the plurality of vertical pixels ~~of the at least three states~~ in which ~~the~~ second image signals are generated using second signals based on second signal charges accumulated in a second area of the light receiving surface with a second magnification factor, and

a third state having a third interval of the plurality of vertical pixels ~~of the at least three states~~ in which ~~the~~ third image signals are generated using third signals based on third signal charges accumulated in a third area of the light receiving surface with a third magnification factor, ~~and~~

wherein, while a state is between the first state and the second state when continuously changing the magnification factor in accordance with the zoom operation, the electric camera is configured to change areas of the light receiving surface to be used in accordance with changing the magnification factor between the first magnification factor and the second magnification factor and keep the first interval constant~~the image sensing device outputs signals to generate image signals based on signal charges accumulated with a first interval of vertical pixels~~,

wherein, while a state is between the second state and the third state when continuously changing the magnification factor in accordance with the zoom operation, the electric camera is configured to change areas of the light receiving surface to be used in accordance with changing the magnification factor between the second magnification factor and the third magnification factor and keep the second interval constant~~the image sensing device outputs signals to generate image signals~~

~~based on signal charges accumulated with a second interval of vertical pixels which is different from the first interval~~.

8. (Currently amended) An operating method for an electric camera comprising:

receiving light with an image sensing device having a light receiving surface including an array of pixels arranged vertically and horizontally, and outputting signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

generating the image signals by using the signals outputted by the image sensing device;

continuously changing a magnification factor of a zoom operation; and

wherein, as the zoom operation continuously changes the magnification factor, the outputting of the signals of the image sensing device includes outputting the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels, and

wherein:

the generating of the image signals includes, in a first state of the at least three states having a first interval of the plurality of vertical pixels, generating ~~the~~ first

image signals using first signals output by the image sensing device based on a first area of the light receiving surface with a first magnification factor,

the generating of the image signals includes, in a second state of the at least three states having a second interval of the plurality of vertical pixels, generating ~~the~~ second image signals using second signals output by the image sensing device based on a second area of the light receiving surface with a second magnification factor, and

the generating of the image signals includes, in a third state of the at least three states having a third interval of the plurality of vertical pixels, generating ~~the~~ third image signals using third signals output by the image sensing device based on a third area of the light receiving surface with a third magnification factor,

wherein, while a state is between the first state and the second state when the zoom operation continuously changes the magnification factor, changing areas of the light receiving surface to be used in accordance with changing the magnification factor between the first magnification factor and the second magnification factor and keeping the first interval constant~~outputting with the image sensing device signals to generate image signals based on signal charges accumulated with a first interval of vertical pixels~~, and

wherein, while a state is between the second state and the third state when the zoom operation continuously changes the magnification factor, changing areas of the light receiving surface to be used in accordance with changing the magnification factor between the second magnification factor and the third magnification factor and

keeping the second interval constant~~outputting with the image sensing device signals to generate image signals based on signal charges accumulated with a second interval of vertical pixels which is different from the first interval~~.

9. (Canceled).

10. (Previously presented) The operating method according to claim 8, wherein the outputting of the signals with the image sensing device includes outputting mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

11. (Currently amended) The operating method according to claim 8, wherein, as the zoom operation continuously changes the magnification factor during recording of a moving video in a moving video mode, the outputting of the signals with the image sensing device includes outputting the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

12. (Previously presented) The operating method according to claim 8, wherein the electric camera has a static image mode for taking a static image and, wherein, in the static image mode, the generating of the image signals includes

generating the static image by using all signals accumulated in all of an effective number of the vertical pixels.

13. (Currently amended) An operating method for an electric camera comprising:

receiving light with an image sensing device having a light receiving surface having an array of pixels arranged vertically and horizontally, and outputting signals to generate image signals based on signal charges accumulated in the pixels with an interval of a plurality of vertical pixels;

controlling with processor circuitry generating the image signals by using the signals outputted by the image sensing device and controlling to continuously change a magnification factor in accordance with a zoom operation;

wherein, as the zoom operation is controlled with the processor circuitry to continuously change the magnification factor, the outputting of the signals of the image sensing device includes outputting the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise;

wherein the electric camera has at least three states which have different intervals of the plurality of vertical pixels, and

wherein:

the generating of the image signals includes, in a first state of the at least three states having a first interval of the plurality of vertical pixels, generating ~~the~~ first

image signals using first signals output by the image sensing device based on first signal charges accumulated in a first area of the light receiving surface with a first magnification factor,

the generating of the image signals includes, in a second state of the at least three states having a second interval of the plurality of vertical pixels, generating ~~the~~ second image signals using second signals output by the image sensing device based on second signal charges accumulated in a second area of the light receiving surface with a second magnification factor, and

the generating of the image signals includes, in a third state of the at least three states having a third interval of the plurality of vertical pixels, generating ~~the~~ third image signals using third signals output by the image sensing device based on third signal charges accumulated in a third area of the light receiving surface with a third magnification factor,

wherein, while a state is between the first state and the second state when the zoom operation continuously changes the magnification factor, changing areas of the light receiving surface to be used in accordance with changing the magnification factor between the first magnification factor and the second magnification factor and keeping the first interval constant~~outputting with the image sensing device signals to generate image signals based on signal charges accumulated with a first interval of vertical pixels~~, and

wherein, while a state is between the second state and the third state when the zoom operation continuously changes the magnification factor, changing areas of

the light receiving surface to be used in accordance with changing the magnification factor between the second magnification factor and the third magnification factor and keeping the second interval constant~~outputting with the image sensing device signals to generate image signals based on signal charges accumulated with a second interval of vertical pixels which is different from the first interval~~.

14. (Previously presented) The electric camera according to claim 7, wherein the image sensing device outputs the signals which are mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

15. (Currently amended) The electric camera according to claim 7, wherein, as the processor circuitry controls to continuously change the magnification factor during recording of a moving video in a moving video mode, the image sensing device outputs the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

16. (Previously presented) The electric camera according to claim 7, wherein the electric camera has a static image mode for taking a static image and, when in the static image mode, the processor circuitry controls to generate the

static image by using all signals accumulated in all of an effective number of the vertical pixels.

17. (Previously presented) The operating method according to claim 13, wherein the outputting of the signals with the image sensing device includes outputting mixed or culled signals accumulated in the pixels with the interval of the plurality of vertical pixels.

18. (Currently amended) The operating method according to claim 13, wherein, as the zoom operation continuously changes the magnification factor during recording of a moving video in a moving video mode, the outputting of the signals with the image sensing device includes outputting the signals to generate the image signals based on the signal charges accumulated while changing the interval of the plurality of vertical pixels stepwise.

19. (Previously presented) The operating method according to claim 13, wherein the electric camera has a static image mode for taking a static image and, wherein, in the static image mode, the generating of the image signals includes generating the static image by using all signals accumulated in all of an effective number of the vertical pixels.

REMARKS

Claims 1, 4-8 and 10-19 are pending in this application. Claim 2, 3 and 9 were previously canceled without prejudice and without disclaimer. Claims 1, 5, 7-8, 11, 13, 15 and 18 have been amended. No new matter has been added.

Information Disclosure Statement

Applicant appreciates the Examiner's consideration of the references submitted in the Information Disclosure Statement filed February 27, 2019.

Interview Summary

Applicant appreciates the Examiner granting a telephone interview on July 11, 2019 at 10:00 AM. During the interview, proposed amendments were discussed regarding the rejections under 35 U.S.C. §112(b). No agreement was reached during the interview.

Rejections Under 35 U.S.C. §112

The Examiner has rejected claims 1, 4-8 and 10-19 under 35 U.S.C. §112(b) or 35 U.S.C. § 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

It is submitted that claims 1, 5, 7-8, 11, 13, 15 and 18 have been amended for clarification and to provide proper antecedent basis in regards to the rejections under 35 U.S.C. §112(b).

Request for Continued Examination

A Request for Continued Examination is being filed with this paper to ensure entry and consideration of the foregoing amendments.

Conclusion

In view of the foregoing amendments and remarks, Applicant requests reconsideration of the rejection and allowance of the claims.

The Commissioner is authorized to charge any shortage in the fees due, or credit any overpayment, to Deposit Account No. 50-1417 (referencing Attorney Docket No. ASA-9606-08).

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Registration No. 30,293
703-684-1120

PTO/SB/06 (09-11)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/386,656	Filing Date 12/21/2016	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $80 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $420 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	08/08/2019	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 18	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	= 0		x $460 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/CHANTAE S DESSAU/
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(Not for submission under 37 CFR 1.99)

Application Number	15386656
Filing Date	2016-12-21
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-08

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6335760	B1	2002-01-01	SATO	
	2	6018363	A	2000-01-25	HORII	
	3	7903162	B2	2011-03-08	JUEN	
	4	4740828	A	1988-04-26	KINOSHITA	
	5	6563535	B1	2003-05-13	ANDERSON	
	6	6529236	B1	2003-03-04	WATANABE	
	7	6661451	B1	2003-12-09	KIJIMA et al.	
	8	5502483	A	1996-03-26	TAKASE et al.	

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	Attorney Docket Number	ASA-9606-08

	9	4612575	A	1986-09-16	ISHMAN et al.	
	10	5444482	A	1995-08-22	MISAWA et al.	

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	1	0 802 688	EP	A1	1997-10-22	HITACHI, LTD.		

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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Apple Inc.'s Invalidity Contentions which were filed in the following litigation: MAXELL, LTD. v. APPLE INC., Civil Action No. 5:19-cv-00036-RWS (E.D. TX), filed August 14, 2019	
	2	The Sony Digital Video Recorder (DCR-TRV900) User Manual ("DCR-TRV900 Manual"), published by Sony Corporation in 1998	

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	Attorney Docket Number	ASA-9606-08

	3	Sony Consumer Electronics Guide: DCR-TRV900 - More Specifications, webpage published by Sony Corporation, April 24, 1999, URL: https://web.archive.org/web/19990424085854/http://www.sel.sony.com/SEL/consumer/ss5/office/camcorder/digitalvideoproducts/dcr-trv900_specs.shtml	
	4	Sony Consumer Electronics Guide: DCR-TRV900 - More Specifications, webpage published by Sony Corporation, January 28, 1999, URL: https://web.archive.org/web/19990128112515/http://www.sel.sony.com:80/SEL/consumer/ss5/office/camcorder/digitalvideoproducts/dcr-trv900.shtml	
	5	Getting Started With the QuickTake 200 Camera, "QuickTake 200 User's Manual", published by Apple Inc. in 1997	
	6	Using the QuickTake 200 AC Adapter, published by Apple Inc. in 1997	
	7	Published advertisement from The Indianapolis News (Indianapolis, Indiana) dated September 4, 1998	
	8	Published advertisement from The Indianapolis News (Indianapolis, Indiana) dated September 12, 1998	
	9	J. Ozer, "Digital Video Cameras," PC Magazine, Vol. 18, No. 7, April 6, 1999	
	10	Published advertisement from Popular Photography magazine dated October 1999	
	11	Published advertisement from The Daily Sentinel (Grand Junction, Colorado) newspaper dated Sunday, June 13, 1999	
	12	Digital Camcorder JVC GR-DVL9600 GR-DVL9500 User's Manual, "JVCVRDVL9500 Manual", published by the Victor Company of Japan, Ltd. in 1999	
	13	Excerpts from the JVC America Website, URL: https://web.archive.orgweb/19990117003015/http://jvc-america.com:80/digital_camcorders/digital_camcorders.html	

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	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

	14	Published review from the Iowa City Press (Iowa City, Iowa) newspaper dated January 12, 1999	
	15	Published advertisement from The Courier-News (Bridgewater, New Jersey) newspaper dated February 17, 1999	
	16	Hitachi, "MPEGCAM MP-EG1A Instruction Manual", 1997, E1-E98, JAPAN	
	17	"First Looks: The Digital Chameleon at 72", MP-EG1 PC Mag, PC Magazine, July 1997	
	18	SONY MVC-FD88/FD83 Manual	

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	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

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Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

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See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-09-03
Name/Print	John R. Mattingly	Registration Number	30,293

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

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1	Foreign Reference	EP0802688.pdf	1283490 756cb7c14bb3f95e03f170870dfde00babc5eb20	no	25

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2	Non Patent Literature	NPL1-E5037-08EU_InvalidityContentions.pdf	867009 18e36f438b6d491c6367dd9934777175cd37d116	no	135
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3	Non Patent Literature	NPL2-DigitalVideoRecorder-1998-A.pdf	16183592 e8cdc809187bafaad2e54fa9bcd38edd5e720591	no	40
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6	Non Patent Literature	NPL2-DigitalVideoRecorder-1998-D.pdf	14226016 de0c04597789fda2c09c1bc3bef33ae0a94377b9	no	37
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8	Non Patent Literature	NPL4-SonyConsumerElectronicsGuide-1999.pdf	204803 d9b89abd1e7e78be43396d2c8baca0d7618a5269	no	2
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14	Non Patent Literature	NPL10-PopularPhotographyAd.pdf	1190584 ba8d10dab4c5802d8bbee4f13016edc8339c7586	no	2
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17	Non Patent Literature	NPL13-JVCSite.pdf	287402 676516b2bb12d358faaee6a3e1a53383df8fcf1d	no	8
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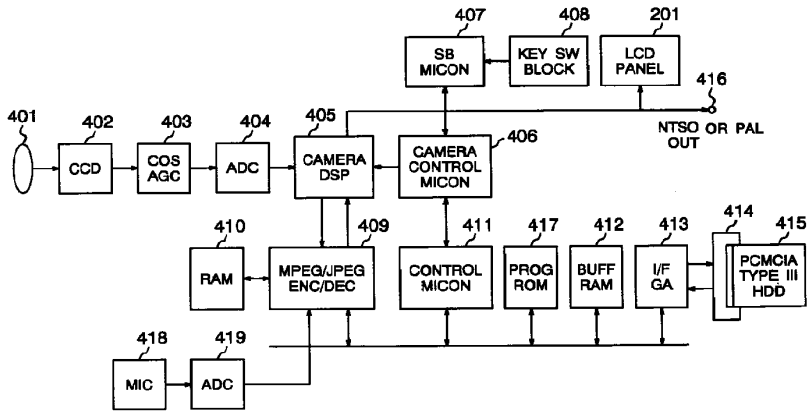
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(54) Apparatus for recording and reproducing digital image and speech

(57) A digital image and speech recording and reproducing apparatus is arranged to quickly and simply retrieve, classify, and erase a great deal of data for improving the operativity in small-sized equipment. The apparatus includes a recording and reproducing unit (401, 402, 403, 404, 405, 409, 412, 415) for a moving image signal, a recording and reproducing unit (401, 402, 403, 404, 405, 409, 412, 415) for a still image signal, a recording and reproducing unit (418, 419, 409, 415) for a digital speech signal operated in synchronous to the image, a display (201) for displaying the image for said moving image signal or said still image signal, a recording condition recording unit for recording recording conditions containing data information about recorded data for distinguishing said moving image from said still image and recording time information for recording an image or a speech. The recording conditions consisting of at least the data information and the recording time information about the recorded data are graphically and literarily displayed on the display, so that the recorded data item may be selected on the display screen.

FIG. 4



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Description

BACKGROUND OF THE INVENTION

The present invention relates to operativity of a portable digital camcorder.

The prior art relevant to the portable digital camcorder has been published as an electronic photograph system, that is, the so-called electronic still camera that is arranged to record a still image signal as a video signal in a memory composed of a semiconductor (termed as a semiconductor memory or simply a memory) as disclosed in JP-A-2-292974. With recent prevail of personal computers, recording mediums such as semiconductor memories and harddisks are progressively made lower in cost, smaller in size, and greater in capacity. At a time, the advance of signal compressing technology such as JPEG or MPEG allows even the small-sized equipment to record greater number of still images and moving ones. Taking a harddisk drive as an example, the resulting harddisk drive is kept as small as a card and has as great a capacity as about 300 Mbytes.

This type of harddisk drive enables to record about 3000 still images through the use of the JPEG compression and about 20-minutes moving picture through the use of the MPEG compression. It is thus necessary to improve the operativity of the portable equipment for retrieving, grouping, and deleting a great deal of recording data. The technique disclosed in JP-A-2-292974, however, does not provide means for retrieving a great deal of recording data quickly and easily. In actual, therefore, the technique does not have any means except the method of retrieving the great deal of recorded data as checking all images reproduced on screen from the recorded data.

In case that 3000 JPEG still images are recorded on a feasible media such as the aforementioned harddisk drive and then are retrieved as expanding those images on the screen one by one, about one second for expanding one JPEG still image is required. It means that the expansion of 3000 images needs about one hour. This method lacks in practicability. In order to retrieve a great deal of data, therefore, it is necessary to enhance the operating speed of the system.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an apparatus which is arranged to overcome the foregoing shortcoming and enhance the operativity even if the apparatus is small-sized.

In carrying out the object, for improving the operativity of a small-sized apparatus, the present invention is achieved by an apparatus which comprises recording means for recording both imaging time information and imaging mode information for distinguishing moving images from still images at a time when taking the still image or moving image, display means for displaying as a list the informations as well as expanded images on a liquid crystal display screen built in the main body of the apparatus itself, and keying means for retrieving, classifying, and erasing the recorded data.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing a state transition of a program used in an apparatus according to the present invention;

Fig. 2 is a view showing an outer appearance of a portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 3 is an expanded view showing an operating switch portion provided in the portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 4 is a circuit diagram showing an arrangement of a portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 5 is a view showing a display screen provided in the portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 6 is a view showing a display screen on which the recorded data is classified;

Fig. 7 is a view showing a display screen on which the recorded data is selected;

Fig. 8 is a view showing a display screen with expanded images in which the recorded data is selected;

Fig. 9 is a view showing a display screen on which the function details of the recorded data are selected;

Fig. 10 is a flowchart showing a method for selecting the function details;

Fig. 11 is a view showing a display screen on which the classifications of the recorded data are changed;

Fig. 12 is a view showing a display screen on which the displaying sequence of the recorded data is changed;

Fig. 13 is a view showing a display screen on which each date of the recorded data is changed;

Fig. 14 is a view showing a display screen on which each erasing attribute of the recorded data is changed;

Fig. 15 is a view showing a display screen on which a remaining state of the recording medium is displayed;

Fig. 16 is a flowchart showing a method for reading recorded data from a harddisk driver and reproducing it;

Fig. 17 is a view showing an imaged screen appearing if a still image recording mode is selected when recording an image;

Fig. 18 is a view showing an imaged screen appearing if a moving image recording mode is selected when recording an image; and

Fig. 19 is a view showing marks for modes;

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Later, the description will be oriented to the embodiments of the present invention with reference to Figs. 1 to 19.

Fig. 1 shows a flow of a software program according to an embodiment of the present invention.

The software program shown in Fig. 1 flows through the process of selecting a classification containing data to be played back or handled (101) and reaches the process of playing back the data (103) or flows to a function selecting items (105) in which a temporary discard (106), a complete abandon (107), a state display (112) of a storage unit, setting of protection from erasion (111), change of a display list (109), or change of a record date and hour (110) is selected. Moreover, when selecting a classification (101), the flow goes to the function selecting items (105) in which a temporary discard (106), a complete abandon (107), a state display of a storage unit (112), or automatic playback is selected. In the playback (103), a move to next data (115), a move to previous data (116), a fast playback (117), a rewind playback (118), or a temporary stop (121) is selected. In the temporary stop (121), a forward frame advance (119) or reverse frame advance (120) is selected.

Fig. 2 shows an example of an outer appearance of a portable digital comcorder 200 in which the software program shown in Fig. 1 is executed. This comcorder 200 provides a capability of recording and reproducing an NTSC or PAL TV system signal.

Fig. 3 is an expanded view showing an operating switch portion of the portable digital camcorder shown in Fig. 2. In the portable digital camcorder 200 shown in Fig. 2, with the operating switches, a digital moving signal obtained from the camera system is compressed to one MPEG (Moving Picture Expert Group) format and then is recorded on a harddisk storage medium sized to a memory card. In the playback, with the operating switches, the MPEG1 format signal recorded in a memory card is expanded and then displayed on a display unit 201 built in the camcorder itself. The display unit may be connected to the outside of the comcorder 201. The portable digital camcorder 200 shown in Fig. 2 may recorded the MPEG moving image data as well as the JPEG data for the still images and the MPEG speech format for the speech data.

Fig. 4 schematically shows a circuit arrangement of the portable digital comcorder 200. At first, the description will be oriented to the procedure of recording the moving image through the portable digital comcorder 200. When a user presses a recording switch 301, an image of an object obtained through a lens 401 is converted into the corresponding electric signal through the effect of a CCD sensor 402. The signal read out of a sensor is electrically processed through a CDS (Correlated Double Sampling) circuit for suppressing the low-frequency noises of the signal and a circuit 403 integrated with a AGC circuit for controlling an automatic gain of the signal for stabilizing the signal level. Then, the processed signal is converted into a digital signal through an ADC 404 and then is applied to a camera signal processing circuit 405.

A camera signal processing circuit (camera DSP) 405 is configured of a function of converting a digital pixel signal from the sensor into a luminance signal Y and color difference signals U and V, a function of adding a synchronous signal, a function of controlling relation between an iris and a shutter speed, a function of adjusting a white balance, and a function of digitally zooming in or out the signal. Though not illustrated in detail in Fig. 4, the camera DSP 405 is operated to feed a horizontal and a vertical driving signal pulses to the CCD sensor 402 and read the signal from the CCD sensor 402 as adjusting the timing between the synchronous signal and the pulses. Moreover, a camera control microcomputer 406 is operated to feed operating parameters for the DSP 405 to the camera DSP 405 in order to control the overall camera system.

On the other hand, the digital luminance signal Y and the digital color difference signals U and V obtained by the camera DSP 405 are sent to an MPEG1 encoder 409 through a digital bus line. The MPEG1 is a standard compression format for the digital signal for a moving image. The encoder 409 operates to compress the data according to the MPEG1 format and then convert it into the digital data. A numeral 410 denotes a working memory used in encoding the data according to the MPEG1 format. The data converted into the MPEG1 format is sent to a microcomputer 411 for controlling a transmission rate of the digital output data. The MPEG1 encoder 409, the working memory 410 and the microcomputer 411 compose the overall system for compressing the moving image.

The microcomputer 411 for controlling the transmission rate stores a constant amount of MPEG1-formatted data in a buffer memory 412. The formatted data is passed through an interface circuit 413 and a card connector 414 and reaches a harddisk drive 415. The card connector 414 is configured on the PCMCIA standards and thus contains 68 pins. The harddisk drive 415 is sized to a memory card and subject to the PC card standards defined by the PCMCIA (Personal Computer Memory Card International Association).

The foregoing description has concerned with the method for recording the moving image. In case the still image recording mode is selected by the user, the MPEG encoder 409 is switched to a JPEG compressing circuit. Then, a still image data is generated at the encoder 409 and then transferred to the microcomputer 411 for doing the same operation as described above. The MPEG compression data process and the JPEG compression data process have the same common points, so that the use of both the data formats may effectively save the circuit scale. This is a well-known method for saving the circuitry.

Further, the speech signal is converted into an analog electric signal through a microphone 418. The ana-

log electric signal is sent to a speech ADC 419 for converting the analog electric signal into the corresponding digital data. The digital speech data is applied into the data bus through the effect of the MPEG encoder 409. Then, the microcomputer 411 performs the MPEG-format-based compression through the program run therein so that the digital speech data is added to the moving image data or the still image data in precise time sequences.

According to this embodiment, the portable digital comcorder 200 is arranged to record the MPEG1-formatted data, the JPEG-formatted data, and the MPEG1-formatted speed data.

In recording the data, the microcomputer 411 also enables to record a data, a time, and a symbol for representing any one of the MPEG1-formatted data, the JPEG-formatted data, and the MPEG1-formatted data on a time when the recording switch 301 is pressed. At a time, the microcomputer 411 enables to record a symbol for representing a classification for retrieving the recorded data and a symbol for representing whether or not the operation of erasing the recorded data is prohibited. In recording the data, the classification symbol is recorded as "not classified" and the deletion symbol is recorded as "erasable".

In the general disk operating system, the symbol for indicating the imaging mode is discriminated using a code for a data type. The symbol for representing the classification and the symbol for representing if the data is erased are recorded in the corresponding files.

On the other hand, when recording the data, a digital signal applied to the camera DSP 405 as a monitoring signal is converted into an analog TV signal through the effect of an NTSC or PAL encoder built in the circuit 405 and then is fed at an output terminal 416 and the built-in display unit 201. The foregoing description has concerned with the MPEG1-formatted moving image data with the speech. In actual, the JPEG-formatted data or the MPEG1-formatted speech data may be solely processed in the similar manner to the above operation.

When the system stays at the playback mode, the signal flows in an opposite manner to the flow at the recording mode. Fig. 16 is a flowchart showing the reproduction of the signal. Text data indicating information of data is read from the harddisk drive 415 (step 1601). Next, the user retrieves data from a list of data displayed on the built-in display unit 201 and specifies the data to be played back with the operating switch 408 (step 1604). The list of the recorded data displayed on the display unit 201 is a feature of the invention. With the specification, a file system is started (step 1605) so that the data is read out of the harddisk drive 415 and then sent to the microcomputer 411 (step 1606).

Then, the data type is discriminated (steps 1607 and 1608). If the recorded data is the moving image, the MPEG-formatted moving image data and the MPEG-formatted speech data are both decoded (step 1609). If the recorded data is the still image, the JPEG-formatted still image data is decoded (step 1610). If the recorded data is the still image with the speech, the JPEG-formatted still image data and the MPEG-formatted speech data are both decoded (step 1611). Then, the decoded image and the decoded speech if any are displayed on the screen (step 1612).

An indication signal issued by the operating switch 408 is read by a sub-microcomputer 407 and then is sent to the microcomputer 411 through a camera-controlling microcomputer 406. The software program according to this embodiment is read out of a ROM 417 (Read-only Memory) for storing a program and then is executed. In this embodiment, the program is stored in the ROM 417. In place of the ROM 417, another storage unit such as a flash RAM or a harddisk drive may be used for the purpose.

Next, the data is transferred to the buffer memory 412 through the PCMCIA connector 414 and the interface circuit 413. The timing of the data stored in the buffer memory 412 is controlled by the microcomputer 411. Then, the data whose timing is adjusted is sent to the MPEG1 decoder 409. The decoder 409 switches the MPEG1 coding to the MPEG1 decoding or vice versa.

The data decoded by the MPEG1 decoder 409 is sent to the camera DSP circuit 405 through the digital path line. The decoded data is converted into an analog video signal through the effect of an NTSC or PAL encoder and a DAC built in the circuit 405 and then is led at an output terminal 416 and from the built-in display unit 201 to the outside of the apparatus. The foregoing description has concerned with the MPEG1-formatted moving picture data with the speech. The JPEG-formatted still image data or the MPEG1-formatted speech data may be solely processed in the same manner as described above.

The portable comcorder of this embodiment is arranged to use a harddisk unit of 260 MB for the harddisk drive 415. In case that only the JPEG-formatted still image data is recorded, about 3000 still images may be recorded. In actual, the portable comcorder of this invention enables to retrieve 3000 items of data quickly and easily using the classifying function.

Fig. 4 shows a circuit arrangement about the moving image. The corresponding circuit arrangement to that of Fig. 4 is required for the still images and the speech. That is, the portable comcorder of this embodiment is arranged to have a general-purpose means for imaging a moving object / a still object, a microphone, means for digitally converting a moving image / a still image, means for digitally converting speech, and means for digitally recording a moving image, a still image, and a speech signal.

Fig. 5 shows the screen of the built-in display unit 201 used in the embodiment of the invention, in which the diagonal length is 1.8 inch (45.7 mm), the horizontal length is 36.6 mm, and the vertical length is 27 mm. The illustrated screen arrangement uses a liquid crystal consisting of 352 pixels and 240 pixels. In order to reduce

the power consumption and the size of the portable digital camcorder 200, the 1.8-inch liquid crystal is used for the built-in display unit 201. This built-in display unit 201 shows an imaging screen formed by a monitoring signal when recording the signal, a retrieval screen formed by the program when retrieving the data, and a playback screen formed by the decoded data when playing back the data.

In recording the data, the moving image recording mode (MPEG compression recording mode) or the still image recording mode (JPEG compression recording mode) may be switched each time the mode selecting button is pressed. As the user can select the recording mode with this button, as shown in Figs. 17 and 18, the mark for each mode located in the upper left portion of the imaging screen is switched each time the mode is switched.

Fig. 17 shows the imaging screen appearing when the still image recording mode is selected when recording data. In Fig. 17, a numeral 1701 denotes a mark representing a still image mode. Fig. 18 shows the imaging screen appearing when the moving image recording mode is selected when recording data. In Fig. 18, a numeral 1801 denotes a mark representing the moving image mode. The mark for each mode appears on the screen so that the user can visually recognize the current imaging mode as he or she is pushing the mode selecting button. This mark allows the user to handle the comcorder without having to keep his eyes out of the imaging screen. It means that the digital comcorder offers convenient operativity to the user.

The mark for each mode is displayed on the retrieving screen through the effect of the program sent from a data containing unit. The retrieving screen will be discussed in detail together with the display of the mode mark. Fig. 19 shows the concrete mark for each mode. In actual, however, the marks are not limited to the illustrative ones. Any mark may be used if it can distinguish the modes from each other.

In Fig. 5, the display screen 500 consists of 20 x 9 characters at maximum, each character consisting of 16 and 24 pixels. The character size consisting of 16 x 24 pixels keeps the maximum recognizable size compatible with efficient digitizing of the character data. The blanks of a left side 501, a right side 502, an upper side 503, and a lower side 504 of the screen are secured because the display unit or the built-in display unit 201 connected to an output terminal 416 disables to display the overall area of the main screen.

A numeral 505 denotes an operating state display area where the operating state of the program of this embodiment is displayed. A numeral 506 denotes an area where the information of the recorded data and the functions to be operated for specifying the data details of the data by pressing a function switch 304 are displayed as individual items in partitioned sub-screens. A numeral 507 denotes an area where an operating procedure suggests the operating method to the user.

Fig. 6 shows a display screen 600 appearing when a program starting switch 303 is pressed by the user for starting the program of this embodiment. The display screen 600 corresponds to a classifying selection 101 of Fig. 1 for indicating the state transition of the operation. As mentioned earlier, the data recorded by the user is unconditionally recorded "unclassified" when recording the data. The figure (number of files) displayed on the "unclassified" row stands for the number of MPEG1-formatted moving image data items with the speech 602, the number of JPEG-formatted still image data pieces 603, and the number of MPEG1-formatted speech 604.

Likewise, the figure displayed on each row of a mark 605 for indicating the first classification, a mark 606 for indicating the second classification, and a mark 607 for indicating the third classification indicate the numbers of data items arbitrarily classified by the user, respectively. A mark 608 for indicating all data items at a batch indicates the total number of the data items on the "unclassified" row 601, the "first classified" row 605, the "second classified" row 606, and the "third classified" row 607.

A mark 609 for indicating the "temporary discard" means a classification for temporarily discarding the data items so that the user cannot erroneously erase the data items. With the mark 609, the user can temporarily move the "unclassified", "first classified", "second classified", and "third classified" data items to the "temporary discard" row. The figure represented on the row of the mark 609 does not contain a figure represented on the row of the mark 608 for indicating all data items at a batch.

In Fig. 6, the row of the mark 601 for indicating the unclassification is reversed to the rows of the other marks. It indicates that the mark 601 for indicating the unclassification is the selected item. In place of the reversing, another kind of way may be used such as change of a color. The software program is executed by the user so that the recorded data items whose classifying destinations are not changed are contained in the row of the mark 601 for indicating the unclassification.

When the upper arrow switch 305a of Fig. 3 is pressed by the user, the selected item is shifted upward by one row, while the lower arrow switch 305c is pressed, the selected item is shifted downward by one row.

In case that the selected item is an item on the first row of the display area 506, that is, on the mark 601 for indicating the unclassification, when the user presses the upper arrow switch 305a, the selected item is shifted to the item on the sixth row of the display area 506, that is, on the mark 609 for indicating the temporary discard. In case that the selected item is an item on the sixth row of the display area 506, that is, on the mark 609 for indicating the temporary discard, when the user presses the lower arrow arrow 503c, the selected item is shifted to the item on the first row of the display area 506, that is, on the mark 601 for indicating the unclassification.

When the user presses the right arrow switch 305b, the display screen is shifted into the screen on which

the content of the classification of the selected row is represented.

Moreover, the guide indication 610 for the operating procedure is displayed so as to remind the user of the operation.

As an example, Fig. 7 shows a display screen 700 on which the mark 605 for indicating the first classification is selected so that the data items on the row of the mark 605 appear as ones to be selected if the right arrow switch 305b is pressed by the user. This function corresponds to the data selection 102 shown in Fig. 1.

The display screen 700 is a screen on which a data item is to be retrieved from a data list and played back. The data list is a feature of the present invention. On the screen 700, the data items recorded by the portable digital comcorder 200 may be listed using a mark 703 for representing a sort of data content of a recording start time 702, a moving image, a still image, and a speech, a classifying mark 704, and a mark 705 for protecting data from being erased by the erroneous operation.

The data items displayed on the screen 700 are ranged from the top to the down in the sequence of the recording year/month/day 701 and the recording start time 702. Hence, the latest recorded data is listed on the topmost row, so that the user can effectively retrieve the data. The number of the pages of the displayed lists is checked, so that the lists are displayed as pages as indicated by a numeral 707. In the page display 707, a denominator indicates all the list pages, while a numerator indicates the current one of the list pages.

The imaging status of the user such as the recording date and time and the data type are automatically recorded as the aforementioned information, so that the user can manually record these pieces of information. Since the user may optionally change the classifying destination according to his or her purpose, the user's retrieval work for the destination data is made simpler and more efficient.

These pieces of information are all composed of a list represented in characters. This does not need a time consumed in expanding the compressed image data recorded on the media. Further, if the user selects a data item using the operating button, the screen can be rewound quickly, so that the quick retrieval is made possible.

This list retrieving operation may offer comfortable operativity without having to impose stress on the user who wants to quickly select the recorded image.

The selecting classification 706 indicates a classification selected by a display screen 600. This embodiment has concerned with the user's selection of the first classification 605 on the display screen 600.

The display list of the data items on the display screens 700 and 800 is arranged in the sequence of recording the data on the harddisk drive 415, that is, in the sequence that the latest data item comes to the topmost row. Since the user may change the sequence of recording the data items on the harddisk driver 415, he or she may change the display sequence. The data immediately after imaging is recorded on the topmost row (701 of Figs. 7 and 8) of the display area 506 on the unclassified data selecting screen. If the user makes sure of the just imaged data, he or she only reproduces the data and makes sure of the topmost row of the display area 506 on the unclassified data selecting screen.

Like the display screen 600, when the user presses the upper arrow switch 305a, the selected data item is shifted upward by one row. When the user presses the lower arrow switch 305c, the selected data item is shifted downward by one row. In this embodiment, the six rows of the data items are displayed on one screen. In case the user selects the sixth data item, if the lower arrow switch 305c is pressed, the seventh data item is displayed on the first row of the display area 506. It means that the seventh data item is the selected item. The eighth, the ninth and the following data items are displayed on the second, the third, and the following rows, respectively.

On the other hand, for example, in case the seventh data item is selected, if the upper arrow switch 305a is pressed, the seventh data item is displayed on the first row of the display area 506. The second, the third, the fourth, the fifth, and the sixth data items are respectively displayed on the rows after the first one, so the selected data item is changed to the sixth data item.

That is, the n-th data item is displayed on a remainder-th row on the display area 506, in which the remainder is obtained by dividing n by 6.

In case the head data item or the tail one is selected, if the upper arrow switch 305a or the lower arrow switch 305c is pressed, like the display screen 600, the data items containing the head and the tail items are displayed as a list so that the head or the tail data item is selected. Though Fig. 6 shows the one-page screen on which the number of folders is fixed, Figs. 7 and 8 show the screen on which the pages are increased or decreased in number according to the number of data items.

If the user selects the upper arrow switch 305a and the lower arrow switch 305c shown in Fig. 3 and depresses the right arrow switch 305, the selected data is fed out of the output terminal 416 and is played back on the built-in display unit 201.

While the data is being played back, the upper arrow switch 305a, the lower arrow with 305c, and the left arrow switch 30, as shown in Fig. 3, are served as fast feed, rewind, and stop, respectively. While the data is being played back, if the left arrow switch 305d served as a stop switch is pressed by the user, the playback is stopped, and the display screen 700 is displayed again. The state transition during the data playback is denoted by a numeral 103 of Fig. 1.

Next, the description will be oriented to the display content on which reduced images are added to the recording date and time so that the content of the data may be easily recognized. In the state of the display screen 700, if the user presses the reduced image display switch 302, a reduced image 801 of the first frame

of the data listed on the subject row is displayed on the display screen 800 shown in Fig. 8. This makes it possible to surprisingly enhance the retrieval of the data. The state transition in the reduced image display function is denoted by a numeral 104 of Fig. 1.

For example, in case that the viewable area of the 1.8-inch built-in LCD display unit 201 consists of 379 dots in horizontal and 220 dots in vertical, the reduced image 801 is adjusted to consist of 64 dots in horizontal and 48 dots in vertical. (if the LCD panel consists of 352 and 240 dots, the reduced image 801 consists of 240/48 = 5 dots in vertical and 352/5 = 70.4 in horizontal. From a vertical viewpoint, the reduced image is one-fifth and from a horizontal viewpoint, the reduced image is one-fifth with a slight margin.) In this reduction, three reduced images, the recording starting year month day 701, the recording starting time 702, the mark 703 representing the content type of the data indicating the moving image, the still image, and the speech, the classification mark 704, and the mark 705 for protecting the data from being erroneously erased can be all displayed on one screen. This screen arrangement makes it possible to secure more visible reduced images on the display. Like the display screen 700, on this display screen 800, the data may be played back by pressing the operating button 305 and the like.

In this state, if the reduced image display switch 302 is pressed again, the display screen is returned to the display screen 600 for displaying the data classification. The reduced image is depicted in the RAM 410 shown in the circuit block of Fig. 4 through the effect of the control microcomputer 411 and the MPEG encoder 409.

In turn, the description will be oriented to a function selecting display screen 900 for easily changing the display state from the data selecting display screen 700. The function selecting display screen 900 includes the reduced number of operation switches and function items displayed thereon so that the ease of use in operation may be improved as viewing the screen. The operating switches 304, 305a, 305b, 305c, and 305d shown in Fig. 3 implement the operating system for selectively operating the function. The state transition on the display screen 900 is denoted by a numeral 105 of Fig. 1.

On the reduced image display screen 800, the function selecting display screen 900 is displayed by the same procedure. On the display screen 600, the display screen having the necessary functions such as "empty a garbage", "move to a garbage", "display a state", and "auto play" shown in Fig. 1 is displayed by the same procedure. In this case, the function items on the display screen 900 are not required to be identical with the function items on the data classifying display screen 600.

The flow of operation on the display screen 900 is shown in Fig. 10. The display screen 900 is displayed when the user pressed the function switch 304 on the display screen 700 (step 1001). The selective movement of each item is indicated by the upper arrow switch 305a and the switch lower arrow switch 305c. If the user pressed the upper arrow switch 305a, the selected data item is moved upward by one row. If the lower arrow switch 305c is pressed, the selected data item is moved downward by one row (step 1002). If the user presses the right arrow switch 305b (step 1003), the function of the selected data item is executed (step 1004). If the left arrow function switch 305d is pressed, the display screen 900 is returned to the data selecting display screen 700 (step 1005).

As mentioned earlier, in this embodiment, the erasion of the data is realized by moving the data to the temporary discard location and then erase the data contained in the temporary discard location. The state transition of this function is denoted by a numeral 106 of Fig. 1.

The procedure of erasing the data will be described below.

If the data is erased, the data is moved to the temporary discard location. In this case, the procedure for selectively executing "move the data to a garbage" will be described with reference to Fig. 9.

At first, on the display screen 700, the user selects the data item to be temporarily discarded with the upper arrow switch 305a and the lower arrow operating switch 305c and then depresses the function switch 304. Then, the display screen 700 is changed to the display screen 900. The user selects the "move data to a garbage" 901 with the upper arrow operation switch 305a and the lower arrow function switch 305c and then depresses the right arrow switch 305b. Then, the selected data item is moved to the garbage that is the temporary discard location. If the user presses the switch 306, the similarly selected data is moved to the garbage.

When the user selects the "empty a garbage" 902 on the display screen 900, all the data items left in the garbage are erased. The state transition of this function is denoted by a numeral 107 of Fig. 1.

In the operating system, the user is required to do two operations for erasing the data. The two operations protect the data from the user's erroneous erasion.

As mentioned earlier, when recording the data, the classifying symbol to be allocated to each data item is an unclassified one. When playing back the data, the classification may be changed by the user's operation. This classifying function is used for classifying the data item. Hence, since the user classifies the data item for each destination, the ease of use of the retrieval may be surprisingly enhanced. The state transition of this function is denoted by a numeral 108 of Fig. 1.

Later, the description will be oriented to the procedure for changing the data classification. On the display screen 700, the user selects the data item whose classification is to be changed with the upper arrow switch 305a or the lower arrow operation switch 305c and then presses the function switch 304. Then, the display screen is changed to the display screen 900. The user selects the "change a group" 905 that is a function of changing the classification with the upper arrow operation switch 305a and the lower arrow operation switch

305c and then presses the right arrow switch 305b. Then, a display screen 1100 is displayed on which the classification of the selected data shown in Fig. 11 is changed.

If the right arrow switch 305b is pressed on the display screen 1100, the classification is cyclically changed from "unclassification" to 1 to 2 to 3 to "unclassification". In this embodiment, the update of the symbol for the classification according to the display screen is executed by the control microcomputer 411 at a time when the user presses the left arrow switch 305d and the display screen 600 appears. This is intended for enhancing the processing speed and retrying the user's operation.

As described earlier, unless the user does the following operation, the list indicated on the display screen 700 is arranged in the recording sequence of the recorded data. When playing back the data, the sequence may be changed so as to implement a simple editing function. The state transition of this function is denoted by a numeral 109 of Fig. 1.

The procedure of changing the data displaying sequence will be described below. At first, on the display screen 700, the user selects the data item whose displaying sequence is to be changed with the upper arrow switch 305a and the lower arrow switch 305c. Then, if the function switch 304 is pressed, the display screen 900 is displayed.

The user selects the "change a data display sequence" 906 that is a function of changing the display sequence with the lower arrow switch 305c and depresses the right arrow switch 305b. Then, the display screen 1200 shown in Fig. 12 is displayed, so that the display sequence of the selected data item may be changed. Next, the user specifies the location where the selected data is to be inserted with the upper arrow switch 305a and the lower arrow switch 305c. Then, if the right arrow switch 305b is pressed, the selected data item is inserted to the specified location. In this case, the sequence of the data item located after the specified location is shifted lower by one.

The portable digital camcorder 200 of this embodiment incorporates an internal clock for displaying on the display screen 700 the date and the time when the data is recorded. However, if failure such as rundown of a battery takes place while imaging an object, the recorded data and time may not be correctly displayed on the display screen 700. In this embodiment, the user may operate to optionally change the date and time when the data is recorded. The state transition of this function is denoted by a numeral 110 of Fig. 1.

Later, the description will be oriented to the procedure for changing the date and time. The user selects the data whose recording date and time are to be changed using the upper arrow switch 305a and the lower arrow switch 305c. Then, if the function switch 304 is pressed, the display screen 900 is displayed. The user selects the "change a recording date and time" 907 that is a function of changing the displaying sequence with the upper arrow switch 305a and the lower arrow switch 305c. Next, if the right arrow switch 305b is pressed, the display screen 1300 shown in Fig. 13 is displayed where the recording date and time of the selected data are to be changed.

In this state, when the user pressed the upper arrow switch 305a, the year figure 1301 is increased by 1, while the lower arrow switch 305c is pressed, the year figure 1301 is decreased by 1. When the right arrow switch 305b is pressed, the year figure 1301 is determined as a numeric value represented at the time point. Next, the user may specify the increment or decrement of the numeric value of a month figure 1302.

Likewise, if the upper arrow switch 305a is pressed, the month figure 1302 is increased by 1, while if the lower arrow switch 305c is pressed, the month figure 1302 is decreased by 1. If the right arrow switch 305b is pressed, the month figure 1302 is determined as a numerical value displayed at the time point. Next, the user may specify the increment or decrement of a numerical value of a day figure 1303.

Further, when the left arrow switch 305d is pressed, the year figure 1301 may be retried. The similar operation may be executed to set the day figure 1303, an a.m or p.m. indication 1304, a time figure 1305, and a minute figure 1306. After adjusting a value of the minute figure 1306, if the right arrow switch 305b is pressed, the change of the recording date and time is terminated and the date and time of the data is changed to a new numeric value.

In the case of specifying an numeric value that does not exist in the calendar such as February 30, the numeric value is changed to the nearest date (that is, March 1) to the value.

In this embodiment, though the user can freely erase the data, the user may provide the data with an attribute of prohibiting the erasion for preventing the data from being erased. The state transition of this function is denoted by a numeral 111 of Fig. 1.

Later, the description will be oriented to the procedure for adding the attribute of protecting the data from the erasion to the data. At first, on the display screen 700, the user selects the data whose erasing attribute is to be changed with the upper arrow switch 305a or the lower arrow switch 305c. Then, the function switch 304 is pressed, so that the display screen 700 is changed to the display screen 900. The user selects the "change a lock" 904 that is a function of changing the erasing attribute with the upper arrow switch 305a or the lower arrow switch 305c. Then, if the right arrow switch 305b is pressed, the display screen 1400 is displayed where the erasing attribute of the selected data shown in Fig. 14 is changed.

When the user pressed the right arrow switch 305b, the erasing attribute is cyclically changed from "disabled" to "enabled" to "disabled". The protecting mark 705 is displayed or not displayed according to the erasing attribute.

In this embodiment, the user can know the remain-

ing volume of the harddisk drive 415. The state transition of this function is denoted by a numeral 112 of Fig. 1.

Hereafter, the description will be oriented to the procedure for checking the remaining volume of the harddisk drive 415. On the display screen 700, if the user presses the function switch 304, the display screen 700 is changed to the display screen 900. The user selects the "display a state" 903 that is a function of changing the displaying sequence with the upper arrow switch 305a or the lower arrow switch 305c. Then, if the right arrow switch 305b is pressed, the display screen 1500 is displayed where the remaining volume of the harddisk drive 415 shown in Fig. 15 is shown.

On the display screen 1500, a remaining time 1501 left if only the MPEG1-formatted moving image data with the speech is recorded on the harddisk drive 415, a remaining pages left if only the JPEG-formatted still image data is recorded, a remaining time 1503 left if only the MPEG1-formatted speech data is recorded, and a remaining volume 1504 represented in bytes are all displayed as a list. Since the remaining volume of the harddisk drive is listed with respect to each recordable data type, the user can more easily grasp the remaining volume of the harddisk drive 415.

In this embodiment, when playing back the data, the user needs to use only the switches 305a, 305d, 305c and 305d for playing back the data. It is epoch-making that the minimum number of operating switches are just required for playing back the data.

Another epoch-making point is the increase of the functions without increasing the operating buttons by using the functional selecting screen 900.

In this embodiment, as shown in Fig. 6, the classified number of data items is four including "unclassified". The classified number of data may take any value. On the data selecting display screen 700, the data items may be displayed as a list independently of the types of the moving image, the still image, and the speech. This embodiment may apply to the function of automatically classifying the data according to the data type with the user's specification.

Moreover, the control microcomputer 411 is operated to automatically select the data according to the imaging modes such as the moving image and the still image. For example, the user can select only the imaging mode for the still image, pick up only the image type of the still image, and reproduce it.

The foregoing description has been concerned with the specific embodiments of the invention. The present invention may apply to the following arrangement.

For example, the present invention may be achieved by an image recording apparatus which includes converting means for converting a video signal into a digital signal, a codec unit for selectively performing a MPEG system or a JPEG system compression about the digital signal, for generating the compressed data, a recording unit for recording the compressed data, and a selective indicating means for a compression mode, for selectively indicating the MPEG system compression or the JPEG system compression.

This image recording apparatus may be applicably arranged to switch the compressing system of the codec unit according to the indication given by the selective indicating means.

Further, the image recording apparatus may be applicably arranged to add a code for indicating the compression system to the compressed data according to the indication given by the selective indicating means.

Further, the image recording apparatus may be applicably arranged so that the codec unit may be a circuit for performing the MPEG system and the JPEG system processing at one process.

Moreover, the image recording apparatus may be applicably arranged so that the video signal is obtained from an imaging element and the recording unit is a harddisk drive.

The present invention may be also achieved by the image reproducing apparatus which includes a recording unit for receiving compressed data generated according to the MPEG system or the JPEG system and recording the compressed data, specifying means for specifying a data item to be reproduced of the compressed data recorded in the recording unit, readout means for retrieving and reading out the compressed data specified by the specifying means from the recording unit, a codec unit for selectively performing the MPEG system or the JPEG system expansion about the compressed data and generating the digital signal, and converting means for converting the digital signal generated by the codec unit into a video signal.

Moreover, the image reproducing apparatus may be applicably arranged so that the expanding system of the codec unit may be switched according to the compressed data read out of the readout means.

Further, the image reproducing apparatus may be applicably arranged so that the compressed data of the recording unit pre-contains the code indicating the compressing system and the expanding system of the codec unit may be switched according to the code for indicating the compressing system added to the compressed data read out of the readout means.

Further, the image reproducing apparatus may be applicably arranged so that the codec unit may be a circuit for performing the MPEG system and the JPEG system expansion at one process, the video signal is output to the built-in display unit, and the recording unit may be a harddisk drive.

The present invention may be achieved by the image recording and reproducing apparatus for converting a video signal into a digital signal, recording the digital signal, converting the digital signal into the video signal, and reproducing the video signal, which includes a codec unit for selectively performing the MPEG system or the JPEG system compression about the digital signal for generating the compressed data in recording the data and selectively performing the MPEG system or the JPEG system expansion about the compressed

data for generating the digital signal in reproducing the data, a recording unit for recording the compressed data, selective indicating means for the compressing mode for selectively indicating the MPEG system compression or the JPEG system compression, specifying means for specifying the data to be reproduced of the compressed data recorded in the recording unit, and readout means for retrieving and reading the compressed data specified by the specifying means from the recording unit.

Moreover, the image recording and reproducing apparatus may be applicably arranged so that the codec unit may switch the compressing system according to the indication given by the selective indicating means in recording the data or the expanding system according to the compressed data read out of the readout means in reproducing the data.

Further, the image recording and reproducing apparatus may be applicably arranged so that in recording the data, the recording unit adds the code for indicating the compressing system to the compressed data according to the indication given by the selective indicating means and records the compressed data and in reproducing the data, the codec unit switches the expanding system according to the code for indicating the compressing system added to the compressed data read out of the readout means.

Moreover, the image recording and reproducing apparatus may be applicably arranged so that the codec unit may be a circuit for performing the MPEG system and the JPEG system processing at one process, the video signal to be recorded is obtained from an imaging element, the video signal to be reproduced is output to the built-in display unit, and the recording unit is a hard-disk drive.

As described above, as keeping the capacity of the recording medium larger and advancing the compressing technology, the data items to be recorded on one recording medium are increased in number. This embodiment, however, makes it possible to do the recording and the reproducing operations with quite few keys. Hence, this embodiment offers the below-indicated effects, so that it may improve the operativity even if it is applied to the small-sized apparatus with a limited space prepared for the operation buttons or switches.

This embodiment may display the recording date and time information and the marks for modes such as the moving image, the still image, and the still image with the speech as a list. Hence, the user can efficiently and quickly retrieve the data as grasping the content of the data. In recording the data, the marks are switchably displayed on the imaging screen each time the mode is switched so that the user can grasp the current imaging mode. Hence, the user can focus his or her attention onto the imaging screen at any mode when recording the data.

The display list is composed of a date and a time. The apparatus of this embodiment may automatically create the overall list and at once output the reduced images, so that the user can more easily grasp the content of the data.

The imaged data may be classified to the predetermined locations. Hence, the imaged data may be classified on the mode information and the date and time information according to the imaging statue and the object. This classification makes it easier for the user to retrieve the data.

Further, the displaying sequence of the list and the generating sequence of the data are allowed to be replaced depending on the mode information and the date and time information. Hence, the optimal reproducing effect can be obtained without having to depend on the recording sequence.

Then, the classification of "temporary discard" is provided for preventing the erasion of the data resulting from the user's erroneous operation and reusing the unnecessary data if it is made necessary after being deleted.

As described above, if the operation on the relatively simple graphic screen is executed to record a great deal of data, the function of this embodiment enables to offer quicker retrieval than the conventional function of reproducing the data as expanding all image screens.

Claims

1. A digital image and speech recording and reproducing apparatus comprising:

   means (401, 402, 403, 404, 405, 409, 412, 415) for recording and reproducing a digital video signal of a moving image;
   means (418, 419, 409, 415) for recording and reproducing a digital speech signal in synchronous to said moving image;
   means (401, 402, 403, 404, 405, 409, 412, 415) for recording and reproducing a digital still image;
   display means (201) for displaying said moving image signal and said still image signal;
   means (411) for recording recording conditions containing data information about said recorded data for distinguishing said moving image signal from said still image signal and recording time information for indicating when said image or speech is recorded; and
   wherein the recording condition composed of at least said data information and said recording time information is graphically or literarily displayed on a screen of said display means and said displayed recorded data is selected on said screen.

2. A digital image and speech recording and reproducing apparatus comprising:

   means (401, 402, 403, 404, 405, 409, 412,

415) for recording and reproducing a digital moving image signal;
means (418, 419, 409, 415) for recording and reproducing a digital speech signal in synchronous to said moving image signal;
means (401, 402, 403, 404, 405, 409, 412, 415) for recording and reproducing a digital still image signal;
means (418, 419, 409, 415) for recording and reproducing a digital speech signal in synchronous to said still image signal;
display means (201) for displaying said moving image signal and said still image signal;
means (411) for recording recording conditions containing data information about said recorded data for distinguishing said moving image signal from said still image signal and recording time information for indicating when said image or speech is recorded;
wherein the recording condition composed of at least said data information and said recording time information is graphically or literarily displayed on a screen of said display means and said displayed recorded data is selected on said screen.

3. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein the recording condition of said recorded data displayed on said display screen contains information about the reduced image of said recorded data.

4. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, comprising:

means (401, 402) for imaging a moving image;
means (401, 402) for imaging a still image; a microphone (418) for recording speech data;
means (404) for converting said imaged moving image signal into a digital moving image signal;
means (404) for converting said still image signal into a digital still image signal;
means (419) for converting said recorded speech signal into a digital speech signal; and
means (415) for recording said digitized moving image signal, said digitized still image, and said digitized speech signal.

5. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein said display means for displaying said recording condition is composed of a liquid crystal display panel having a horizontal side of 36.6 mm, a vertical side of 27 mm, and a diagonal of 45.7 mm.

6. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein on the display screen of said recording condition, a recording start date (1302, 1303) and a recording start time (1304, 1305, 1306) are displayed as said recording time information.

7. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein on the display screen of said display means, a number of recorded data items are displayed for two or more classifications for retrieval, a storage area for data is secured for each classification, and said recorded data item is saved in said storage area.

8. A digital image and speech recording and reproducing apparatus as claimed in claim 7, wherein on the display screen for said retrieving classification, one of said classifications is selectively operated so that the display screen may be changed into the display screen for indicating the recording condition displayed graphically or literarily.

9. A digital image and speech recording and reproducing apparatus as claimed in claim 7, wherein when reproducing the recorded data, if the classification is not specified, the recorded data contained in the predetermined classification of the topmost row on the display screen is displayed.

10. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein the recording condition of said recorded data displayed on said display screen contains information about the function of preventing erasion to be optionally specified by a user.

11. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein a button for changing the display screen for displaying the number of said recorded data items in each retrieval classification into the display screen for displaying the recording condition composed of said data information and said recording time information, a button for selecting each recording data item from a list of the recording data on the display screen for displaying said recording condition, a button for indicating a function of playing back, stopping, fast-feeding, and rewinding the image, and a button for returning said display screen for indicating the functions into the display screen for indicating said recording condition are composed as the same button (304).

12. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein on the display screen for graphically or literarily displaying the recording condition of said

recorded data, the data items recorded later are displayed on higher locations of the display screen.

13. A digital image and speech recording and reproducing apparatus as claimed in claim 3, wherein a reduced image of said recorded data is formed by thinning out the pixels obtained in actual recording in the horizontal and the vertical directions by one-fifth and is displayed on the same row as the graphic and the literary notation.

14. A digital image and speech recording and reproducing apparatus as claimed in claim 7, wherein one of said storage areas is a temporary discard area where said recorded data is reproducible, and the overall data in said discard area may be erased by the user's specification.

15. A digital image and speech recording and reproducing apparatus as claimed in claim 12, wherein the display sequence of the recording condition for said recorded data may be changed by the user's specification, so that a specific recording condition may be moved from one to another row on said display screen.

16. A digital image and speech recording and reproducing apparatus as claimed in claim 1 or 2, wherein on said display screen for graphically and literarily displaying the recording condition of said recorded data, a function of moving said recorded data to a temporary discard area, a function of erasing all data from said temporary discard area, a function of changing a retrieving classification of said recorded data, a function of changing the displaying sequence of the recorded condition of said recorded data, a function of changing an erasing attribute of said recorded data, a function of displaying a remaining volume of the stored volume of said recorded data are all displayed, and any one of said displayed functions may be specified.

17. A image recording apparatus for converting a video signal into a digital signal and recording an image to be displayed on a screen, comprising:

a compressing unit (409) for selectively compressing said digital signal of a moving image or a still image, for generating compressed data;
a recording unit (415) for recording said compressed data;
a recording mode selection indicating unit (408) for selectively indicating if the image to be compressed is said moving image or still image; and

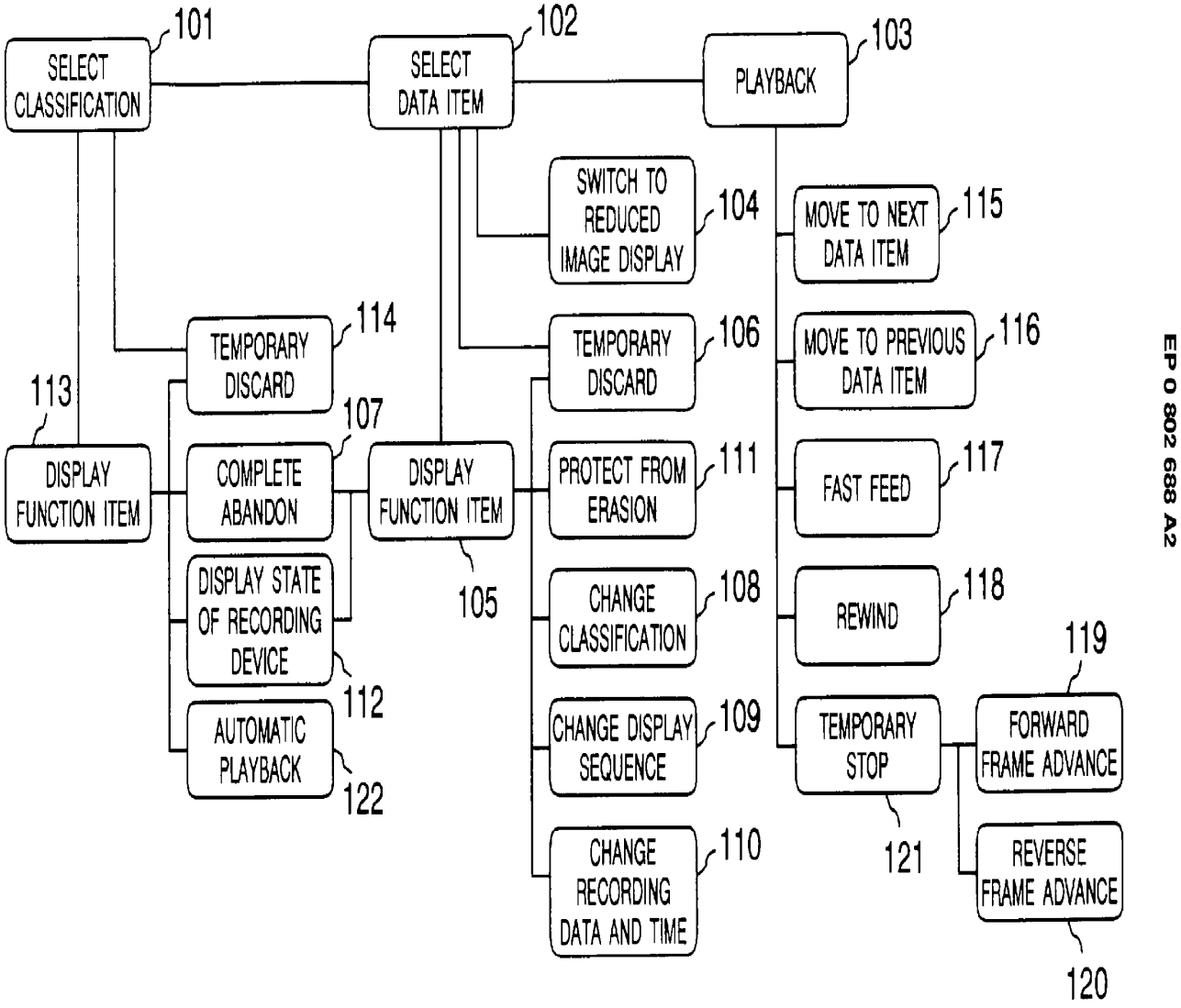
wherein on said screen, the type of said moving image or still image is displayed in association with the selection of said recording mode selection indicating unit (411), and said compressing unit (409) operates to selectively compress said moving image or still image in accordance with the indication given on the types of said moving image and said still image appearing said screen by said recording mode selection indicating unit.

18. A digital image reproducing apparatus comprising:

a storage unit (412) for storing compressed data generated by compressing a moving image or a still image;
an expanding unit (409) for generating a digital signal by selectively expanding said compressed moving image or still image;
said digital signal generated in said expanding unit being converted into the corresponding video signal so that an image for said video signal may appear on a display screen;
means (408) for specifying a data item to be reproduced of said compressed data stored in said storage unit;
means (411) for retrieving and reading out said compressed data item specified by said specifying means from said storage unit; and

wherein the data information indicating the types of said moving image and still image is displayed on said screen in association with said compressed data stored in said storage unit, and said expanding unit operates to selectively expand the compressed data of said moving image or still image if the compressed data is specified according to the data information for indicating the types of said moving image and still image.

FIG. 1



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FIG. 2

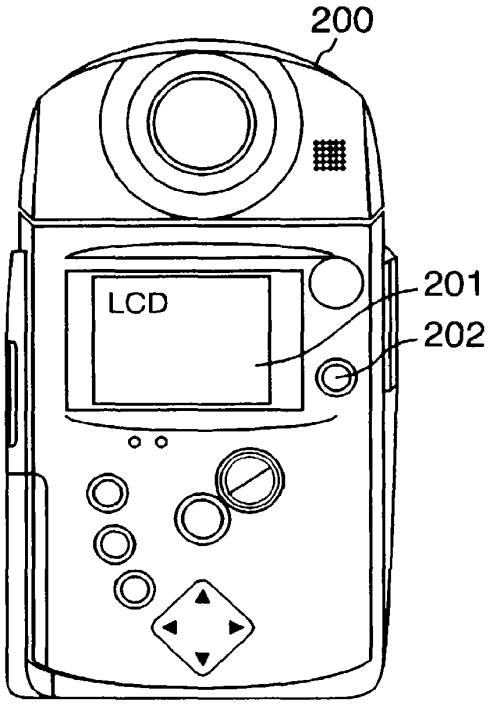

200
LCD
201
202

FIG. 3

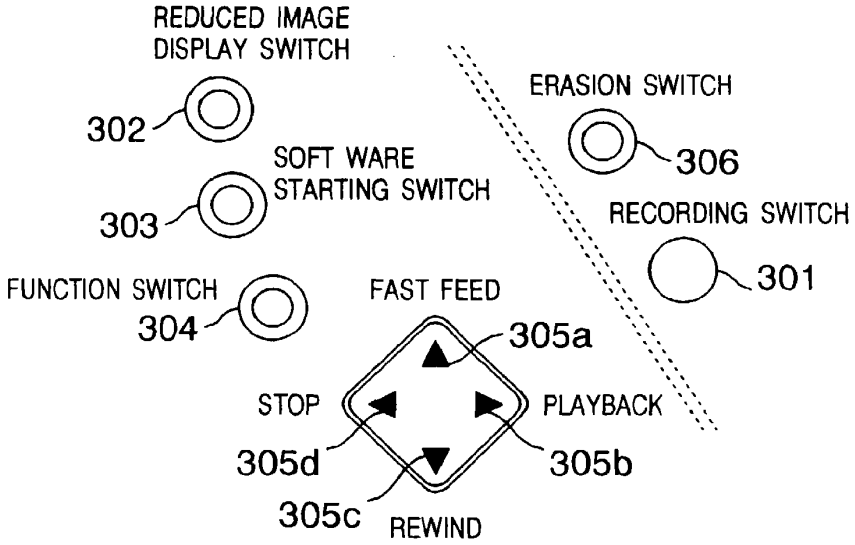
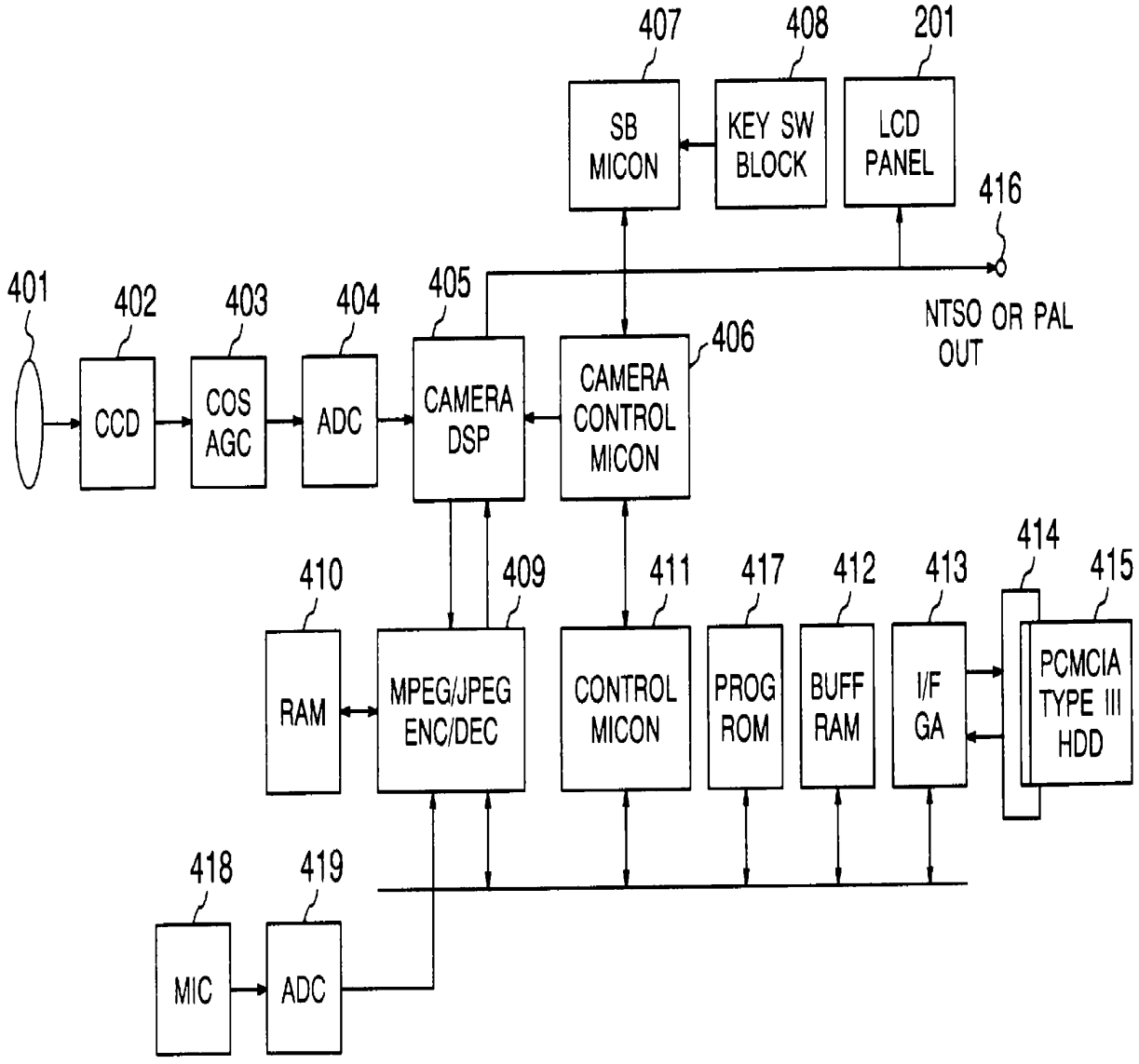

REDUCED IMAGE
DISPLAY SWITCH
302
SOFT WARE
STARTING SWITCH
303
FUNCTION SWITCH
304
ERASION SWITCH
306
RECORDING SWITCH
301
FAST FEED
305a
STOP
PLAYBACK
305d
305b
305c
REWIND

FIG. 4



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FIG. 5

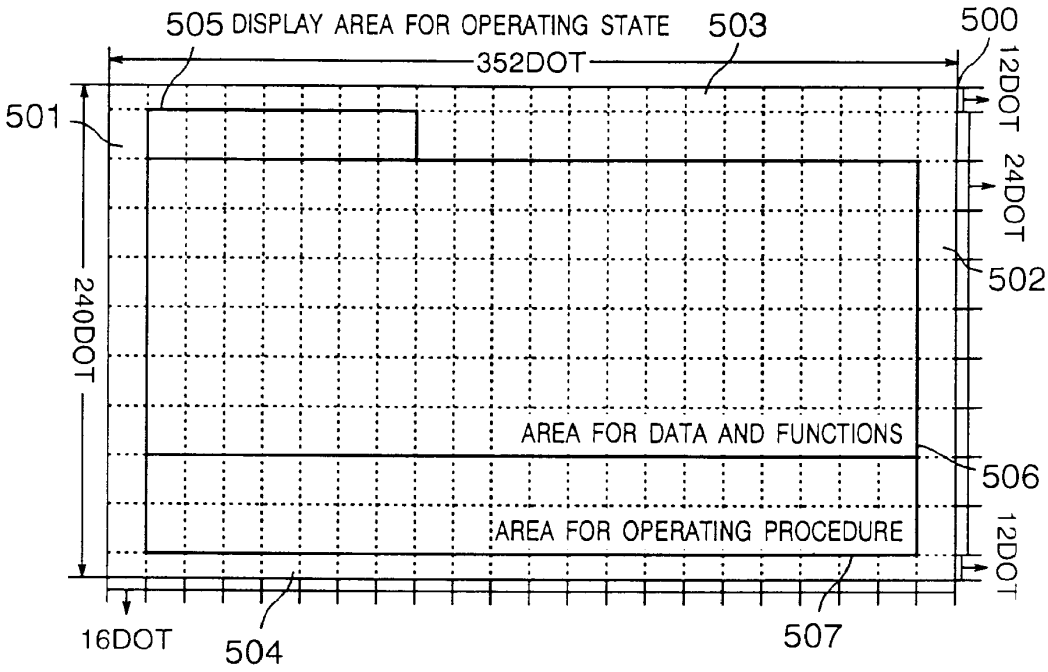

505 DISPLAY AREA FOR OPERATING STATE
503
500
352DOT
12DOT
24DOT
501
240DOT
502
AREA FOR DATA AND FUNCTIONS
506
AREA FOR OPERATING PROCEDURE
12DOT
16DOT
504
507

FIG. 6

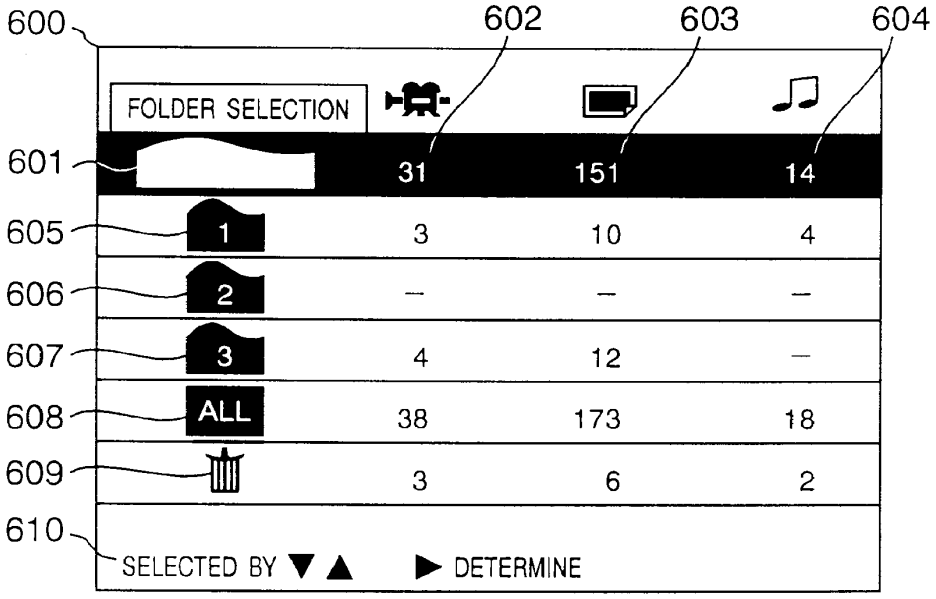

600
602
603
604
FOLDER SELECTION
601
31
151
14
605
1
3
10
4
606
2
—
—
—
607
3
4
12
—
608
ALL
38
173
18
609
3
6
2
610
SELECTED BY ▼ ▲
▶ DETERMINE

FIG. 7

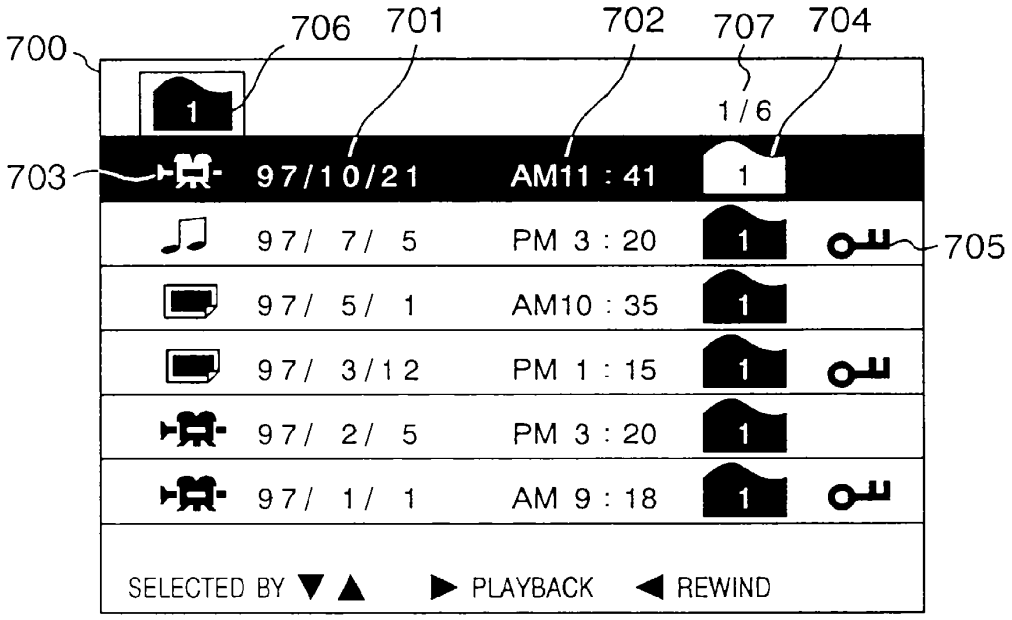

700
706
701
702
707
704
1
1/6
703
97/10/21
AM11 : 41
1
97/ 7/ 5
PM 3 : 20
1
705
97/ 5/ 1
AM10 : 35
1
97/ 3/12
PM 1 : 15
1
97/ 2/ 5
PM 3 : 20
1
97/ 1/ 1
AM 9 : 18
1
SELECTED BY ▼ ▲
▶ PLAYBACK
◀ REWIND

FIG. 8

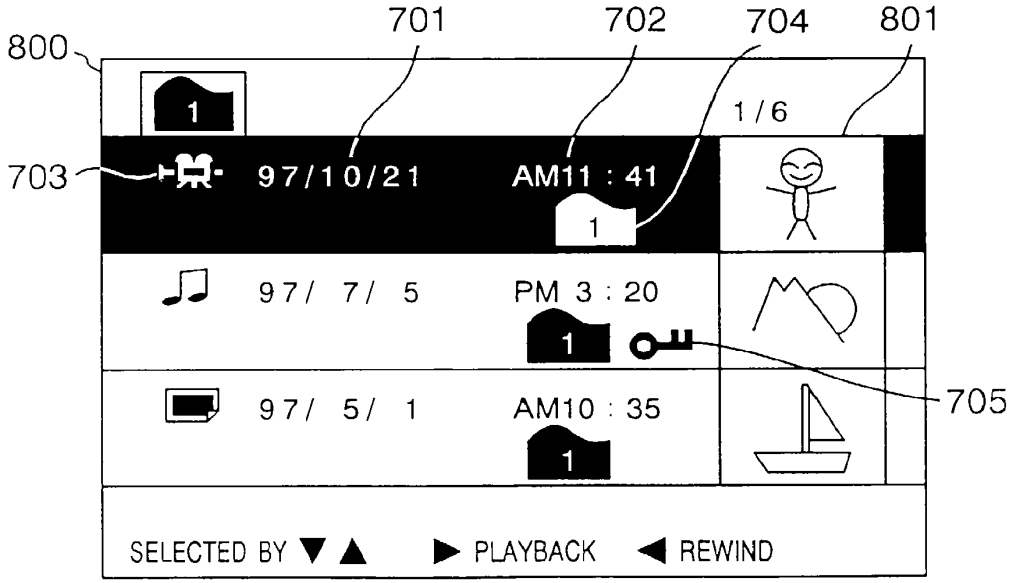

800
701
702
704
801
1
1/6
703
97/10/21
AM11 : 41
1
97/ 7/ 5
PM 3 : 20
1
705
97/ 5/ 1
AM10 : 35
1
SELECTED BY ▼ ▲
▶ PLAYBACK
◀ REWIND

FIG. 9

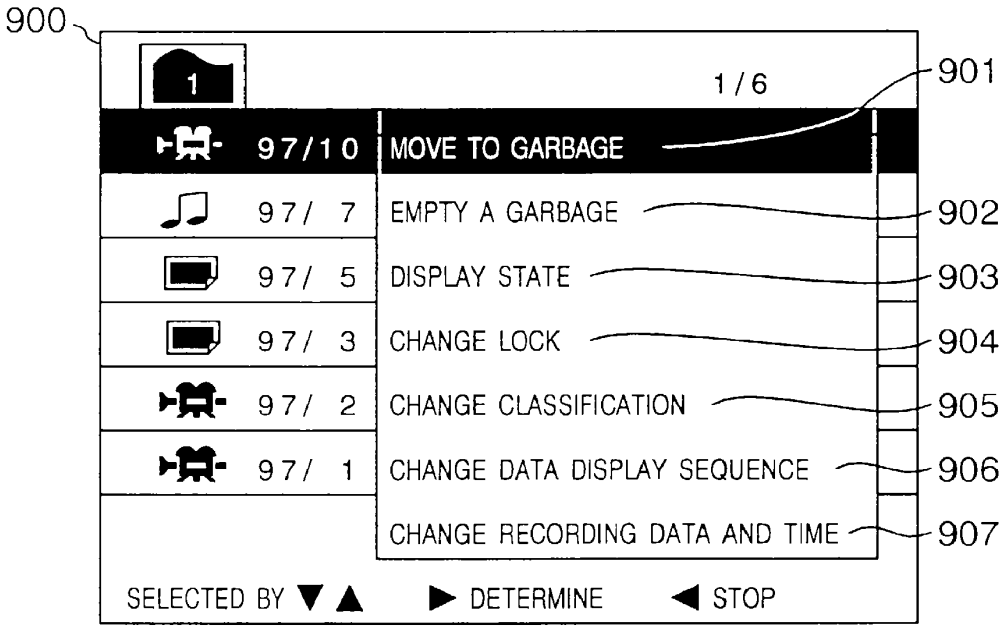

900
1
1/6
901
97/10
MOVE TO GARBAGE
97/ 7
EMPTY A GARBAGE
902
97/ 5
DISPLAY STATE
903
97/ 3
CHANGE LOCK
904
97/ 2
CHANGE CLASSIFICATION
905
97/ 1
CHANGE DATA DISPLAY SEQUENCE
906
CHANGE RECORDING DATA AND TIME
907
SELECTED BY ▼ ▲
▶ DETERMINE
◀ STOP

FIG. 10

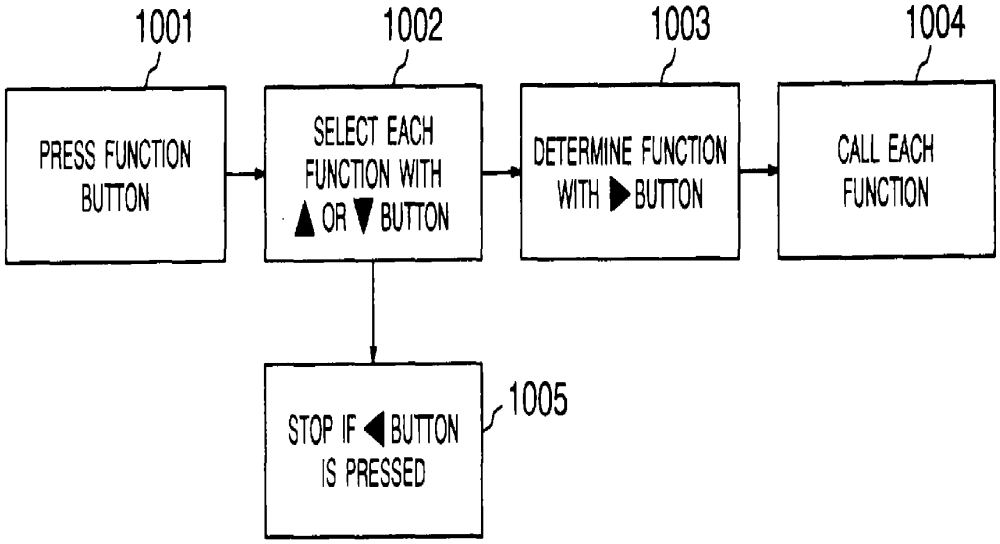

1001
1002
1003
1004
PRESS FUNCTION BUTTON
SELECT EACH FUNCTION WITH ▲ OR ▼ BUTTON
DETERMINE FUNCTION WITH ▶ BUTTON
CALL EACH FUNCTION
STOP IF ◀ BUTTON IS PRESSED
1005

FIG. 11

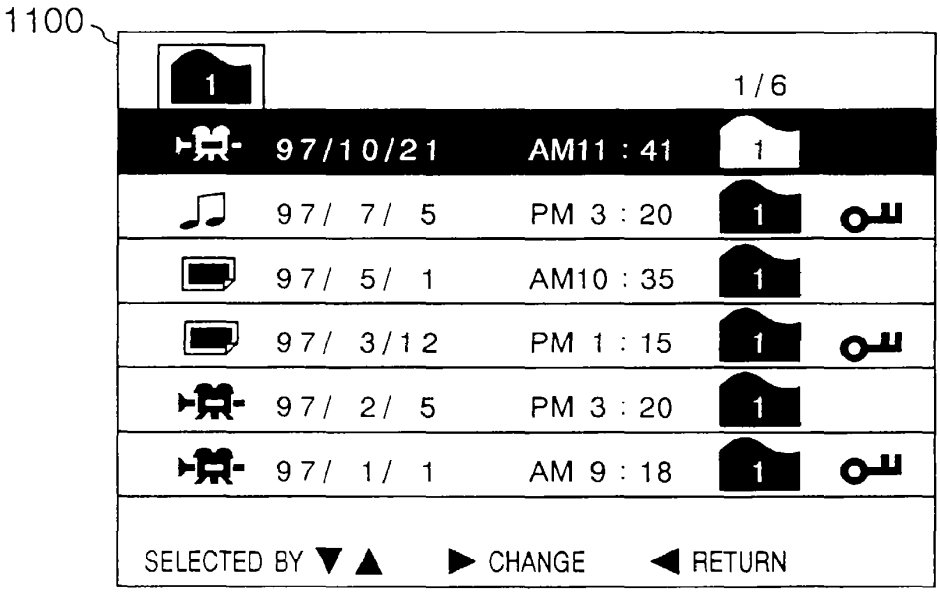

1100
1
1/6
97/10/21 AM11 : 41 1
97/ 7/ 5 PM 3 : 20 1
97/ 5/ 1 AM10 : 35 1
97/ 3/12 PM 1 : 15 1
97/ 2/ 5 PM 3 : 20 1
97/ 1/ 1 AM 9 : 18 1
SELECTED BY ▼ ▲ ▶ CHANGE ◀ RETURN

FIG. 12

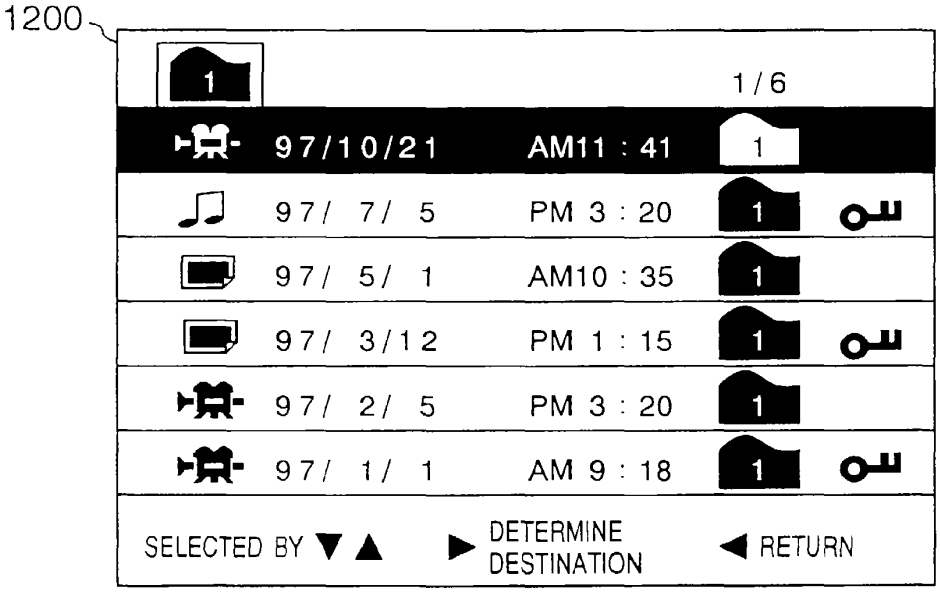

1200
1
1/6
97/10/21 AM11 : 41 1
97/ 7/ 5 PM 3 : 20 1
97/ 5/ 1 AM10 : 35 1
97/ 3/12 PM 1 : 15 1
97/ 2/ 5 PM 3 : 20 1
97/ 1/ 1 AM 9 : 18 1
SELECTED BY ▼ ▲ ▶ DETERMINE DESTINATION ◀ RETURN

FIG. 13

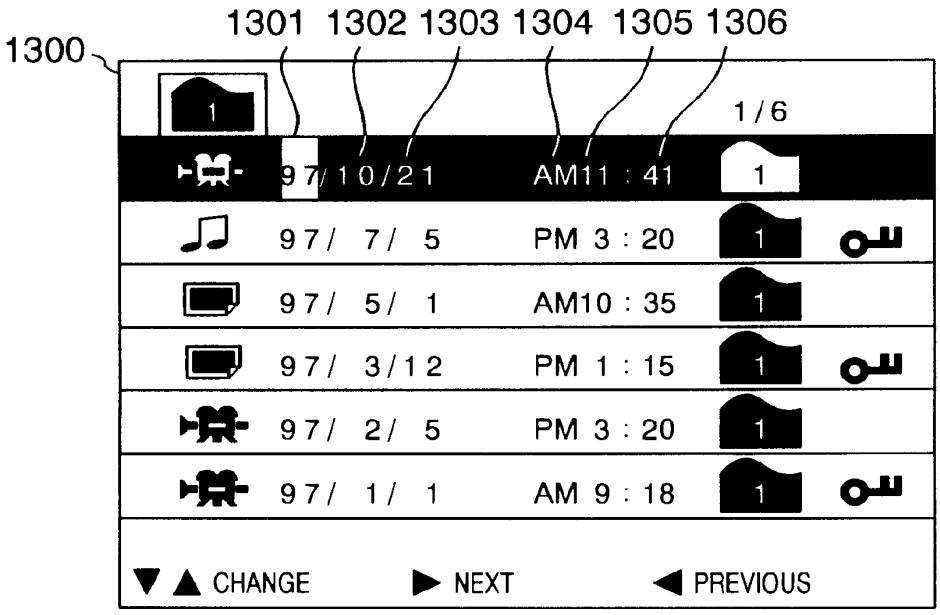

1300
1301 1302 1303 1304 1305 1306
1
1/6
97/10/21 AM11 : 41 1
97/ 7/ 5 PM 3 : 20 1
97/ 5/ 1 AM10 : 35 1
97/ 3/12 PM 1 : 15 1
97/ 2/ 5 PM 3 : 20 1
97/ 1/ 1 AM 9 : 18 1
▼ ▲ CHANGE ▶ NEXT ◀ PREVIOUS

FIG. 14

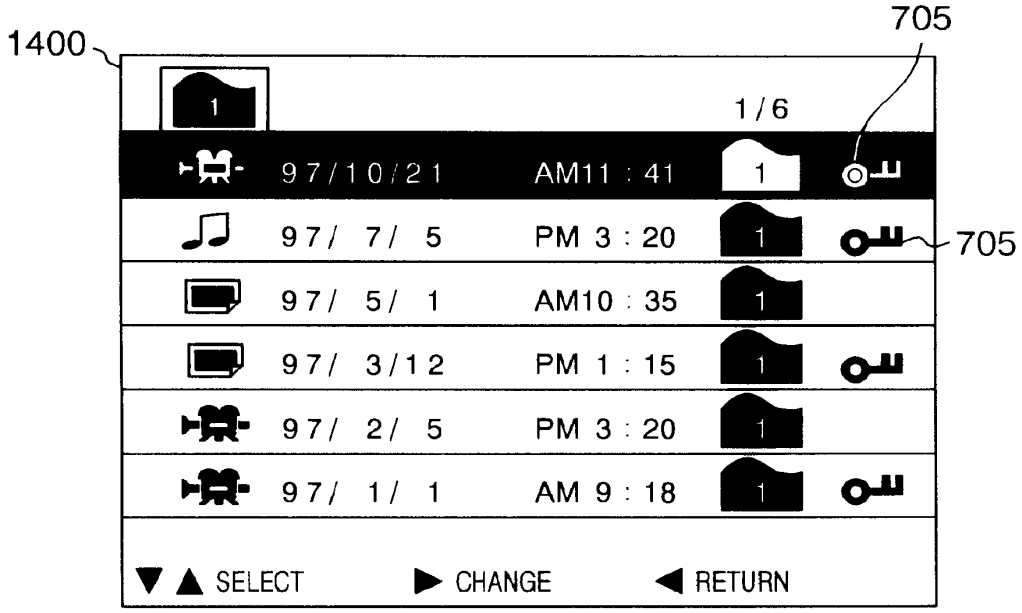

1400
705
1
1/6
97/10/21 AM11 : 41 1
97/ 7/ 5 PM 3 : 20 1
705
97/ 5/ 1 AM10 : 35 1
97/ 3/12 PM 1 : 15 1
97/ 2/ 5 PM 3 : 20 1
97/ 1/ 1 AM 9 : 18 1
▼ ▲ SELECT ▶ CHANGE ◀ RETURN

FIG. 15

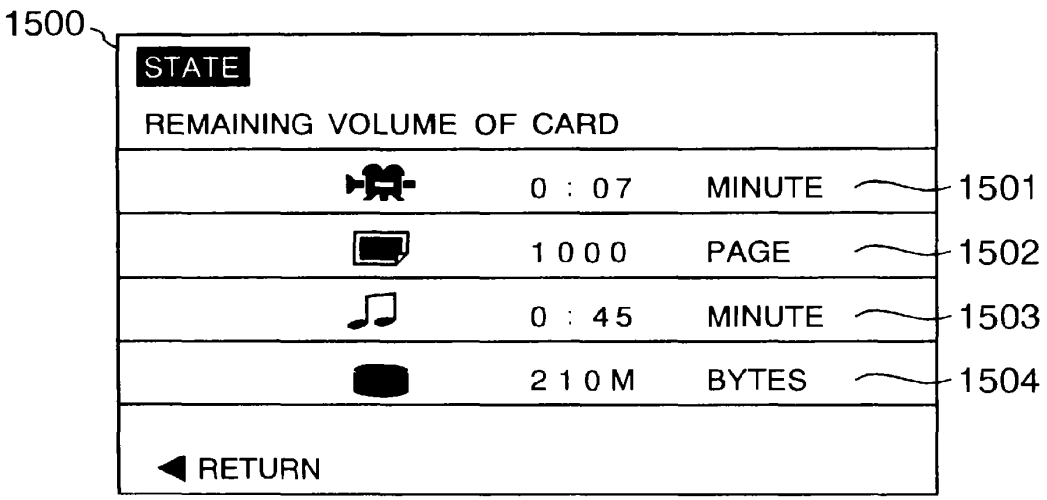

1500
STATE
REMAINING VOLUME OF CARD
0 : 07
MINUTE
1501
1000
PAGE
1502
0 : 45
MINUTE
1503
210M
BYTES
1504
RETURN

FIG. 16

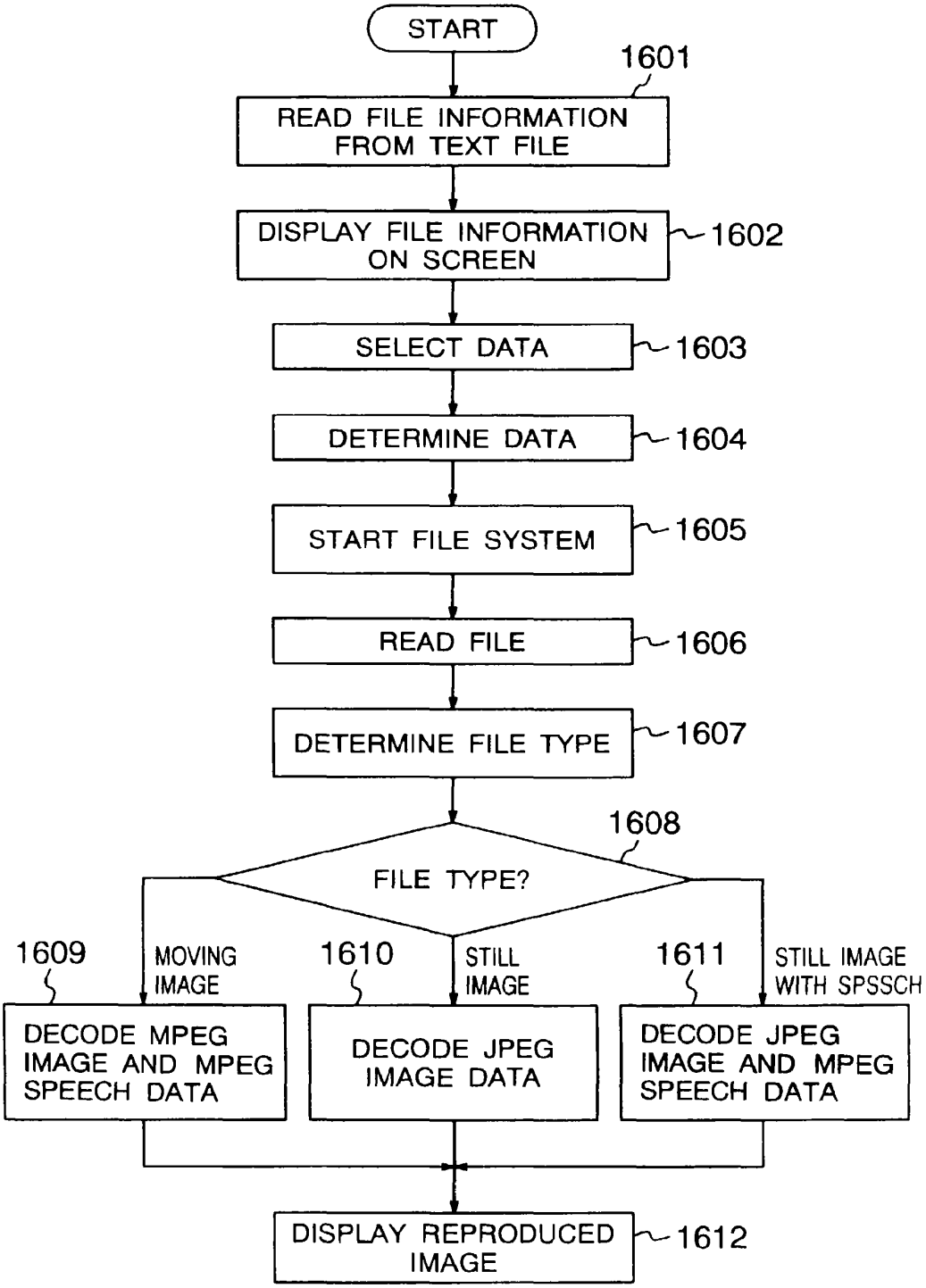

START
1601
READ FILE INFORMATION FROM TEXT FILE
DISPLAY FILE INFORMATION ON SCREEN
1602
SELECT DATA
1603
DETERMINE DATA
1604
START FILE SYSTEM
1605
READ FILE
1606
DETERMINE FILE TYPE
1607
1608
FILE TYPE?
1609
MOVING IMAGE
1610
STILL IMAGE
1611
STILL IMAGE WITH SPSSCH
DECODE MPEG IMAGE AND MPEG SPEECH DATA
DECODE JPEG IMAGE DATA
DECODE JPEG IMAGE AND MPEG SPEECH DATA
DISPLAY REPRODUCED IMAGE
1612

FIG. 17

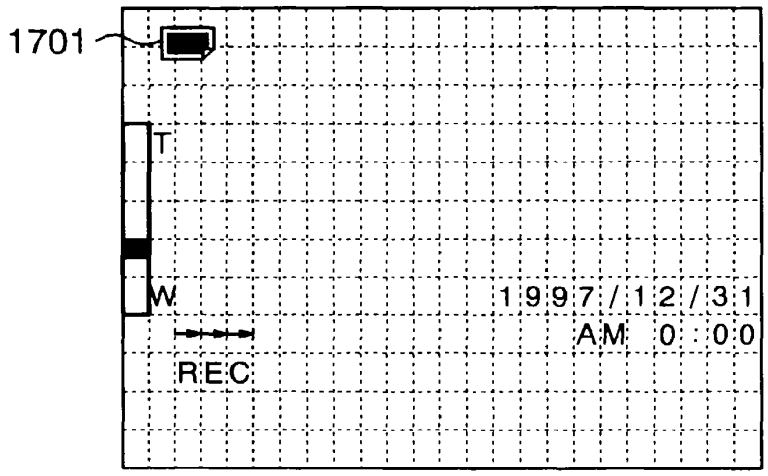


FIG. 18

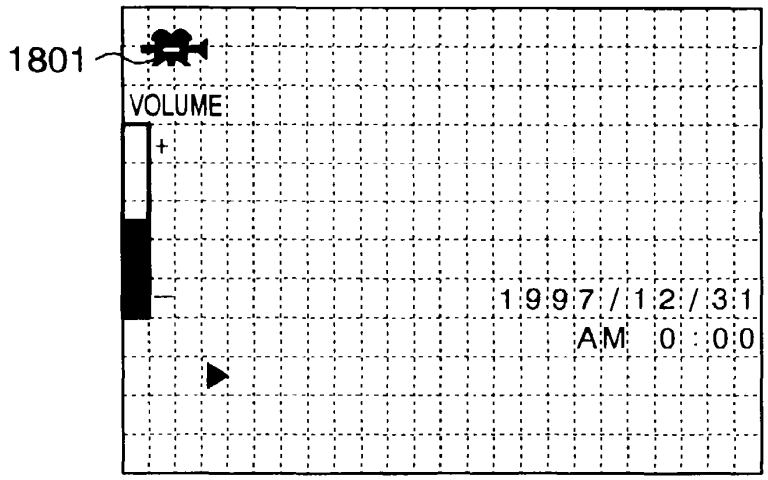


FIG. 19

RECORDING MODE	MODE SYMBOL
MOVING IMAGE	
STILL IMAGE	
SERIAL STILL IMAGE	
STILL IMAGE WITH SPEECH	

Atty. Docket No. ASA-9606-08

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No.	: 15/386,656	Confirmation No.	: 3687
Applicant	: Maxell, Ltd.	TC/GAU	: 2698
Filed	: December 21, 2016	Examiner	: NGUYEN, L.T.
Title	: ELECTRIC CAMERA		

Customer No.: 24956

NOTICE OF RELATED PATENTS INVOLVED IN LITIGATION

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

September 3, 2019

Sir:

Applicant notifies the Office that one related patent, U.S. Patent No. 8,339,493 which matured from application 10/660,710, and from which the above-identified application claims priority under 35 U.S.C. 120, is involved in the following litigation:

Maxell, Ltd. v. Apple Inc., Civil Action No. 5:19-cv-00036-RWS (E.D. TX), filed March 15, 2019.

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly, Reg. No. 30,293
(703) 684-1120

Electronic Acknowledgement Receipt

EFS ID:	37016145
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-08
Receipt Date:	03-SEP-2019
Filing Date:	21-DEC-2016
Time Stamp:	14:12:00
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	NPL15-ADfromNJ.pdf	289529 c9f30a7f96701a20f00a1549875b6f2ac7f99c4b	no	1

Warnings:

Information:					
2	Non Patent Literature	NPL16-MPEGCAMMP-EG1AInstructionManual.pdf	17899261 6131ac2f0b6dc4baa107aadfb594a265f4be8e2b	no	101
Warnings:					
Information:					
3	Non Patent Literature	NPL17-TheDigitalChameleon-July1997PCMagazine.pdf	2833405 c642dd073e321ace96e4b740a836944a305fc3c2	no	1
Warnings:					
Information:					
4	Non Patent Literature	NPL18-SONYMVC-FD88-FD83MANUAL-000197-000328.pdf	1564100 8416ae059af3ac5f22a0da82c99527cf1682f975	no	132
Warnings:					
Information:					
		Total Files Size (in bytes):	22586295		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

24956 7590 09/18/2019

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER
NGUYEN, LUONG TRUNG

ART UNIT	PAPER NUMBER
2698	

DATE MAILED: 09/18/2019

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08	3687

TITLE OF INVENTION: ELECTRIC CAMERA

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	12/18/2019

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

24956 7590 09/18/2019
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08	3687

TITLE OF INVENTION: ELECTRIC CAMERA

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	12/18/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, LUONG TRUNG	2698	348-311000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required) ❑Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08	3687

24956 7590 09/18/2019

MATTINGLY & MALUR, PC
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SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
NGUYEN, LUONG TRUNG	
ART UNIT	**PAPER NUMBER**
2698	

DATE MAILED: 09/18/2019

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 15/386,656	Applicant(s) NAKANO et al.	
	Examiner LUONG T NGUYEN	Art Unit 2698	AIA (FITF) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to RCE and Amendment filed on 08/07/2019.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1,4-8 and 10-19 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information , please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☑ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☑ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☑ Certified copies of the priority documents have been received in Application No. 14/661,227 .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 09/03/2019.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2698

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application is being examined under the pre-AIA first to invent provisions.

Continued Examination Under 37 CFR 1.114

2. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 08/07/2019 has been entered.

Information Disclosure Statement

3. The information disclosure statement (IDS) submitted on 09/03/2019 is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner.

Allowable Subject Matter

4. Claims 1, 4-8, 10-19 are allowed.

The following is an examiner's statement of reasons for allowance:

Regarding claim 1, the prior art of the record fails to show or fairly suggest an electric camera comprising:

a third state having a third interval of the plurality of vertical pixels in which third image signals are generated using third signals based on third signal charges accumulated in a third area of the light receiving surface with a third magnification factor,

wherein, while a state is between the first state and the second state when the zoom operation unit is operated to continuously change the magnification factor, the electric camera is configured to change areas of the light receiving surface to be used in accordance with changing the magnification factor between the first magnification factor and the second magnification factor and keep the first interval constant, and

wherein, while a state is between the second state and the third state when the zoom operation unit is operated to continuously change the magnification factor, the electric camera is configured to change areas of the light receiving surface to be used in accordance with changing the magnification factor between the second magnification factor and the third magnification factor and keep the second interval constant, in combination with other claim elements.

Claims 4-6 are allowed as being dependent from claim 1.

Claim 7 is allowed for the same reasons given in claim 1.

Claims 14-16 are allowed as being dependent from claim 7.

Claim 8 is a method claim of apparatus claim 1, therefore, claim 8 is allowed for the same reasons given in claim 1.

Claims 10-12 are allowed as being dependent from claim 8.

Claim 13 is a method claim of apparatus claim 7, therefore, claim 13 is allowed for the same reasons given in claim 7.

Claims 17-19 are allowed as being dependent from claim 13.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled “Comments on Statement of Reasons for Allowance.”

Conclusion

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to LUONG TRUNG NGUYEN whose telephone number is (571)272-7315. The examiner can normally be reached on 7:30AM-5:00PM, MONDAY - THURSDAY.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, TWYLER HASKINS can be reached on (571) 272-7406. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2698
09/10/2019

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	Art Unit
	LUONG T NGUYEN	2698

CPC - Searched*		
Symbol	**Date**	**Examiner**
H04N5/372; H04N5/23248; H04N5/3741; H04N5/23258; H04N9/045; H04N5/3454; H04N5/23274	2/1/2017	LTN
H04N5/372, H04N5/23248, H04N5/3741, H04N5/23258, H04N9/045	11/9/2017	LTN
H04N5/372, H04N5/23248, H04N5/3741, H04N5/23258, H04N9/045	08/18/2018	LTN
H04N5/372, H04N5/23248, H04N5/23258, H04N5/23274, H04N5/3741, H04N2209/045, H04N9/045	05/06/2019	LTN
H04N5/372, H04N5/23248, H04N5/23258, H04N5/23274, H04N5/3741, H04N2209/045, H04N9/045	09/10/2019	LTN

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

/L.T.N/ Primary Examiner, Art Unit 2698	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	Art Unit
	LUONG T NGUYEN	2698

Search Notes		
Search Notes	**Date**	**Examiner**
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	2/1/2017	LTN
Inventorship search	2/1/2017	LTN
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	11/9/2017	LTN
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	08/18/2018	LTN
IPR2018-00236 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,339,493	08/18/2018	LTN
IPR2018-00238 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,736,729	08/18/2018	LTN
IPR2018-00904 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,339,493	08/18/2018	LTN
IPR2018-00908 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,100,604	08/18/2018	LTN
IPR2018-00909 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,100,604	08/18/2018	LTN
IPR2018-00910 Reviewed Petition for Inter Partes Review of U.S. Patent No. 8,059,177	08/18/2018	LTN
IPR2019-00068 Reviewed Petition for Inter Partes Review of U.S. Patent No. 7,403,226	05/06/2019	LTN
IPR2019-00069 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,544,517	05/06/2019	LTN
IPR2019-00087 Reviewed Petition for Inter Partes Review of U.S. Patent No. 6,765,616	05/06/2019	LTN
IPR2019-00097 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,100,604	05/06/2019	LTN
IPR2019-00656 Reviewed Petition for Inter Partes Review of U.S. Patent No. 9,544,517	05/06/2019	LTN
EAST (USPAT; USPGPUB; JPO; EPO; DERWENT; IBM_TDB; USOCR; FPRS), see search history	09/10/2019	LTN
Inventorship search	09/10/2019	LTN

/L.T.N/ Primary Examiner, Art Unit 2698	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	Art Unit
	LUONG T NGUYEN	2698

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**
	USPAT; USPGPUB; text search, see interference search history	09/10/2019	LTN

/L.T.N/ Primary Examiner, Art Unit 2698	

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	**Art Unit**
	LUONG T NGUYEN	2698

CPC						
Symbol					**Type**	**Version**
H04N	/	5	/	372	F	2013-01-01
H04N	/	5	/	23248	I	2013-01-01
H04N	/	5	/	23258	I	2013-01-01
H04N	/	5	/	23274	I	2013-01-01
H04N	/	9	/	045	I	2013-01-01
H04N	/	5	/	3741	I	2013-01-01
H04N	/	2209	/	045	A	2013-01-01

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	16	
/LUONG T NGUYEN/ Primary Examiner, Art Unit 2698	10 September 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	7

U.S. Patent and Trademark Office — Part of Paper No.: 20190910

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	**Art Unit**
	LUONG T NGUYEN	2698

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H04N5/372	/	5	/	372
H04N5/232	/	5	/	232
H04N9/04	/	9	/	04

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE (Assistant Examiner) (Date)	**Total Claims Allowed:** 16	
/LUONG T NGUYEN/ Primary Examiner, Art Unit 2698 (Primary Examiner) 10 September 2019 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 7

U.S. Patent and Trademark Office Part of Paper No.: 20190910

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	**Art Unit**
	LUONG T NGUYEN	2698

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	7	10	16	19										
	2	8	11												
	3	9	12												
2	4	10	13												
3	5	11	14												
4	6	12	15												
5	7	13	16												
6	8	14	17												
	9	15	18												

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 16	
/LUONG T NGUYEN/ Primary Examiner, Art Unit 2698 (Primary Examiner)	10 September 2019 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 7

U.S. Patent and Trademark Office Part of Paper No.: 20190910

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/386,656	NAKANO et al.
	Examiner	**Art Unit**
	LUONG T NGUYEN	2698

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	02/01/2017	11/09/2017	08/21/2018	05/10/2019	09/10/2019				
1	1	✓	✓	✓	✓	=				
	2		✓	-	-	-				
	3		✓	O	-	-				
2	4		✓	O	✓	=				
3	5		✓	O	✓	=				
4	6		✓	O	✓	=				
5	7			✓	✓	=				
6	8			✓	✓	=				
	9			O	-	-				
7	10			O	✓	=				
8	11			O	✓	=				
9	12			O	✓	=				
10	13			✓	✓	=				
11	14				✓	=				
12	15				✓	=				
13	16				✓	=				
14	17				✓	=				
15	18				✓	=				
16	19				✓	=				

Bibliographic Data

Application No: 15/386,656

Foreign Priority claimed: (•) Yes ( ) No

35 USC 119 (a-d) conditions met: [✓] Yes [ ] No [ ] Met After Allowance

Verified and Acknowledged: /LUONG T NGUYEN/ Examiner's Signature | Initials

Title: ELECTRIC CAMERA

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
12/21/2016	348	2698	ASA-9606-08
RULE			

APPLICANTS

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INVENTORS

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Ryuji NISHIMURA Tokyo, JAPAN

Toshiro KINUGASA Tokyo, JAPAN

CONTINUING DATA

This application is a CON of 14661227 03/18/2015 PAT 9544517

14661227 is a CON of 14264243 04/29/2014 PAT 9100604

14264243 is a CON of 13681495 11/20/2012 PAT 8736729

13681495 is a CON of 12845266 07/28/2010 PAT 8339493

12845266 is a CON of 10660710 09/12/2003 PAT 8059177

10660710 is a DIV of 09520836 03/08/2000 PAT 6765616

FOREIGN APPLICATIONS

JAPAN 2000-006064 01/11/2000

IF REQUIRED, FOREIGN LICENSE GRANTED**

02/13/2017

STATE OR COUNTRY

JAPAN

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UNITED STATES

FILING FEE RECEIVED

$1,600

Receipt date: 09/03/2019

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	15386656
Filing Date	2016-12-21
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-08

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6335760	B1	2002-01-01	SATO	
	2	6018363	A	2000-01-25	HORII	
	3	7903162	B2	2011-03-08	JUEN	
	4	4740828	A	1988-04-26	KINOSHITA	
	5	6563535	B1	2003-05-13	ANDERSON	
	6	6529236	B1	2003-03-04	WATANABE	
	7	6661451	B1	2003-12-09	KIJIMA et al.	
	8	5502483	A	1996-03-26	TAKASE et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

Receipt date: 09/03/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

	9	4612575	A	1986-09-16	ISHMAN et al.	
	10	5444482	A	1995-08-22	MISAWA et al.	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	0 802 688	EP	A1	1997-10-22	HITACHI, LTD.		

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Apple Inc.'s Invalidity Contentions which were filed in the following litigation: MAXELL, LTD. v. APPLE INC., Civil Action No. 5:19-cv-00036-RWS (E.D. TX), filed August 14, 2019	
	2	The Sony Digital Video Recorder (DCR-TRV900) User Manual ("DCR-TRV900 Manual"), published by Sony Corporation in 1998	

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

Receipt date: 09/03/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

	3	Sony Consumer Electronics Guide: DCR-TRV900 - More Specifications, webpage published by Sony Corporation, April 24, 1999, URL: https://web.archive.org/web/19990424085854/http://www.sel.sony.com/SEL/consumer/ss5/office/camcorder/digitalvideoproducts/dcr-trv900_specs.shtml	
	4	Sony Consumer Electronics Guide: DCR-TRV900 - More Specifications, webpage published by Sony Corporation, January 28, 1999, URL: https://web.archive.org/web/19990128112515/http://www.sel.sony.com:80/SEL/consumer/ss5/office/camcorder/digitalvideoproducts/dcr-trv900.shtml	
	5	Getting Started With the QuickTake 200 Camera, "QuickTake 200 User's Manual", published by Apple Inc. in 1997	
	6	~~Using the QuickTake 200 AC Adapter, published by Apple Inc. in 1997~~ No copy submitted.	
	7	Published advertisement from The Indianapolis News (Indianapolis, Indiana) dated September 4, 1998	
	8	Published advertisement from The Indianapolis News (Indianapolis, Indiana) dated September 12, 1998	
	9	J. Ozer, "Digital Video Cameras," PC Magazine, Vol. 18, No. 7, April 6, 1999	
	10	Published advertisement from Popular Photography magazine dated October 1999	
	11	Published advertisement from The Daily Sentinel (Grand Junction, Colorado) newspaper dated Sunday, June 13, 1999	
	12	Digital Camcorder JVC GR-DVL9600 GR-DVL9500 User's Manual, "JVCVRDVL9500 Manual", published by the Victor Company of Japan, Ltd. in 1999	
	13	Excerpts from the JVC America Website, URL: ~~https://web.archive.org/web/19990117003015/~~http://jvc-america.com:80/digital_camcorders/digital_camcorders.html No date shown on submitted copy.	

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

Receipt date: 09/03/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

	14	Published review from the Iowa City Press (Iowa City, Iowa) newspaper dated January 12, 1999	
	15	Published advertisement from The Courier-News (Bridgewater, New Jersey) newspaper dated February 17, 1999	
	16	Hitachi, "MPEGCAM MP-EG1A Instruction Manual", 1997, E1-E98, JAPAN	
	17	"First Looks: The Digital Chameleon at 72", MP-EG1 PC Mag, PC Magazine, July 1997	
	18	SONY MVC-FD88/FD83 Manual , 1999.	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/LUONG T NGUYEN/	Date Considered	09/10/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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	Attorney Docket Number	ASA-9606-08

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

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OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-09-03
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S204	1	15/386656	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 11:23
S205	298	((("NAKANO") near3 ("Takahiro"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/09/10 11:31
S206	46	((("NISHIMURA") near3 ("Ryuji"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/09/10 11:33
S207	43	((("KINUGASA") near3 ("Toshiro"))).INV.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/09/10 11:34
S208	228	(pixel$1 same interval) same zoom$3 same (area or portion)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 12:46
S209	26	S208 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 12:46
S210	660	(thin$4) same ((electronic near zoom$3) or (optical near zoom$3))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 13:15
S211	47	S210 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 13:16
S212	50897	(H04N5/372 or H04N5/23248 or H04N5/23258 or H04N5/3741 or H04N5/23274 or H04N9/045 or H04N2209/045).CPC.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	2019/09/10 13:35

			IBM_TDB			
S213	15022	(scan$4 with line) and (NTSC or standard) and (television or TV) and (mix$3 or combin$3 or cull$3 or add$3) and (pixel$1 or charge$1 or signal$1) and (sensor$1 or CCD$1 or CMOS)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 13:35
S214	620	S212 and S213	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 13:35
S215	342	S214 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 13:35
S216	1536	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (sensor$1 or CCD$1 or CMOS) same zoom$	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:00
S217	151	S212 and S216	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:00
S218	19	S217 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:00
S219	897	zoom$3 and (magnification near factor) same (chang$3 or varying)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:02
S220	56	S212 and S219	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:02
S221	353	((magnification near factor) or zoom$3) same (vertical near pixel$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2019/09/10 14:04

			JPO; DERWENT; IBM_TDB			
S222	66	S221 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:04
S223	3383	(magnification near factor) same (area or region)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:11
S224	32	S212 and S223	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:11
S225	40	(magnification near factor) same (vertical near pixel$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:13
S226	22	("4054915" | "5170249" | "5187569" | "5287192" | "5402173" | "5438365" | "5638132" | "5734424" | "5828406" | "5847758" | "6195125" | "6519000" | "6661451" | "6765616" | "6781634" | "6798448" | "6906746" | "6970191" | "7154539" | "7352391" | "7403226" | "8059177").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/09/10 14:14
S227	10	("4558368" | "4670777" | "4712135" | "4763204" | "4775885" | "4805037" | "4831453" | "4833527" | "4839734" | "4878121").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/09/10 14:16
S228	271	zoom$3 same (chang$3 or varying) same pixel$1 same interval	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:21
S229	25	S228 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:21
S230	8	("3011164" | "3499760" | "4257044" | "4366475" | "4532605" | "Re31200").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/09/10 14:27

S231	234	S219 and S223	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:28
S232	81	S231 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:28
S233	30	S219 and S221	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:30
S234	79	(vertical near pixel$1) same (magnification near (factor or ratio))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:32
S235	15	(vertical near pixel$1) same magnification same interval	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:34
S236	6	("20070296837" | "20080043096" | "20150207999" | "5936628" | "7679657" | "8044994").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/09/10 14:34
S237	3	(magnification or zoom$4) same (area or region) same (vertical near pixel$1) same interval	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:37
S238	22	("4054915" | "5170249" | "5187569" | "5287192" | "5402173" | "5438365" | "5638132" | "5734424" | "5828406" | "5847758" | "6195125" | "6519000" | "6661451" | "6765616" | "6781634" | "6798448" | "6906746" | "6970191" | "7154539" | "7352391" | "7403226" | "8059177").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2019/09/10 14:37
S239	3790	(magnification or zoom$4) same (area or region) same interval	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:38
S240	55	S212 and S239	US-PGPUB;	OR	ON	2019/09/10

			USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			14:39
S241	129	S239 and S213	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:39
S242	17	S241 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:40
S243	68	S239 and S216	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:41
S244	3	S208 and S210	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:42
S245	36	S216 and S221	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:43
S246	80625	magnification same (chang$3 or varying)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:45
S248	87	magnification same (chang$3 or varying) same (vertical near pixel$1)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:46
S249	1093	S246 and S239	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	2019/09/10 14:50

			IBM_TDB			
S251	0	S249 and S216	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:50
S252	14	S249 and S213	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:51
S253	173	(mix$3 or combin$3 or cull$3 or add$3) same (pixel$1 or charge$1 or signal$1) same (sensor$1 or CCD$1 or CMOS) same zoom$ same vertical	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:52
S254	40	S253 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:53
S255	367	((magnification near factor) same (area or region)) and zoom$3 and (vertical)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:57
S256	112	S255 and (@ad<="20000111" or @rlad<="20000111")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/10 14:57

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S257	4	(magnification same (chang$3 or varying) same (vertical near pixel$1)).clm.	US-PGPUB; USPAT	OR	ON	2019/09/10 14:59
S258	13	(magnification same (chang$3 or varying) same interval same pixel$1).clm.	US-PGPUB; USPAT	OR	ON	2019/09/10 15:00
S259	4	((magnification near factor) and (pixel$1 same interval) and zoom$3).clm.	US-PGPUB; USPAT	OR	ON	2019/09/10 15:04
S260	1	(zoom$3 and ((magnification near factor) same (chang$3 or varying)) and (interval with (vertical near pixel$1))).clm.	US-PGPUB; USPAT	OR	ON	2019/09/10 15:05

S261	1	(zoom$3 and ((magnification near factor) same (chang$3 or varying)) and ((vertical near pixel$1))).clm.	US-PGPUB; USPAT	OR	ON	2019/09/10 15:07

9/ 10/ 2019 3:09:07 PM
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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
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Attorney Docket Number	ASA-9606-08

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

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	1	Using the QuickTake 200 AC Adapter, published by Apple Inc. in 1997	
	2	Excerpts from the JVC America Website, 1999, URL: https://web.archive.orgweb/19990117003015/http://jvc-america.com:80/digital_camcorders/digital_camcorders.html	

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-09-18
Name/Print	John R. Mattingly	Registration Number	30,293

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	37016128
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-08
Receipt Date:	03-SEP-2019
Filing Date:	21-DEC-2016
Time Stamp:	14:10:47
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	EP0802688.pdf	1283490 756cb7c14bb3f95e03f170870dfde00babc5eb20	no	25

Warnings:

Information:					
2	Non Patent Literature	NPL1-E5037-08EU_InvalidityContentions.pdf	867009 18e36f438b6d491c6367dd9934777175cd37d116	no	135
Warnings:					
Information:					
3	Non Patent Literature	NPL2-DigitalVideoRecorder-1998-A.pdf	16183592 e8cdc809187bafaad2e54fa9bcd38edd5e720591	no	40
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
4	Non Patent Literature	NPL2-DigitalVideoRecorder-1998-B.pdf	15704547 abd1443c6c4fc69ca138e208308c69839d6bfd0d	no	41
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
5	Non Patent Literature	NPL2-DigitalVideoRecorder-1998-C.pdf	12003303 31d3406f8d92359633b44b538719a5bae4feb095	no	30
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
6	Non Patent Literature	NPL2-DigitalVideoRecorder-1998-D.pdf	14226016 de0c04597789fda2c09c1bc3bef33ae0a94377b9	no	37
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
7	Non Patent Literature	NPL3-SonyConsumerElectronicsGuide-1999.pdf	280050 b51553c9b2857817f50fc867467dd182f7b4c0d3	no	4
Warnings:					
Information:					

8	Non Patent Literature	NPL4-SonyConsumerElectronicsGuide-1999.pdf	204803 d9b89abd1e7e78be43396d2c8baca0d7618a5269	no	2
Warnings:					
Information:					
9	Non Patent Literature	NPL5-QuickTake200UsersManual.pdf	1149829 71272070a7b08c79dcba1ae759decd5450eb03dc	no	98
Warnings:					
Information:					
10	Non Patent Literature	NPL6-AppleQuickTake.pdf	89174 4ff5cd27eb45e15c66b79f6ac349fc97f98d5201	no	1
Warnings:					
Information:					
11	Non Patent Literature	NPL7-ADfromIN.pdf	407117 6e76c5490e7ef7615d4bd731533bd0afda066389	no	1
Warnings:					
Information:					
12	Non Patent Literature	NPL8-AdfromIN.pdf	238370 53fc1ad5324331a4ece526d8deeb57a73d2eb54f	no	1
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Information:					
13	Non Patent Literature	NPL9-DigitalVideoCameras.pdf	9989167 5ebf7c04ecdd6657fa2e4f71e36277583746b0c7	no	9
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Information:					
14	Non Patent Literature	NPL10-PopularPhotographyAd.pdf	1190584 ba8d10dab4c5802d8bbee4f13016edc8339c7586	no	2
Warnings:					
Information:					

15	Non Patent Literature	NPL11-AdfromCO.pdf	455770 4464b95fba1fa8fc48b531ccfbe4bd2485beeef4	no	1
Warnings:					
Information:					
16	Non Patent Literature	NPL12-JVCVRDVL9500Manual.pdf	2669207 92857076f2ebb31569e705c11975cd1f1ac8a66d	no	80
Warnings:					
Information:					
17	Non Patent Literature	NPL13-JVCSite.pdf	287402 676516b2bb12d358faaee6a3e1a53383df8fcf1d	no	8
Warnings:					
Information:					
18	Non Patent Literature	NPL14-AdfromIA.pdf	287636 885cb6252e25a1d709688fdd9d5b9d1e02c7a8e7	no	1
Warnings:					
Information:					
19	Transmittal Letter	9606-08-NoticeOfPatentinLitigation-2.pdf	15975 f787375c23e67813403fa2934dc51a5595ac5271	no	1
Warnings:					
Information:					
20	Information Disclosure Statement (IDS) Form (SB08)	9606-08-SB08A-Litigation-2.pdf	1035932 2ee7cbb2feb44ebf3d2d016e33a38a3ad41c2ef9	no	6
Warnings:					
Information:					
		Total Files Size (in bytes):	78568973		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	Takahiro NAKANO et al.
		Confirmation No.: 3687
Serial No.	:	15/386,656
Filed	:	December 21, 2016
For	:	ELECTRIC CAMERA
Group	:	2698
Examiner	:	NGUYEN, L. T.
Docket No.	:	ASA-9606-08
Customer No.:		24956

REQUEST FOR RECONSIDERATION OF INFORMATION DISCLOSURE STATEMENT

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

September 18, 2019

Sir:

Applicant respectfully requests reconsideration of the Information Disclosure Statement filed September 3, 2019 in the above application. The Examiner has crossed through references submitted with the Information Disclosure Statement, as an indication that these references have not been fully considered. The crossed through documents have been re-listed on a PTO/SB/08a form submitted herewith to assist the Examiner in providing his initials for the documents to be reconsidered for the following reasons.

A "Copy of Acknowledgement Receipt" document forms an Appendix to this Request in order to efficiently refer to the electronic filing acknowledgement of the document submitted on September 3, 2019 by document number and page number, referring to the "Copy of Acknowledgement Receipt" document.

IDS form PTO/SB/08a submitted on September 3, 2019 (6 pages)

The following references have been crossed through, and the reason Applicant asserts that the references should be initialed as an indication of consideration of the references is set forth as follows.

(i) Using the QuickTake 200 AC Adapter, published by Apple Inc. in 1997

A copy of the document was submitted on September 3, 2019. See document number 10 on page 3 of the "Copy of Acknowledgement Receipt".

(ii) Excerpts from the JVC America Website, URL: https://web.archive.orgweb/19990117003015/http://jvcamerica.com:80/digital_camcorders/digital_camcorders.html

Applicant notes that an archive date code is embedded in the archived URL printed at the bottom of the pages of the article, beginning on page 2 of the document. The date code is in the list of numbers in the middle of the URL and translates as "yyyymmddhhmmss". (*See* Internet Archive Help Center, Using the Wayback Machine). Therefore, the archive date code for the document indicates January 17, 1999.

To assist the Examiner in reconsideration of the document (i), above, another copy is submitted with this Request for Reconsideration.

Conclusion

In view of the foregoing, Applicant respectfully asserts that the documents re-listed on the PTO/SB/08a form submitted herewith were previously submitted on September 3, 2019, and therefore the documents should be considered in accordance with this Request for Reconsideration. Accordingly, Applicant requests that the Examiner initial the documents on the PTO/SB/08a form submitted herewith as an indication that the Examiner has fully considered these references.

The Commissioner is authorized to charge any shortage in the fees due, or credit any overpayment, to Deposit Account No. 50-1417 (referencing Attorney Docket No. ASA-9606-08).

Respectfully submitted,

MATTINGLY & MALUR, PC

/John R. Mattingly/
John R. Mattingly
Registration No. 30,293
703-684-1120

Electronic Acknowledgement Receipt

EFS ID:	37198148
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Emily Scotti
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-08
Receipt Date:	18-SEP-2019
Filing Date:	21-DEC-2016
Time Stamp:	12:24:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	9606-08-SB08A-Litigation-Resubmission.pdf	1034380 f2ef8a0958354e3cc9df16634741d6fe014d0fd0	no	4

Warnings:

Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
2	Non Patent Literature	NPL6-AppleQuickTake.pdf	89174 4ff5cd27eb45e15c66b79f6ac349fc97f98d5201	no	1
Warnings:					
Information:					
3	Non Patent Literature	NPL13-JVCSite.pdf	287402 676516b2bb12d358faaee6a3e1a53383df8fcf1d	no	8
Warnings:					
Information:					
4	Transmittal Letter	9606-08-ElecAckReceipt-3.pdf	99171 d3b6c20377e4f2b3f191fdebda2146bc20321ea3	no	5
Warnings:					
The PDF file has been signed with a digital signature and the legal effect of the document will be based on the contents of the file not the digital signature.					
Information:					
5	Transmittal Letter	9606-08-Request-Reconsideration-IDS.pdf	23413 8ea28bb0399dff3077aaba3c9175e1a960daa838	no	3
Warnings:					
Information:					
		Total Files Size (in bytes):	1533540		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

24956 7590 09/18/2019
MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08	3687

TITLE OF INVENTION: ELECTRIC CAMERA

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	12/18/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, LUONG TRUNG	2698	348-311000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Mattingly & Malur, PC
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE	(B) RESIDENCE: (CITY and STATE OR COUNTRY)
Maxell, Ltd.	Kyoto, Japan

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ☒ Corporation or other private group entity ❑ Government

4a. Fees submitted: ☒ Issue Fee ❑ Publication Fee (if required) ❑ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

☒ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 50-1417

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /John R. Mattingly/ Date December 18, 2019

Typed or printed name John R. Mattingly Registration No. 30,293

Electronic Patent Application Fee Transmittal

Application Number:	15386656
Filing Date:	21-Dec-2016
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Filer:	John Roberts Mattingly/Jasmyn Martinez
Attorney Docket Number:	ASA-9606-08

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	1501	1	1000	1000

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**1000**

Electronic Acknowledgement Receipt	
EFS ID:	38064907
Application Number:	15386656
International Application Number:	
Confirmation Number:	3687
Title of Invention:	ELECTRIC CAMERA
First Named Inventor/Applicant Name:	Takahiro NAKANO
Customer Number:	24956
Filer:	John Roberts Mattingly/Jasmyn Martinez
Filer Authorized By:	John Roberts Mattingly
Attorney Docket Number:	ASA-9606-08
Receipt Date:	18-DEC-2019
Filing Date:	21-DEC-2016
Time Stamp:	13:09:43
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1000
RAM confirmation Number	E2019BHD11159282
Deposit Account	501417
Authorized User	Jasmyn Martinez
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	9606-08-Issue_Fee_Transmittal.pdf	102140 499880c0c7f5c54e2cd5fd638bf7408c1d076d11	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30233 bbff8985a32f4a66e1e463b85111cd05fe2e8241	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	132373		

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<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
<u>National Stage of an International Application under 35 U.S.C. 371</u>
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<u>New International Application Filed with the USPTO as a Receiving Office</u>
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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	12/21/2016	Takahiro NAKANO	ASA-9606-08	3687

24956 7590 12/20/2019

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD
SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
NGUYEN, LUONG TRUNG	

ART UNIT	PAPER NUMBER
2698	

NOTIFICATION DATE	DELIVERY MODE
12/20/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ptomail@mmiplaw.com

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR/ PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
15/386,656	12/21/2016	NAKANO et al.	ASA-9606-08

MATTINGLY & MALUR, PC
1800 DIAGONAL ROAD SUITE 210
ALEXANDRIA, VA 22314

EXAMINER	
LUONG T NGUYEN	
ART UNIT	PAPER
2698	20191217

DATE MAILED: _____

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner for Patents

The Information Disclosure Statement (IDS) filed on 09/18/2019 has been considered.

However, the Non-patent Literature document No.1 "Using the Quick Take 200AC Adapter" has been lined through since there is no copy submitted. The copy submitted has a different title "Update to QuickTake 200 User's Manual."
Also, the citation refers to an AC Adapter, but the content of the submitted copy refers to attaching the NTSC video plug which is not the same thing.

The date 1999 in the cited Non-patent Literature document No.2 has been lined through since there is no date 1999 shown on the submitted copy.

Attachment: Initialed Information Disclosure Statement PTO/SB/08a filed on 09/18/2019.

/LUONG T NGUYEN/
Primary Examiner, Art Unit 2698

PTO-90C (Rev.04-03)

Receipt date: 09/18/2019

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
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(Not for submission under 37 CFR 1.99)

Application Number	15386656
Filing Date	2016-12-21
First Named Inventor	NAKANO, T.
Art Unit	2698
Examiner Name	NGUYEN, L. T.
Attorney Docket Number	ASA-9606-08

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

/L.T.N/	1	No copy submitted. ~~Using the QuickTake 200 AC Adapter~~, published by Apple Inc. In 1997	
/L.T.N/	2	Date not shown on submitted copy. Excerpts from the JVC America Website, ~~1999~~, URL: https://web.archive.orgweb/19990117003015/http://jvc-america.com:80/digital_camcorders/digital_camcorders.html	

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

Receipt date: 09/18/2019

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15386656
	Filing Date	2016-12-21
	First Named Inventor	NAKANO, T.
	Art Unit	2698
	Examiner Name	NGUYEN, L. T.
	Attorney Docket Number	ASA-9606-08

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Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

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OR

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See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/John R. Mattingly/	Date (YYYY-MM-DD)	2019-09-18
Name/Print	John R. Mattingly	Registration Number	30,293

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2016-12-21
	First Named Inventor	T. NAKANO
	Art Unit	
	Examiner Name	NGUYEN, L.
	Attorney Docket Number	ASA-9606-08

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Change(s) applied to document, /G.R.P./ 11/21/2019	19	6734424		05-2004 ~~1998-03-31~~	Lennon et al. ~~SASAKI~~	

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.N/

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/386,656	02/04/2020	10554917	ASA-9606-08	3687

24956 7590 01/15/2020

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SUITE 210
ALEXANDRIA, VA 22314

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Maxell, Ltd., Kyoto, JAPAN;
Takahiro NAKANO, Tokyo, JAPAN;
Ryuji NISHIMURA, Tokyo, JAPAN;
Toshiro KINUGASA, Tokyo, JAPAN;

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EXHIBIT 1013

US005502483A

United States Patent [19]

Takase et al.

[11] Patent Number: 5,502,483

[45] Date of Patent: Mar. 26, 1996

[54] **VIDEO CAMERA APPARATUS**

[75] Inventors: **Satoshi Takase**, Takasaki; **Takuya Imaide**, Fujisawa; **Toshiro Kinugasa**, Hiratsuka; **Hiroyuki Komatsu**, Yokohama, all of Japan

[73] Assignee: **Hitachi, Ltd.**, Japan

[21] Appl. No.: **171,005**

[22] Filed: **Dec. 21, 1993**

[30] **Foreign Application Priority Data**

Dec. 24, 1992 [JP] Japan 4-344369

[51] **Int. Cl.**[6] **H04N 5/228**; H04N 7/01

[52] **U.S. Cl.** **348/208**; 348/413; 348/416

[58] **Field of Search** 348/208, 425, 348/319, 448, 413; 382/300, 107; H04N 5/228, 7/01

[56] **References Cited**

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Primary Examiner—Joseph Mancuso

Assistant Examiner—Andrew B. Christensen

Attorney, Agent, or Firm—Bardehle Pagenberg Geissler et al.

[57] **ABSTRACT**

The present invention relates to a video camera apparatus which can automatically correct an image vibration, such as a handling or the like electronically. A control circuit changes an interpolation coefficient α of an interpolation processing circuit in response to a detected output from a vibration detecting apparatus or an output from a motion vector calculating apparatus that detects a vibration of a video signal. Also, the control circuit controls a scanning pulse generating circuit that derives a scanning pulse for scanning the imager. The scanning pulse generating circuit changes a combination of two scanning lines that are to be interpolated by the interpolation processing circuit using the interpolation coefficient α by changing the scanning state of the imager when $0 \leqq \alpha < X$ or $(1-X) < \alpha \leqq 1$ and $X \leqq \alpha \leqq (1-X)$ if X is a limited value of the interpolation coefficient α and the limited value X is a value smaller than ½. Thus, a resolution of a reproduced picture based on the video signal thus obtained by the above interpolation processing can be prevented from being deteriorated.

7 Claims, 5 Drawing Sheets

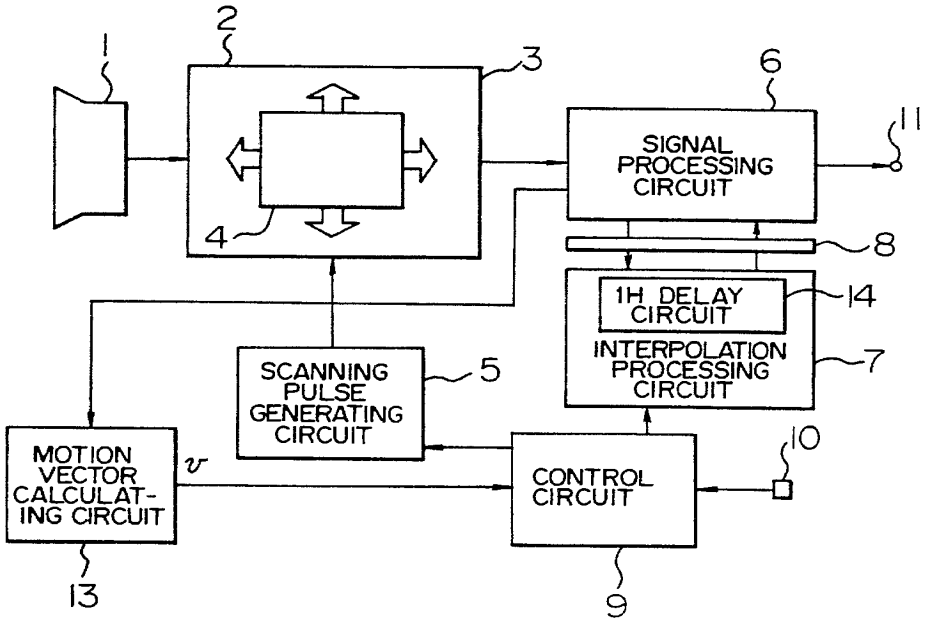


FIG. 1 PRIOR ART

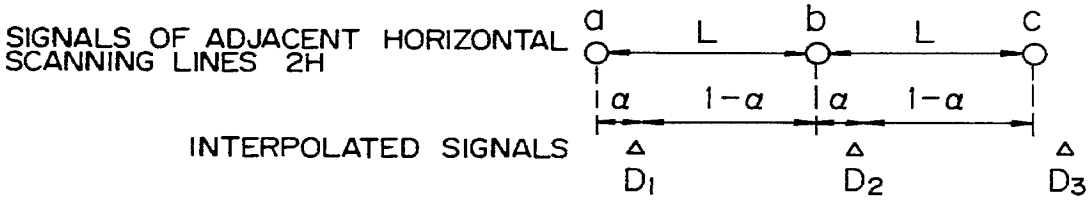


FIG. 2 PRIOR ART

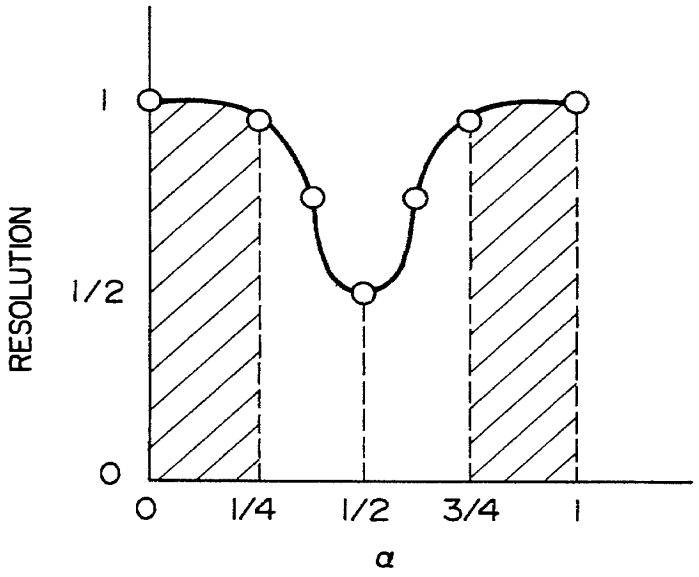


FIG. 3

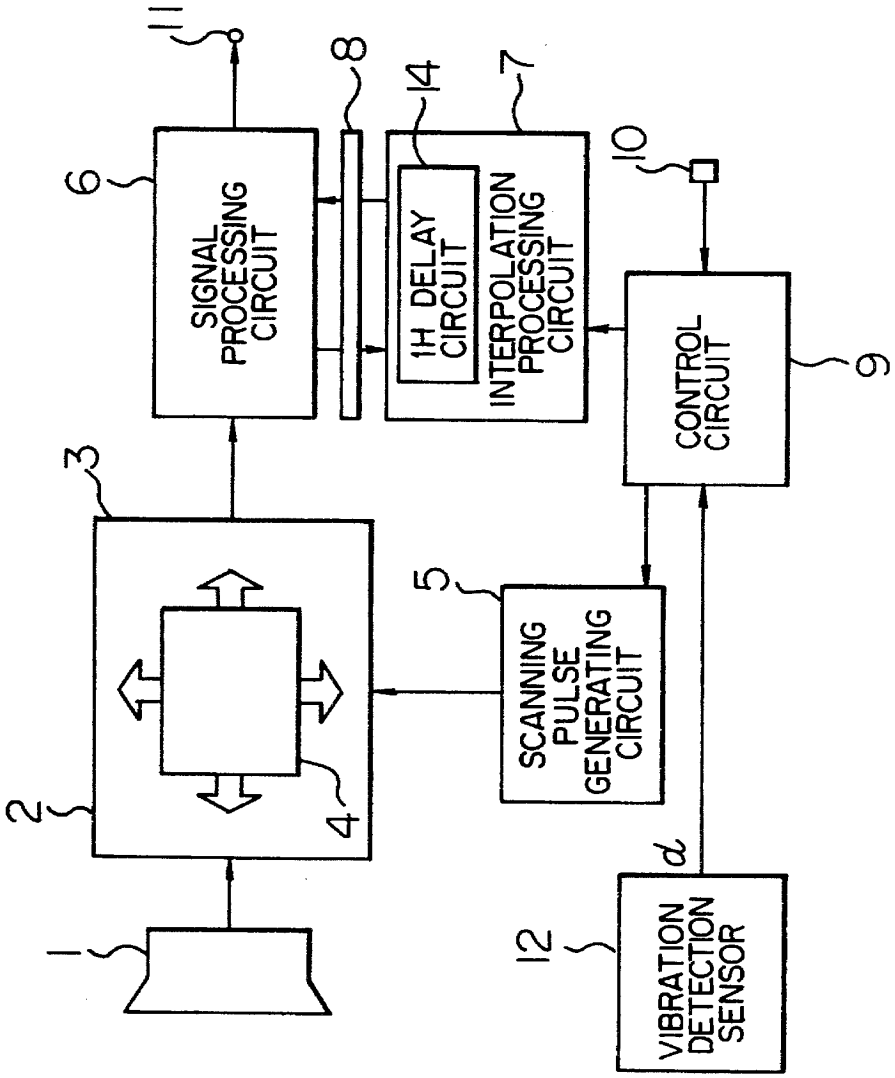

11
8
14
7
10
6
SIGNAL PROCESSING CIRCUIT
1H DELAY CIRCUIT
INTERPOLATION PROCESSING CIRCUIT
CONTROL CIRCUIT
9
3
5
SCANNING PULSE GENERATING CIRCUIT
2
4
d
12
VIBRATION DETECTION SENSOR
1

FIG. 4A

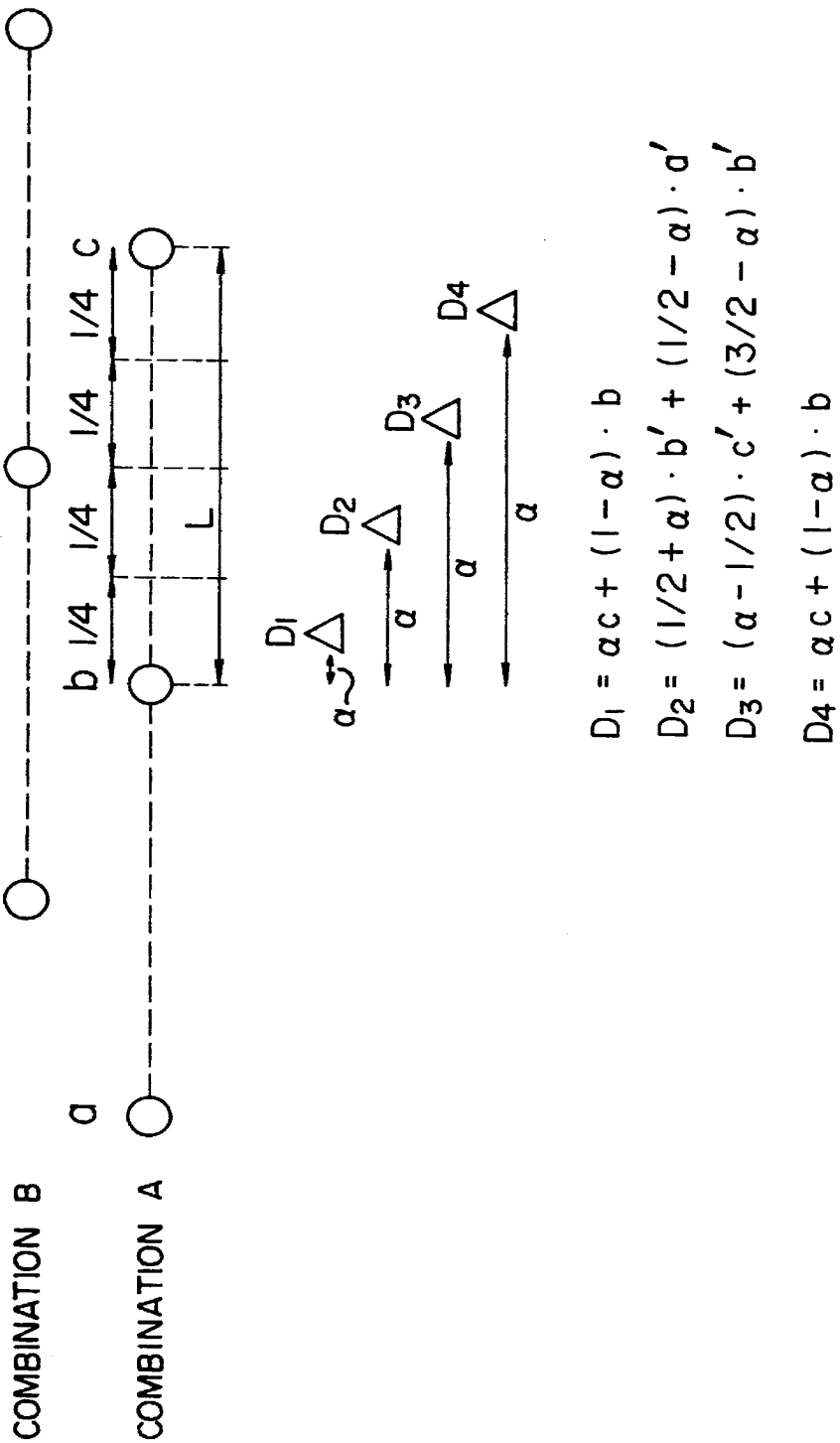
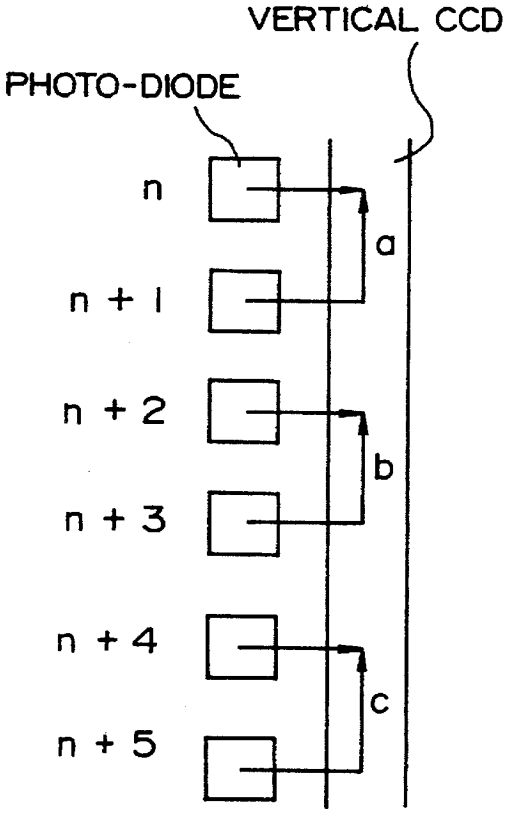
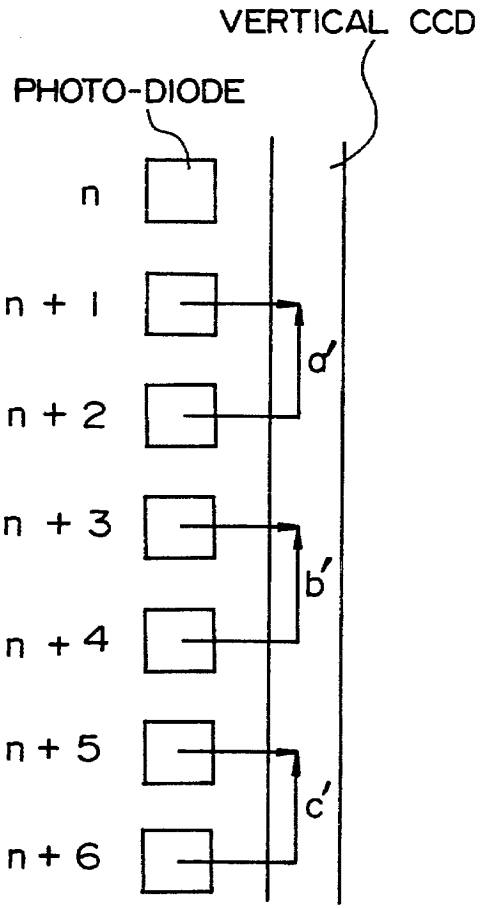

c'
b'
a'
b 1/4
1/4
1/4
1/4 c
L
a
COMBINATION B
COMBINATION A
D1
D2
D3
D4
α
α
α
α
D1 = αc + (1−α) · b
D2 = (1/2+α) · b' + (1/2−α) · a'
D3 = (α−1/2) · c' + (3/2−α) · b'
D4 = αc + (1−α) · b

FIG. 4B



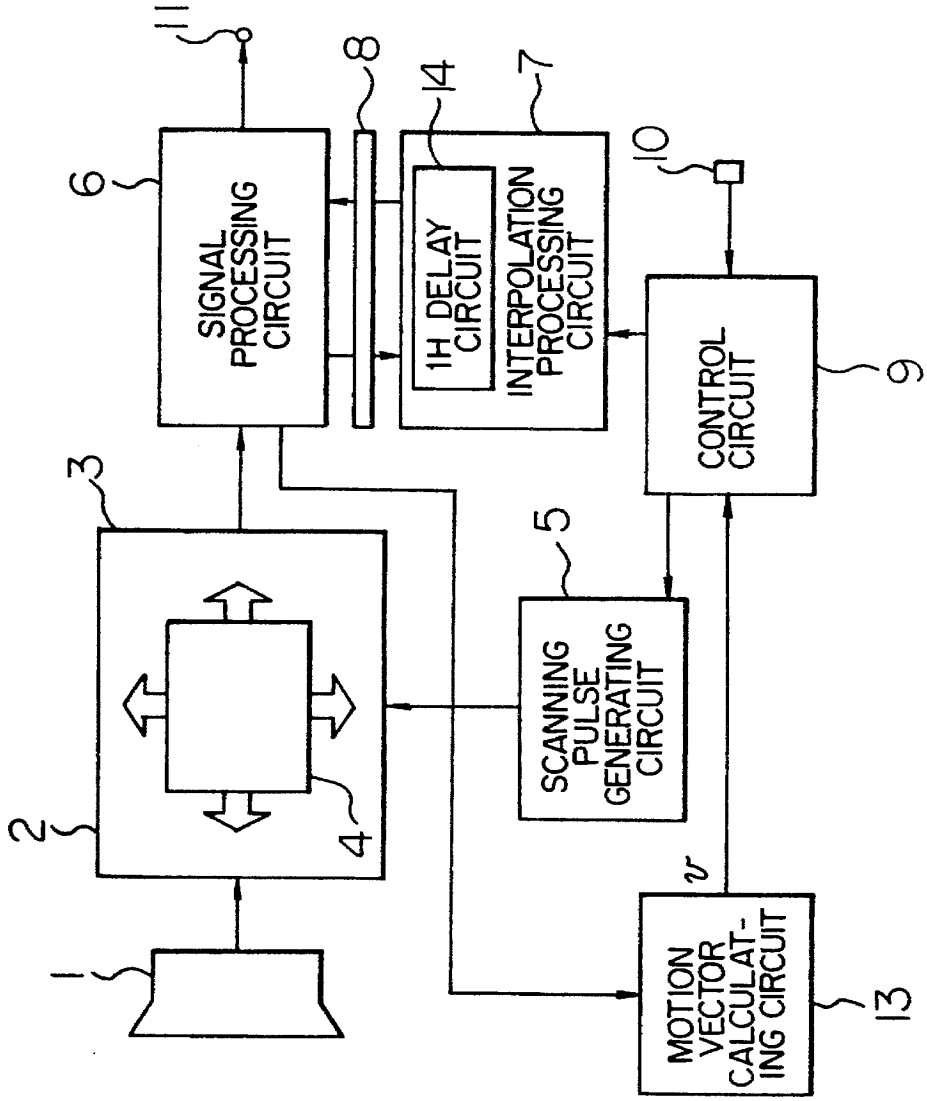
COMBINATION A

FIG. 4C



COMBINATION B

FIG. 5


11
8
14
7
6
SIGNAL PROCESSING CIRCUIT
1H DELAY CIRCUIT
INTERPOLATION PROCESSING CIRCUIT
10
CONTROL CIRCUIT
9
3
5
SCANNING PULSE GENERATING CIRCUIT
2
4
v
MOTION VECTOR CALCULAT-ING CIRCUIT
13
1

VIDEO CAMERA APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a video camera apparatus using an imager and, more particularly, is directed to a video camera apparatus having a function to electronically correct an image vibration caused by a handling or the like.

Recently, with the progress of semiconductor technologies, video camera apparatus have been more and more miniaturized and made light-weight. Concurrently therewith, a very small vibration of a reproduced picture due to a handling or the like becomes conspicuous when a picked-up video signal is reproduced.

To solve the aforesaid problems, the technology for correcting an image vibration caused by a handling or the like has been proposed, in which a video camera apparatus includes a vibration detector for detecting an image vibration caused by a handling or the like and an image vibration caused by a handling or the like can be corrected by mechanically moving an optical lens or moving a scanning area of an imager within a photo-sensitive pixel area on the basis of a detected signal from this vibration detector (see paper "VHS CAMCODER WITH ELECTRONIC IMAGE STABILIZER written by OHIMA et al. on IEEE Trans. on CE Vol. 35, No. 4 (Nov. 1989) pp. 749–757).

In the system for correcting an image vibration caused by a handling or the like by moving the scanning area of the imager within the photo-sensitive pixel area on the basis of the detected output from the above-mentioned vibration detector, signals of adjacent horizontal scanning lines (hereinafter simply referred to as adjacent 2H signals) are respectively multiplied by α times (where $0 \leqq \alpha \leqq 1$) and $1-\alpha$ times and then added by an interpolation processing circuit, whereby the scanning area is moved equivalently. A linear interpolation processing will be described with reference to FIG. **1**.

In FIG. **1** of the accompanying drawings, reference symbols a, b and c depict pixel signals of adjacent horizontal scanning lines, and reference symbol α depicts a coefficient used in the interpolation processing, i.e., interpolation coefficient. Also, reference symbols D_1, D_2, . . . , depict signals that are generated by the interpolation processing, respectively. The signals D_1, D_2 are obtained by the following equations (1) and (2) when the signals a and b and the signals b and c are taken as adjacent 2H pixel signals, respectively:

$$D_1=(1-\alpha)\cdot a+\alpha\cdot b \tag{1}$$

$$D_2=(1-\alpha)\cdot b+\alpha\cdot c \tag{2}$$

In the above equation (1), when α is 0, then D_1=a. When α=1, then D_1=b. Also, in the above equation (2), when α=0, D_2=b. When α=1, then D_2=c.

To correct horizontal and vertical image vibrations caused by the handling or the like, an amount that the scanning area of the imager is moved within the photo-sensitive pixel area in response to the detected signal from the vibration detector must be calculated. Further, to move this scanning area within the photo-sensitive pixel area by the calculated moving amount, the scanning area cannot be moved at the unit smaller than the pixel unit only by controlling the scanning pulse that drives the imager. However, by using the above-mentioned interpolation coefficient α used in the interpolation processing, the scanning area can be moved at the pitch smaller than the pixel unit within the photo-sensitive pixel area.

According to the above-mentioned interpolation processing, if the pixel signal D_1 is obtained by interpolating the pixel signals a and b, then the pixel signal D_1 can be regarded as the pixel signal located on a scanning line that is assumed to be shifted from the scanning line of the pixel signal a to the scanning line of the pixel signal b by a shift amount αL where L represents an interval between the adjacent two scanning lines. In other words, the above operation becomes equivalent to the operation that the scanning area is moved by the amount αL.

Incidentally, when the interpolation coefficient α used in the interpolation processing is changed with the movement of the scanning area, there is then the problem that a resolution of a reproduced picture is deteriorated depending on the value of the interpolation coefficient α.

FIG. **2** shows measured results obtained when a resolution of a picture processed by the interpolation processing is changed relative to the change of the interpolation coefficient α. Study of FIG. **2** reveals that a resolution of a reproduced picture is deteriorated as the interpolation coefficient α approaches ½, i.e., the signal that results from processing the adjacent 2H signals by the interpolation processing approaches a signal on the scanning line that is assumed to be located at the intermediate position of the two horizontal scanning lines. Especially, the deterioration of the resolution of the reproduced picture except areas $0<\alpha<¼$ and $¾<\alpha<1$ shown hatched in FIG. **2** is remarkable.

SUMMARY OF THE INVENTION

It is a first object of the present invention to provide a video camera apparatus in which the aforesaid shortcomings can be obviated and in which a deterioration of a resolution of a reproduced picture can be suppressed so that an image vibration due to a handling or the like can be corrected.

It is another object of the present invention to provide a video camera apparatus in which a deterioration of a resolution of a reproduced picture can be suppressed even when a scanning area of an imager is moved within a photo-sensitive pixel area in order to correct an image vibration due to a handling or the like.

In order to achieve the aforesaid objects, according to the present invention, a control circuit changes an interpolation coefficient α of an interpolation circuit in response to a detected output of a vibration detecting means, and also controls a scanning pulse generating circuit of an imaging device. The scanning pulse generating circuit changes a combination of two scanning lines that are to be processed by the interpolation processing circuit using the interpolation coefficient α by changing the scanning state of the imager when $0 \leqq \alpha < X$ or $(1-X) < \alpha \leqq 1$ and $X \leqq \alpha \leqq (1-X)$ if X assumes a limited value of the interpolation coefficient α and the limited value V is a value smaller than ½.

According to the present invention, similarly to the prior art, the scanning area of the imager can be moved at the unit smaller than the pixel unit within the photo-sensitive pixel area by changing the interpolation coefficient of the interpolation processing circuit in response to the amount of vibration, such as the handling or the like and interpolating the signals of the adjacent horizontal scanning lines 2H by using this interpolation coefficient α. When the interpolation coefficient is close to ½, the control circuit controls the scanning pulse generating circuit so that the signals of the adjacent horizontal scanning lines 2H that are to be processed by the interpolation processing circuit are made different. Accordingly, the scanning lines on which pixels

are read are shifted on the imaging screen of the imager and hence the interpolation coefficient α of the interpolation processing circuit relative to the signals of the adjacent horizontal scanning lines 2H is set to be a value distant from ½. Therefore, a resolution of a reproduced picture based on a video signal obtained by the above-mentioned interpolation processing can be almost prevented from being deteriorated.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the present invention will now be described in conjunction with the accompanying drawings, in which:

FIG. **1** is a schematic diagram used to explain an interpolation processing according to the prior art;

FIG. **2** is a diagram showing measured results of a resolution of a reproduced picture relative to an interpolation coefficient α used in the interpolation processing:

FIG. **3** is a block diagram showing a circuit arrangement of a video camera apparatus according to a first embodiment of the present invention;

FIGS. **4**A through **4**C are schematic diagrams showing an interpolation processing of the first embodiment shown in FIG. **3**, respectively; and

FIG. **5** is a block diagram showing a circuit arrangement of the video camera apparatus according to a second embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will hereinafter be described with reference to the drawings.

FIG. **3** is a block diagram showing a video camera apparatus according to a first embodiment of the present invention. As shown in FIG. **1**, a video camera apparatus of the present invention comprises an optical lens **1**, an imager **2**, a photo-sensitive pixel area **3**, a scanning area **4**, a scanning pulse generating circuit **6**, a signal processing circuit **5**, an interpolation processing circuit **7** including a 1H delay circuit, a digital interface **8**, a control circuit **9**, a control switch **10**, an output terminal **11** and a vibration detection sensor **12**.

Referring to FIG. **3**, an object image focused on an imager **2** through the optical lens **1** is photo-electrically converted by the scanning of the imager **2** and then output as an electrical signal. An output signal from the imager **2** is processed by the signal processing circuit **6** and then output from the output terminal **11** as a video signal. A signal processed by the signal processing circuit **6** is supplied through the digital interface **8** to the interpolation processing circuit **7** which effects an interpolation processing.

The vibration detection sensor **12** detects vibrations of horizontal and vertical directions of the video camera apparatus when a handling occurs, and outputs a detected signal. When the control switch **10** is depressed, the control circuit **9** reads the detected signal d of the vibration detection sensor **12** and calculates a moving amount of the scanning area of the imager **2** within the photo)sensitive pixel area of the imager **2** in order to cancel the picture vibration occurred due to the handling or the like. Then, the control circuit **9** supplies data to the scanning pulse generating circuit **5** which generates a scanning pulse used to energize the imager **2** to perform the scanning in response to the calculated moving amount and the interpolation processing circuit **7**.

The scanning pulse generating circuit **5** generates scanning pulses corresponding to the data supplied thereto from the control circuit **9** as shown in FIGS. **4**A through **4**C. Also, the interpolation processing circuit **7** performs the interpolation processing by an interpolation coefficient α corresponding to the data supplied thereto from the control circuit **9**. A signal generated by the interpolation processing in the interpolation processing circuit **7** is supplied through the digital interface **8** to the signal processing circuit **6**. Thus, the signal processing circuit **6** derives a video signal in which a deterioration of a resolution can be suppressed and in which an image vibration due to a handling or the like can be avoided.

The scanning pulse corresponding to the handling and the interpolation processing will be described with reference to FIGS. **4**A through **4**C.

The imager **2** comprises photo)diodes serving as pixels of N rows and M columns. The charges photo-electric transferred by each photo-diode are read out to a vertical CCD (Charge-Coupled Device) by the scanning pulse, and then the charges read out from the adjacent photo-diodes in the vertical direction are mixed. The method for reading out the signal is an ordinary method as "Two Line Mixed Readout". Accordingly, pixel columns of two rows constitute one scanning line.

As shown in FIG. **4**A, reference symbol a depicts a mixed pixel signal from a pixel signal of a photo-diode of a n'th line and a pixel signal of a photo-diode of a (n+1)'th line. Similarly, hereinafter, reference symbol b depicts a mixed pixel signal of a pixel signal of a photo-diode of a (a+2)'th line and a pixel signal of a photo-diode of a (n+3)'th line, and reference symbol c depicts a mixed pixel signal of a pixel signal of a photo-diode of a (n+4)'th line and a pixel signal from a photo-diode of a (n+5)'th line. It is needless to say that pixels signals are read out from the photo-diodes at that time in such a fashion that pixels signals are read from the n'th line and the (n+1)'th line simultaneously, pixel signals are read out from the (n+2)'th line and (n+3)'th line simultaneously, . . . Accordingly, the n'th line and the (n+1)'th line constitute one scanning line. At the same time, the (n+2)'th line and the (n+3)'th line constitute one scanning lines, the (n+4)'th line and the (n+5)'th line constitute one scanning line, . . . , respectively.

When the above-mentioned mixed pixel signals a, b and c are output from the imager **2**, they are shifted in time by 1H each. However, the mixed pixel signals a, b and the mixed pixel signals b, c are made the same in timing by delaying the output signal of the imager **2** by 1H by the 1H delay circuit **14**.

The scanning pulse generating circuit **5** generates a pulse so that, if the above-mentioned read period is taken as an odd field, then the (n+1)'th line and the (n+2)'th line are simultaneously read out, the (n+3)'th line and (n+4)'th line are read out simultaneously, . . . , during the even field as shown in FIG. **4**C. Reference symbols a', b'and c' in FIG. **4**A depict mixed pixel signals obtained at that time, respectively. More specifically, reference symbols a' depicts a mixed pixel signal of pixel signals from the photo)diodes on the (n+1)'th line and the (n+2)'th line, reference symbol b' depicts a mixed signal of pixel signals from the photo-diodes on the (n+3)'th line and the (n+4)'th line, and reference symbol c' depicts a mixed pixel signal of pixel signals from the photo-diodes on the line (n+5)'th line and (n+6)'th line.

Accordingly, in this case, the (n+1)'th line and the (n+2)'th line constitute one scanning line and, similarly, the (n+3)'th line and the (n+4)'th line constitute one scanning line, the (n+5)'th line and the (n+6)'th line constitute one scanning line, . . . , respectively.

In this way, the scanning lines are shifted by a pixel amount of one line in the odd field and the even field. Also in this case, this operation is equivalent to the processing such that, similarly to the video camera apparatus which effects an interlace scanning by reading out every other pixel columns one by one, the scanning lines are read out by shift amounts of one scanning line by reading out every other scanning lines in the odd field and the even field, respectively.

According to the interpolation processing of the first embodiment of the present invention, not only the mixed pixel signals a, b, c, . . . , but also the mixed pixel signals a', b', c' are used by controlling the scanning pulse generating circuit **5** by the control circuit **9** in response to the handling amount. Therefore, the image vibration due to the handling can be corrected and the deterioration of the reproduced picture can be suppressed.

When the control circuit **9** fine adjusts the moving amount of the scanning area at the unit of smaller than the pixel unit in response to the handling amount detected by the vibration detection sensor **12**, the interpolation coefficient α corresponding to this fine adjustment amount is set in the interpolation processing circuit **7**. Then, the control circuit **9** supplies data to the interpolation processing circuit **7** such that the above-mentioned fine adjustment is equivalently carried out by the interpolation processing using this interpolation coefficient α as shown in FIG. **1**.

Further, the control circuit **9** controls the scanning pulse generating circuit **5** in response to data supplied to the interpolation processing circuit **7**, accordingly, the interpolation coefficient α set in the interpolation processing circuit **7** to thereby select the reading of any of the pixel signals shown in FIGS. **4**B and **4**C. When the pixel signals are read out as shown in FIG. **4**B, there are obtained the mixed pixel signals a, b, c as shown in FIG. **4**A (hereinafter this combination of the mixed signals will be referred to as a combination A). When the pixel signals are read out as shown in FIG. **4**C, the mixed pixel signals a', b', c' are obtained as shown in FIG. **4**C (hereinafter this combination of the mixed pixel signals will be referred to as a combination B). The interpolation processing circuit **7** selects the combinations A and B in response to the interpolation coefficient α set by the control circuit **9**. More specifically,

when $0<\alpha\leqq 1/4$ and $3/4<\alpha\leqq 1$, the combination A is selected by the interpolation processing circuit **7**, and when $1/4<\alpha\leqq 3/4$, the combination B is selected by the interpolation processing circuit **7**, respectively.

If a timing at which the interpolation processing is carried out in the mixed pixel signals b and c is determined by selecting the combination A shown in FIG. **4**A, then when $0<\alpha\leqq 1/4$ and $3/4<\alpha\leqq 1$, the combination A is selected, and pixel signals D_1, D_4 that result from the interpolation processing by using the interpolation coefficient α are expressed by the following equations (3) and (4):

$$D_1=\alpha c+(1-\alpha)\cdot b \text{ where } 0<\alpha\leqq 1/4 \quad (3)$$

$$D_4=\alpha c+(1-\alpha)\cdot b \text{ where } 3/4<\alpha\leqq 1 \quad (4)$$

Therefore, assuming that L represents an interval provided between every other scanning lines in the photo-sensitive pixel area, then the scanning area of the imager device **2** is equivalently fine adjusted so as to locate the position $\alpha\cdot L$ from the scanning line of the mixed pixel signal b. In addition, since the interpolation coefficient α is sufficiently distant from the 1/2 ($0<\alpha\leqq 1/4$, $3/4<\alpha\leqq 1$), deterioration of a resolution of a reproduced picture can be suppressed.

Further, when $1/4<\alpha\leqq 1/2$ and $1/2<\alpha\leqq 3/4$, then the combination B is selected and pixels signals D_2, D_3 that result from the interpolation using the interpolation coefficient α are expressed by the following equations (5) and (6):

$$D_2=(1/2-\alpha)\cdot a'+(1/2+\alpha)\cdot b' \text{ where } 1/4<\alpha=1/2 \quad (5)$$

$$D_3=(3/2-\alpha)\cdot b'+(\alpha-1/2)\cdot c' \text{ where } 1/2<\alpha\leqq 3/4 \quad (6)$$

More specifically, the interpolation is performed by using the mixed pixel signal b' that is located at the central position of the mixed pixel signals b and c, and the adjacent mixed pixel signals a' and c'. In this case, when the mixed pixel signal b' is examined, the movement of the scanning area between the mixed pixel signals b and c is carried out such that the fine adjustment of the movement of the scanning area falls within a range of +L/4 from the position of the mixed pixel signal b'. Accordingly, the pixel signals D_2, D_3 are obtained by the above-mentioned calculations.

Therefore, since the interpolation coefficients $(1/2-\alpha)$ and $(\alpha-1/2)$ fall within the range of from 0 to 1/4 and the interpolation coefficients $(1/2+\alpha)$ and $(3/2-\alpha)$ fall within a range of from 3/4 to 1, the pixel signals D_2 and D_3 are obtained by the interpolation processing using the interpolation coefficients sufficiently spaced apart from the 1/2. Thus, the deterioration of the resolution of the reproduced picture can be suppressed.

FIG. **5** is a block diagram showing the video camera apparatus according to a second embodiment of the present invention, wherein reference numeral **13** designates a motion vector calculating circuit. In FIG. **5**, like parts corresponding to those of FIG. **3** are marked with the same references and therefore need not be described in detail.

As shown in FIG. **5**, according to the second embodiment, the vibration detection sensor **12** shown in FIG. **3** is replaced with the motion vector calculating circuit **13**. This motion vector calculating circuit **13** calculates a motion occurred in the video camera apparatus due to a handling on the basis of an image correlation of the video signal as a vector v. As shown in FIG. **5**, when the control switch **10** is depressed, then the control circuit **9** calculates the moving amount of the scanning area of the imager **2** in order to cancel the image vibration due to the handling in response to the motion vector v calculated by the vector calculating circuit **13**. Then, similarly to the above)mentioned first embodiment, the control circuit **9** sets the interpolation coefficient α that is used to effect the interpolation processing in the interpolation processing circuit **7**, and controls the scanning pulse generating circuit **5**.

While the range of the interpolation coefficient α is divided into $0<\alpha\leqq 1/4$, $1/4<\alpha\leqq 1/2$, $1/2<\alpha\leqq 3/4$ and $3/4<\alpha\leqq 1$ as described above in the first and second embodiments, the present invention is not limited thereto and any methods may of course be applied inasmuch as the interpolation coefficient α is divided into portions close to and distant from the 1/2. In general, $0<\alpha\leqq X$, $X<\alpha\leqq 1/2$, $1/2<\alpha\leqq(1-X)$ and $(1-X)<\alpha\leqq 1$ and this control value X can be selected to be a value smaller than the 1/2 determined by the tolerance range in which the deterioration of the resolution can be avoided.

As described above, according to the present invention, even when the scanning area of the imaging device is moved within the photo)sensitive pixel area in order to correct the image vibration, such as the handling or the like, the

deterioration of the resolution of the reproduced picture can be suppressed.

What is claimed is:

1. A video camera apparatus comprising:

an imager for scanning a part of a photo-sensitive pixel area in which a focused objective image is photo-electrically converted;

a scanning pulse generating means for generating a scanning pulse that drives said imager;

interpolation processing means for obtaining signals of two adjacent scanning lines from an output signal of said imager and adding said two adjacent scanning lines after multiplying each respectively by an interpolation coefficient α and $(1-\alpha)$;

signal processing means for processing an output signal of said interpolation processing means;

vibration detecting means for detecting a vibration of said video camera caused by external forces; and

control circuit means for setting said interpolation coefficient α (where $0 \leqq \alpha \leqq 1$) of said interpolation processing means in response to a detected output from said vibration detecting means, for controlling said scanning pulse generating means, wherein a limited value X of said interpolation coefficient α is selected to be a value smaller than ½, and for controlling said interpolation processing means wherein a combination of two scanning lines that are to be processed by said interpolation processing means are made different by making a scanning state of said imager different when $0 \leqq \alpha \leqq X$ or $(1-X) < \alpha \leqq 1$ and $X \leqq \alpha \leqq (1-X)$ if X is limited value of said interpolation coefficient α smaller than ½.

2. A video camera apparatus comprising:

an imager for scanning a part of a photo-sensitive pixel area in which a focused objective image is photo-electrically converted;

scanning pulse generating means for generating a scanning pulse that drives said imager;

interpolation processing means for obtaining signals of two adjacent scanning lines from an output signal of said imager and adding said two scanning lines after multiplying each respectively by α and $(1-\alpha)$;

signal processing means for processing an output signal of said interpolation processing means;

motion vector calculating means for detecting a vibration of a video signal; and

control circuit means for setting an interpolation coefficient α (where $0 \leqq \alpha \leqq 1$) of said interpolation processing means in response to an output of said motion vector calculating means and controlling said scanning pulse generating means, wherein said control circuit means controls said scanning pulse generating means so that a combination of two scanning lines that are to be processed by said interpolation processing means is made different by changing a scanning state of said imager when $0 \leqq \alpha < X$ or $(1-X) < \alpha \leqq 1$ and $X \leqq \alpha \leqq (1-X)$ if a limited value X of said interpolation coefficient α is selected to be a value smaller than ½.

3. A video camera apparatus according to claim **1**, wherein said two scanning lines that are to be processed by said interpolation processing means when $X \leqq \alpha \leqq (1-X)$ are shifted by one scanning line from said two scanning lines that are to be processed by said interpolation processing means when $0 \leqq \alpha < X$ or $(1-X) < \alpha \leqq 1$.

4. A video camera apparatus according to claim **2**, wherein said two scanning lines that are to be processed by said interpolation processing means when $X \leqq \alpha \leqq (1-X)$ are shifted by one scanning line from said two scanning lines that are to be processed by said interpolation processing means when $0 \leqq \alpha < X$ or $(1-X) < \alpha \leqq 1$.

5. A system for suppressing deterioration in resolution of a video signal produced by a video camera having an array of photo-sensitive pixels upon which an objective image is focused, which comprises:

a) an imager means for scanning an area of said array to produce an electrical image signal;

b) vibration detecting means for producing a magnitude signal indicative of an amount of movement of said video camera in response to external forces;

c) control circuit means responsive to said magnitude signal for producing an interpolation coefficient α and an area shift signal;

d) a scanning pulse generating circuit means responsive to said area shift signal for generating a scanning pulse to locate said area at a position on said array that is determined by said area shift signal, and to drive said imager to scan said area to produce an image signal;

e) signal processing circuit means for receiving said image signal and for forming a video signal from interpolations of said image signal; and

f) interpolation processing circuit means responsive to said interpolation coefficient α and in electrical communication with said signal processing circuit means for producing said interpolations of said image signal by multiplying a first of two adjacent scanning lines of said image signal by said interpolation coefficient α and multiplying a second of said two adjacent scanning lines by $(1-\alpha)$, and thereafter adding resulting products when $0 < \alpha \leqq ¼$ and $¾ < \alpha \leqq 1$, and, where a second of three adjacent scanning lines of said image signal is vertically located midway between said two adjacent scanning lines of said image signal, by multiplying a first of said three adjacent scanning lines of said image signal by $(½-\alpha)$ and said second of said three adjacent scanning lines by $(½+\alpha)$ and adding resulting products when $¼ < \alpha \leqq ½$, and by multiplying said second of said three adjacent scanning lines by $(3/2-\alpha)$ and a third of said three adjacent scanning lines by $(\alpha-½)$ and adding resulting products when $½ < \alpha \leqq ¾$.

6. The system set forth in claim **5** wherein a motion vector calculating circuit means is substituted for said vibration detecting means, and said motion vector calculating circuit means receives said image signal from said signal processing circuit means.

7. A method of suppressing deterioration in resolution of a video signal when vibrations smaller than a pixel transversal length occur in a video camera having an array of photo-sensitive pixels upon which an objective image is focused, which comprises the steps of:

a) scanning an area of said array to produce an image signal comprised of signals from each pixel scanned;

b) detecting said vibrations and producing therefrom a magnitude signal indicative of amount of movement of said video camera;

c) producing an interpolation coefficient α and an area shift signal dependent upon said magnitude signal;

d) shifting said area within said array a distance proportional to said magnitude signal;

e) interpolating said image signal to form interpolation signals by multiplying a first of two adjacent scanning lines of said image signal by said interpolation coeffi-

cient α and multiplying a second of said two adjacent scanning lines by $(1-\alpha)$ and thereafter adding resulting products when $0<\alpha\leqq 1/4$ and $3/4<\alpha\leqq 1$, and where a second of three adjacent scanning lines of said image signal is vertically located midway between said two adjacent scanning lines of said image signal, by multiplying a first of said three adjacent scanning lines of said image signal by $(1/2-\alpha)$ and said second of said three adjacent scanning lines by $(1/2+\alpha)$ and adding resulting products when $1/4<\alpha\leqq 1/2$, and by multiplying said second of said three adjacent scanning lines by $(3/2-\alpha)$ and a third of said three adjacent scanning lines by $(\alpha-1/2)$ and adding resulting products when $1/2<\alpha\leqq 3/4$; and

f) forming a video signal from said interpolation signals.

* * * * *

EXHIBIT 1014

United States Patent [19]

Van Heyningen et al.

[11] **Patent Number: 4,949,117**

[45] **Date of Patent: Aug. 14, 1990**

[54] **CAMERA**

[75] Inventors: **Roger S. Van Heyningen**, Rochester; **Cynthia S. Bell**, Webster; **Paul L. Ruben**, Penfield, all of N.Y.

[73] Assignee: **Eastman Kodak Company**, Rochester, N.Y.

[21] Appl. No.: **288,887**

[22] Filed: **Dec. 23, 1988**

[51] **Int. Cl.**[5] **G03B 7/00**

[52] **U.S. Cl.** **354/412**; 358/224; 354/75

[58] **Field of Search** 354/412, 413, 416, 417, 354/429, 432, 402, 75, 76, 219; 358/225, 226, 909, 224

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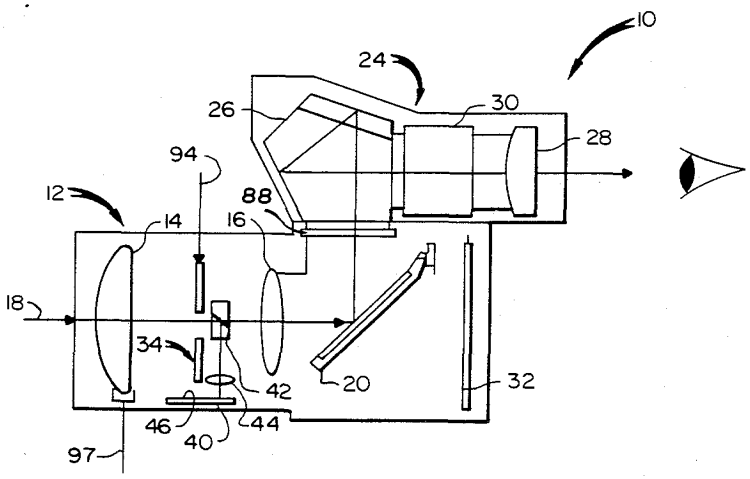
Primary Examiner—Russell E. Adams

Attorney, Agent, or Firm—Donald D. Schaper

[57] **ABSTRACT**

A camera is disclosed which includes elements for recording an image on photographic film and a solid-state image sensor for recording an electronic image. In order to reduce the size and complexity of the camera and to improve the camera performance, the electronic and film recording functions of the camera are integrated. The solid-state image sensor is used both in controlling the recording of an image on film and in producing an electronic image.

10 Claims, 5 Drawing Sheets



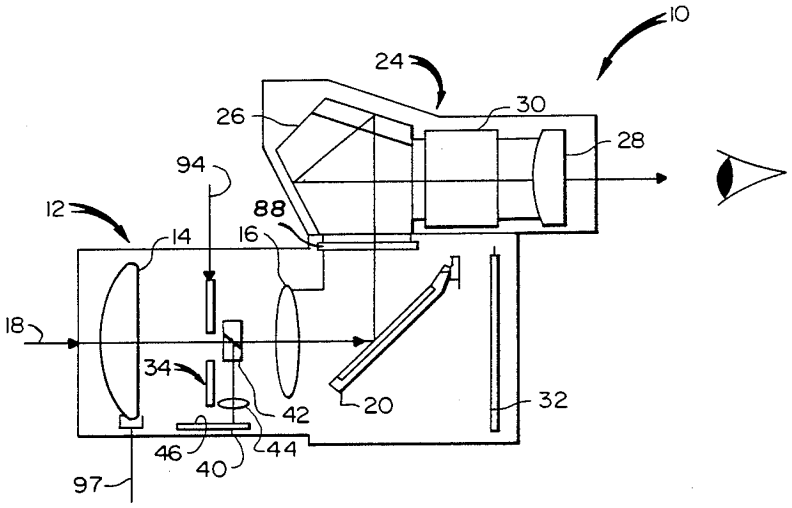

10
24
26
30
28
94
12
88
14
16
18
34
42
20
32
46
40
44
97

FIG. 1

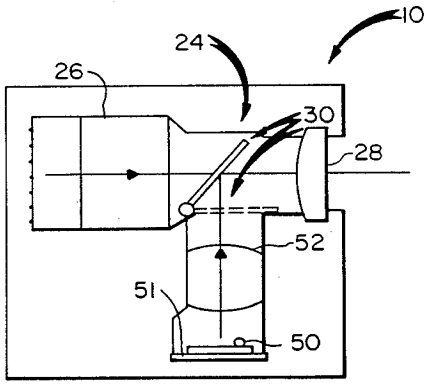

10
24
26
30
28
52
51
50

FIG. 2

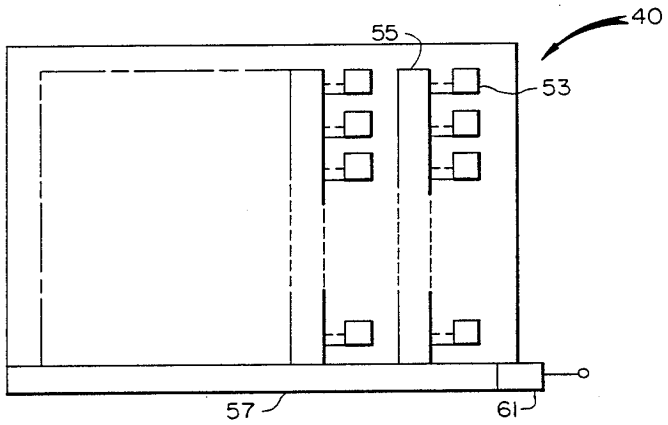


FIG. 3

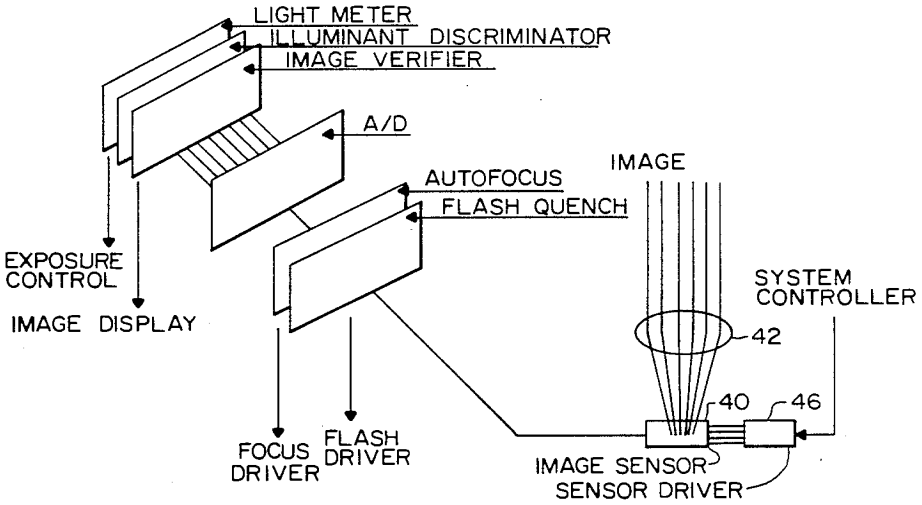


FIG. 4

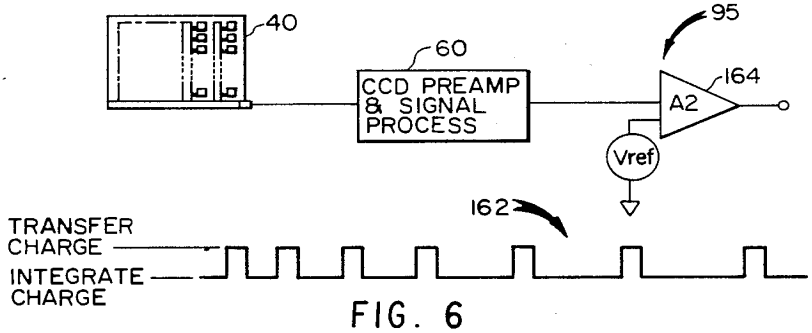


FIG. 6

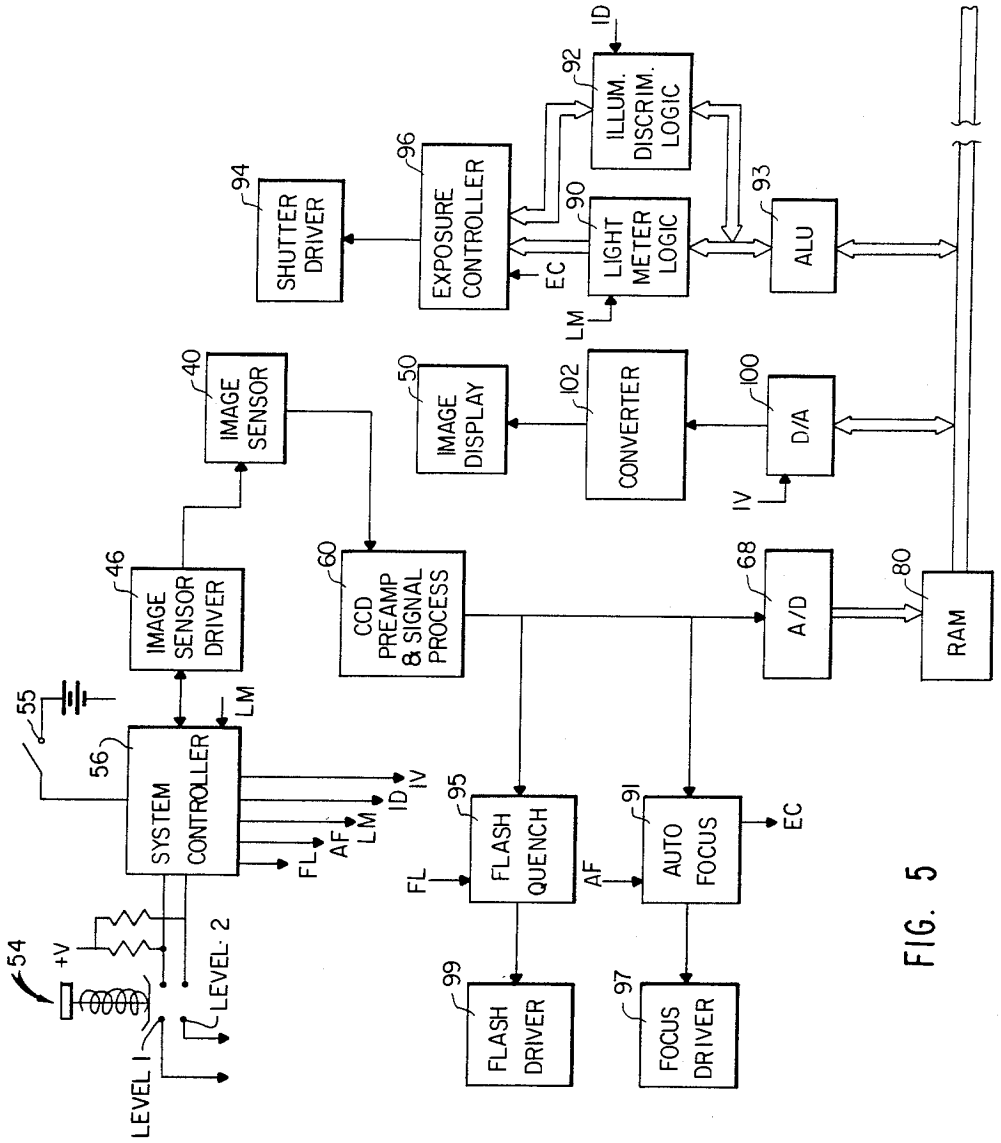

ID
92
ILLUM. DISCRIM. LOGIC
96
EXPOSURE CONTROLLER
94
SHUTTER DRIVER
90
LIGHT METER LOGIC
93
ALU
EC
LM
40
IMAGE SENSOR
50
IMAGE DISPLAY
102
CONVERTER
100
D/A
IV
46
IMAGE SENSOR DRIVER
60
CCD PREAMP & SIGNAL PROCESS
68
A/D
80
RAM
55
56
SYSTEM CONTROLLER
LM
ID
IV
FL
AF
LM
95
FLASH QUENCH
91
AUTO FOCUS
EC
FL
AF
54
+V
LEVEL 2
LEVEL 1
99
FLASH DRIVER
97
FOCUS DRIVER

FIG. 5

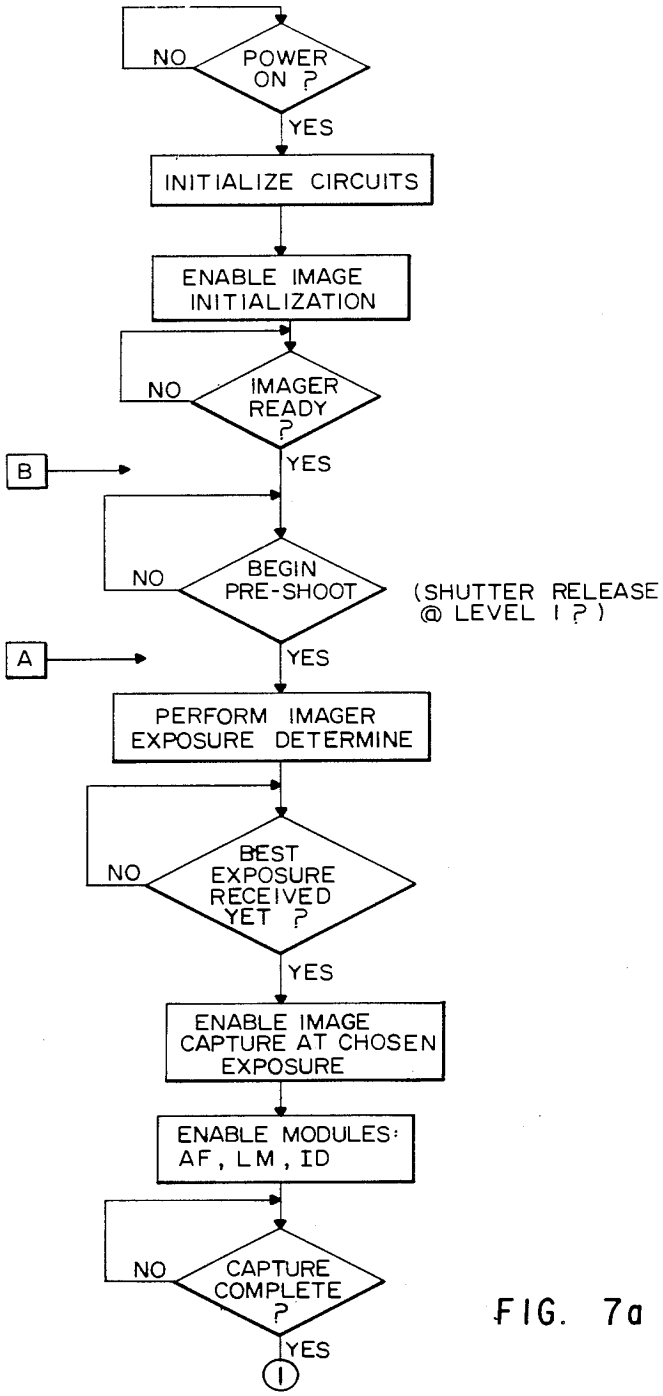

NO
POWER ON ?
YES
INITIALIZE CIRCUITS
ENABLE IMAGE INITIALIZATION
NO
IMAGER READY ?
YES
B
NO
BEGIN PRE-SHOOT
(SHUTTER RELEASE @ LEVEL 1 ?)
A
YES
PERFORM IMAGER EXPOSURE DETERMINE
NO
BEST EXPOSURE RECEIVED YET ?
YES
ENABLE IMAGE CAPTURE AT CHOSEN EXPOSURE
ENABLE MODULES: AF, LM, ID
NO
CAPTURE COMPLETE ?
YES
1

FIG. 7a

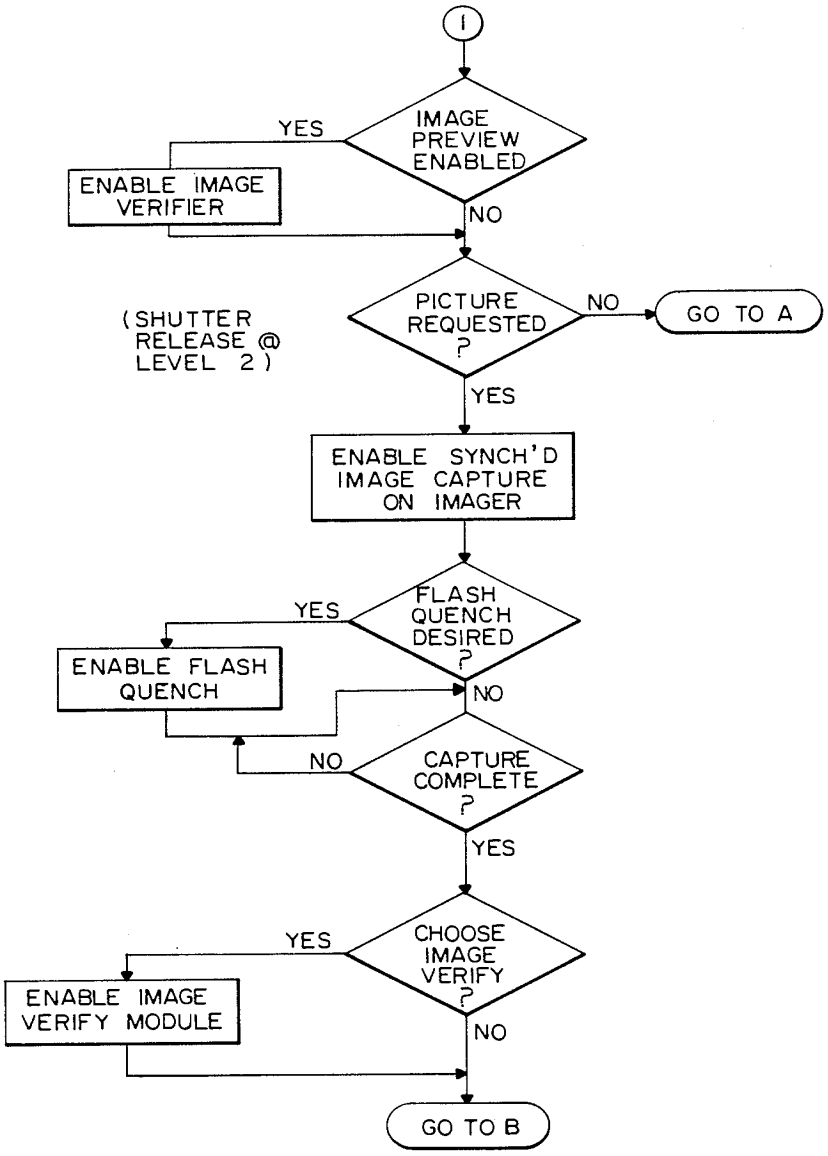

1
IMAGE PREVIEW ENABLED
YES
ENABLE IMAGE VERIFIER
NO
PICTURE REQUESTED ?
NO
GO TO A
(SHUTTER RELEASE @ LEVEL 2)
YES
ENABLE SYNCH'D IMAGE CAPTURE ON IMAGER
FLASH QUENCH DESIRED ?
YES
ENABLE FLASH QUENCH
NO
CAPTURE COMPLETE ?
NO
YES
CHOOSE IMAGE VERIFY ?
YES
ENABLE IMAGE VERIFY MODULE
NO
GO TO B

FIG. 7b

CAMERA

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a camera, and more particularly, to a camera which includes means for forming an image on photographic film and means for producing an electronic image.

2. Description of the Prior Art

Various cameras are known which record an image on photographic film and also record an image electronically. Generally, these cameras include conventional optics and film handling mechanisms for forming an image on film, and they also include a solid-state imager and a display for forming and viewing the electronic image. Such a camera can be used in a preview mode in which a photographer can view an electronically-recorded scene on the display without having to expose the film. The preview mode makes it convenient to arrange the composition and verify the exposure level before a permanent image is captured on film. The camera can also operate in a review mode in which the photographer can view an image on the display which has also been captured on film. An important benefit of the review mode is that it adds the capability to evaluate pictures before leaving a scene, including the evaluation of such photographic variables as composition, flash synchronization, camera and subject motion, exposure level, and depth of field. This review capability is of particular value for functions, such as weddings, where it is important to know that a certain scene has been properly recorded.

U.S. Pat. No. 4,742,369, discloses an electronic still camera which is adapted to form an image on a photosensitive film and on a solid-state imaging element in response to the actuation of a shutter switch. The camera can form the images on the film and sensor simultaneously or in sequence. The camera elements for forming the image on the photosensitive film are conventional camera elements found in a single lens reflex camera. The shutter speed and desired lens aperture are manually controlled by the operator. A beam splitter in the camera directs light from the optical system to a solid-state imager. A disadvantage of the camera shown in this patent, as well as other known prior-art cameras, is that the camera includes essentially two different systems to record the electronic image and to control the recording of the photographic image. This arrangement makes the camera complex and expensive to manufacture.

SUMMARY OF THE INVENTION

It is an object of the present invention to overcome the problems in the prior art described above and to provide an improved camera which is particularly suitable for recording an image on photosensitive film and on an electronic device.

In accordance with one aspect of the present invention, there is provided a camera comprising means for forming an image on photographic film; and means for producing an electronic image signal, the producing means including means for sensing scene parameters and for controlling the forming means in accordance with values of the parameters.

In one embodiment of the present invention, a camera of the single lens reflex type includes an optical means for directing an image onto photographic film or into a viewfinder, depending on the position of a movable mirror. Located in the lens of the camera is a beam splitter which directs a portion of the light entering the camera onto a solid-state image sensor. The image data from the sensor is written into memory, and the data can be retrieved from memory to drive a display located in the viewfinder of the camera. In addition to producing an electronic image signal which can be used to verify the image recorded on film, the solid-state sensor is also used to perform other functions in the camera such as exposure control and autofocus.

The main advantages of the camera of the present invention over known cameras which record electronically and on film are the improved performance and the reduction in size and complexity of the camera. These advantages are achieved as a result of integrating the electronic recording and the film recording functions in the camera. The solid-state sensor is used not only to capture an electronic representation of the image for storage and subsequent display but also to sense image information for use in the autofocus and exposure control mechanisms of the photographic camera.

Other features and advantages will become apparent upon reference to the following Description of the Preferred Embodiment when read in light of the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic elevational view of the camera of the present invention;

FIG. **2** is a top plan view of the camera shown in FIG. **1**, showing the display and the viewfinder;

FIG. **3** is a schematic plan view of the image sensor used in the present invention;

FIG. **4** is a schematic illustration of the various functions which are performed by the image sensor in the camera;

FIG. **5** is a block diagram of the electronic elements of the camera;

FIG. **6** is a schematic illustration of the flash quench device in the camera; and

FIGS. *7a* and *7b* show a flow chart of the sequence of events in recording an image electronically and on film.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIGS. **1** and **2**, there is shown a schematic representation of the camera of the present invention. As shown in these figures, a camera **10** comprises an imaging lens **12** having elements **14** and **16** which are disposed along an optical axis **18**. Light from an object propagates along axis **18** and is reflected onto a ground glass viewing screen **88** by a mirror **20** which is inclined at a 45° angle. An image on screen **88** can be viewed through a viewfinder **24** and a roof penta prism **26**. Viewfinder **24** includes an eyepiece **28** and a mirror **30** which is movable between the solid line position, shown in FIG. **2**, and the position shown therein in phantom. When a desired scene is framed in the viewfinder, mirror **20** is pivoted upwardly to a generally horizontal position (not shown) to expose the film **32**. The exposure of the film **32** is controlled by a combination diaphragm/shutter indicated schematically at **34**.

An electronic image can be recorded in camera **10** through the use of a solid-state image sensor **40** which receives light from a beam splitter **42** located along the optical axis **18**. Light from beam splitter **42** is focused on

image sensor **40** by means of a lens **44**. Beam splitter **42** can be, for example, a so-called **80/20** beam splitter which is adapted to transmit about 80% of the light to film **32** and about 20% of the light to image sensor **40**. When the light is divided in this manner, it will be apparent that the ASA ratings of the film **32** and the image sensor **40** must be adjusted accordingly in order to obtain the proper exposure on both the sensor and the film.

A driver **46** for image sensor **40** is located adjacent the sensor **40**. Image sensor **40** includes a plurality of sensor elements each of which generates a signal in proportion to the amount of luminous energy that impinges thereon. The processing and storage of the signal from sensor **40** will be explained hereinafter. A recorded image can be displayed on a display **50**, shown in FIG. **2**. Display **50** is preferably a liquid crystal display; however, other types of displays can be used. One example of a suitable display is a Seiko-Epson liquid crystal display, Part. No. EVFM0000-1. A backlight **51** is provided for display **50**. Backlight **51** can be, for example, a CAPSUL series EL panel backlight, sold by Luminescent Systems, Inc. An image on display **50** passes through a focusing lens **52**, is reflected by mirror **30**, and can be viewed through eyepiece **28**.

The image sensor **40** for camera **10** can be of a type which uses a charge-coupled device (CCD), for example, an interline CCD image sensor, No. KAI-0280, manufactured by the Eastman Kodak Co., Rochester, N.Y. The KAI-0280 image sensor uses photodiodes as the image sensing elements. A schematic illustration of image sensor **40** is shown in FIG. **3**. An image is captured in sensor **40** through the conversion of incident light into charge which is collected in photodiodes **53**. The amount of charge collected is proportional to light intensity and exposure time. The collected charge is transported from the photodiodes **53** to a vertical CCD shift register **55** where it is shifted to a horizontal CCD shift register **57**. The horizontal CCD shift register **57** shifts the charge to an output section **61** which includes a floating diffusion and a charge-to-voltage converter.

An important feature of the camera of the present invention is the integration of the electronic camera functions and photographic film camera functions. This is accomplished through the use of image sensor **40**, not only to record an electronic image, but also to perform a number of functions in the recording of an image on film. The use of image sensor **40** in this manner is illustrated schematically in FIG. **4**. A signal from image sensor **40** can be used to perform flash quench and autofocus; and after passing through an A/D converter, the digitized signal can be used for image verification and in an illuminant discriminator and a light meter for exposure control.

A flow chart in FIGS. **7***a* and **7***b* shows the sequence of operations performed in capturing an image electronically and on film. A block diagram of the electronic elements of camera **10** is shown in FIG. **5**. A power-on switch **55** is closed to initialize the circuitry shown in FIG. **5**. A system controller **56** then conveys an enable signal to the image sensor driver **46** which effects the removal of the off-state charge, or dark current, from the image sensor **40** to prepare the sensor for the capture of an image. Image sensor driver **46**, which includes an image sensor timing control and voltage translators, functions in a known manner to provide clock signals to sensor **40**. The system controller **56** and the image sensor timing control in driver **46** can each be a Signetics programmable logic sequencer, Model PLS105AN.

When the image sensor **40** is ready for the capture of an image, an operator can start an exposure sequence by the actuation of a shutter release **54**. When the shutter release **54** is moved to level **1**, a preshoot phase is started. In a first step, the system controller **56** conveys an enable signal and a time-varying exposure duration signal to the image sensor driver **46**. The image sensor timing control in driver **46** sends the requisite clocking signals to the image sensor **40** for the capture and subsequent readout of the charge signals. The charge signals from sensor **40** are processed in a well-known manner by a CCD preamp and signal processing circuit **60**.

In order to determine the proper exposure duration, or integration time, of the image sensor **40**, signals from circuit **60** are compared to a reference voltage. The procedure which is used to find the proper exposure duration is generally the same as the procedure used to determine when to quench the flash; the flash quench circuit is illustrated in FIG. **6** and described hereinafter. A variable clock-out rate, as shown in waveform **162** in FIG. **6**, is used in which the integration time increases for each successive pixel. The signal level is compared to the level of a reference voltage by means of a circuit such as comparator **164** shown in FIG. **6**. When the two signals are equal, the exposure duration is registered, and a signal representing this exposure duration is conveyed back to the system controller **56**. Typically, the exposure duration selected is that duration that results in the average signal being one-half of the dynamic range available.

Upon receipt of the selected exposure duration, the system controller **56** sends a second enable signal and a signal indicative of the selected exposure duration to the image sensor driver **46**. The system controller **56** also enables a light meter logic circuit **90**, an autofocus module **91**, and an illuminant discriminator logic circuit **92**. The charge signals from sensor **40** are amplified in signal processing circuit **60**, and the amplified signals are passed to a sample and hold which tracks the reset level of sensor **40** and measures the voltage difference due to the charge signals. The voltage differences representing the image are further amplified and adjusted to a DC reference voltage level in signal processing circuit **60** in order to take maximum advantage of the range of an A/D converter **68** which receives the signals from circuit **60**. The digitized signals from A/D converter **68** are stored in a memory **80** which can be, for example, a RAM (Random Access Memory) which is adapted to store at least 1 frame of data. The A/D converter **68** can be a Samsung A/D converter, No. KVA3100A, and memory **80** can be a Motorola RAM, No. MCM511002.

Autofocus module **91** can process data from the CCD preamp and signal processing circuit **60** as disclosed in commonly assigned U.S. Pat. No. 4,490,037, granted Dec. 25, 1984, in the name of Anagnostopoulos et al. In order to find the scene parameter of subject distance, a beam from an LED (not shown) in camera **10** is projected onto a subject in a scene to illuminate a small area thereon. The scene is imaged on image sensor **40**, and the signals produced by a row of photodiodes **53** in sensor **40** are analyzed to determine the position of the illuminated small area in the scene; a signal, which represents the subject distance, is then delivered to focus driver **97** and to a camera exposure controller **96**.

Light meter logic circuit **90** is adapted to determine the best exposure for the subject in the image. A de-

scription of a light meter device suitable for use in the present invention can be found in commonly-owned U.S. Pat. No. 3,714,442, entitled "Exposure Control Circuitry", granted on Jan. 30, 1973, in the name of Lee F. Frank. In the light meter device disclosed therein, each detector in an array of detectors is responsive to radiation derived from a different area of an image, and this information is processed to achieve an optimum light value.

Illuminant discriminator logic circuit **92** can function as disclosed in commonly assigned U.S. patent application Ser. No. 149,322, entitled "Illuminant Discriminator Designed for Easy Integration", filed on Jan. 28, 1988, in the name of Michael J. Gaboury. As disclosed therein, apparatus is provided for discriminating among various types of illuminants such as fluorescent light, tungsten light and natural daylight. The apparatus includes an analog portion which converts incident light into a conditioned illuminant signal and a digital portion which utilizes a microprocessor to perform a Fourier series analysis on one or more of the harmonics of the illuminant signal. The microprocessor then compares the amplitudes of the harmonics against the amplitudes oF known illuminant sources to identify the source. In the present invention, the teachings of the Gaboury application are incorporated in illuminant discriminator logic **92** which directs ALU **93** to perform the harmonic summations and comparisons necessary to identify the illuminant source.

Signals produced by the light meter logic circuit **90**, illuminant discriminator logic circuit **92** and autofocus module **91** are provided as inputs to the exposure controller **96**. Exposure controller **96** processes these inputs to produce an optimum exposure as described, for example, in commonly-assigned U.S. Pat. No. 4,785,323, granted on Nov. 15, 1988, in the name of C. S. Bell. As disclosed in this patent application, the exposure controller is adapted to maximize overall picture quality. The inputs from circuits **90** and **92** and from module **91** can be used by controller **96** to achieve synergistic effects in the image, such as an improvement in image quality as a result of choosing a light level and illuminant that corresponds with an x and y position of the subject chosen by the autofocus. Exposure controller **96** can also select other camera modules, for example, a module (not shown) for charging the flash.

In the event it is desired to preview the image captured, the recorded image can be viewed on display **50**. When it is desired to display an image stored in memory **80**, the system controller **56** enables an image verifier module which includes a D/A converter **100**. D/A converter **100** delivers an analog signal to a converter **102** which converts the data to a format compatible with the requirements of the image display circuits, typically baseband video. Signals from converter **102** drive the display **50** to form an image of the scene just captured electronically . The display **50** can be viewed in the preview mode in the viewfinder **24**, as described above and shown in FIG. **1**. The duration of the image display enable may be preset in the system controller **56** or made adjustable by the photographer. If no preview is desired, a simultaneous recording of an image on film **32** and image sensor **40** can be effected by depressing the shutter release **54** to level **2**.

When the shutter release **54** is depressed to level **2**, the actual exposure on film is initiated. Using the exposure values determined during the preshoot phase, the camera diaphragm/shutter **34** begins the exposure. The system controller **56** receives a start signal from the shutter driver **94** and effects the capture, simultaneously, of an image on film **32** and on the image sensor **40**. Registers in autofocus module **91** which capture autofocus data may be accessed during the exposure so that accurate focus on the subject is maintained throughout. Registers in flash quench circuit **95** may also be accessed during the exposure.

An example of a flash quench **95** which can be used in the camera of the present invention is shown in FIG. **6**. The arrangement shown in FIG. **6** would replace a conventional flash quench circuit of the type which includes an integration/log circuit. The image sensor **40**, indicated diagrammatically in FIG. **6**, can be be used with a variable clock-out rate in which the integration time is increased as shown by the waveform **162**. In this manner, the integration is achieved in each photosite and simply compared, by means of a comparator **164**, to a desired signal level indicated by V_{ref}. When a pixel meets or exceeds the level of V_{ref}, a signal is delivered to flash driver **99** (FIG. **5**) and the flash (not shown) is quenched.

Upon completion of the picture exposure, the image is processed, digitized and stored in the memory **80**. In the event the operator wishes to verify the image which was simultaneously recorded electronically and on film **32**, the electronic image can be displayed as described above for the preview mode. Thus, an image of the scene just captured on the film can be quickly made available to the photographer.

The invention has been described in detail with particular reference to the preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention. For example, although the present invention has been described herein with reference to a single lens reflex camera, it will be apparent to those skilled in the art that the invention could be used with other types of cameras. The invention could be used in a camera having a viewfinder which functions with optical elements which are independent from the optical elements which form the image on the film and the sensor. Also, the display for the electronic image could be a separate element, and the camera could include a cable connection for transferring an image signal to a remote display.

I claim:

1. A camera of the single lens reflex type, said camera comprising:

means for forming an image on photographic film, said forming means including optical means for producing an image of an object to be photographed;

means for producing an electronic image signal, said producing means including means for sensing scene parameters and for controlling said forming means in accordance with values of said parameters, said sensing and controlling means including means for focussing said optical means and for controlling the exposure of said film;

display means for receiving said image signal and for producing an image therefrom; and

a viewfinder for viewing said object and for viewing an image on said display means, said viewfinder being optically coupled to said optical means by means of a reflecting surface.

2. A camera, as defined in claim **1**, wherein said producing means includes a solid-state image sensor.

3. A camera, as defined in claim 2, wherein said producing means includes image storage means.

4. A camera, as defined in claim 3, wherein said producing means includes a system controller for controlling the functions of said camera in timed sequence.

5. A camera comprising:

optical means including at least two lens elements for forming an image of an object to be photographed, said optical means including a beam splitter located between said lens elements for directing a first portion of light entering said optical means to a first location and the remainder of said light to a second location, said optical means further including light control means for controlling the amount of light which is directed to said locations in response to a signal indicative of ambient light;

means for supporting a photographic film in one of said locations, said supporting means being located in an image plane of said optical means;

a solid-state image sensor disposed in the other of said locations to receive light from said optical means, said solid-state image sensor including means for generating said signal;

display means for displaying an image sensed by said solid-state image sensor; and

a viewfinder which includes means for viewing said object and said display means.

6. A camera, as defined in claim 5, wherein said camera is a single lens reflex camera, and said viewfinder is optically coupled to said optical means by means of a reflecting surface.

7. A camera, as defined in claim 6, wherein said viewfinder includes means for viewing an image selectively formed on said display means.

8. A camera, as defined in claim 6, wherein said viewfinder contains means for selectively viewing an image formed by said optical means or an image formed by said display means.

9. A camera, as defined in claim 8, wherein said camera includes means for simultaneously forming an electronic image and a photographic image.

10. A camera comprising:

means for forming an image on photographic film; and

means for producing an electronic image signal, said producing means including means for sensing scene parameters and for controlling said forming means in accordance with values of said parameters, said sensing and controlling means including means for controlling a flash device.

* * * * *

EXHIBIT 1015

US005150109A

United States Patent [19]

Berry

[11] Patent Number: 5,150,109

[45] Date of Patent: Sep. 22, 1992

[54] **VGA CONTROLLER CARD**

[75] Inventor: **Wayne F. Berry**, Palm Springs, Calif.

[73] Assignee: **Touchstone Computers, Inc.**, Tustin, Calif.

[21] Appl. No.: **310,398**

[22] Filed: **Feb. 13, 1989**

[51] **Int. Cl.**[5] **G09G 3/00**

[52] **U.S. Cl.** **340/811**; 340/703; 340/717

[58] **Field of Search** 340/717, 716, 784, 814, 340/703, 811, 744; 364/521

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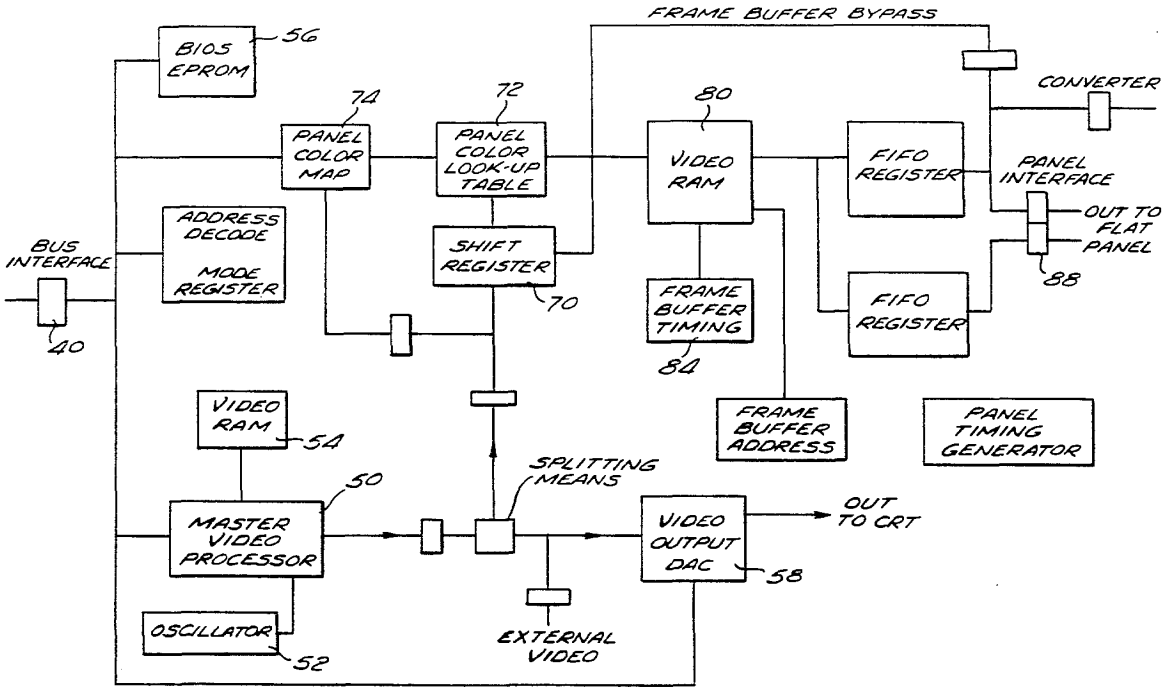
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Primary Examiner—Alvin E. Oberley
Assistant Examiner—Xiao Min Wu
Attorney, Agent, or Firm—Stetina and Brunda

[57] **ABSTRACT**

A bus mountable Video Graphic Array (VGA), controller card for IBM personal computer family products, including the PC, PC/XT, PC/AT, and PS/2 computers and completely compatable clone computer products to provide VGA standard signals to drive conventional Cathode Ray Tube, (CRT) and flat panel displays is disclosed. The VGA controller card is hardware compatable to the IBM PC family products; functions to provide VGA standard signals capable of driving flat panel displays and converts standrad PS/2 VGA signals to simultaneously drive conventional CRT and flat panel displays.

5 Claims, 2 Drawing Sheets



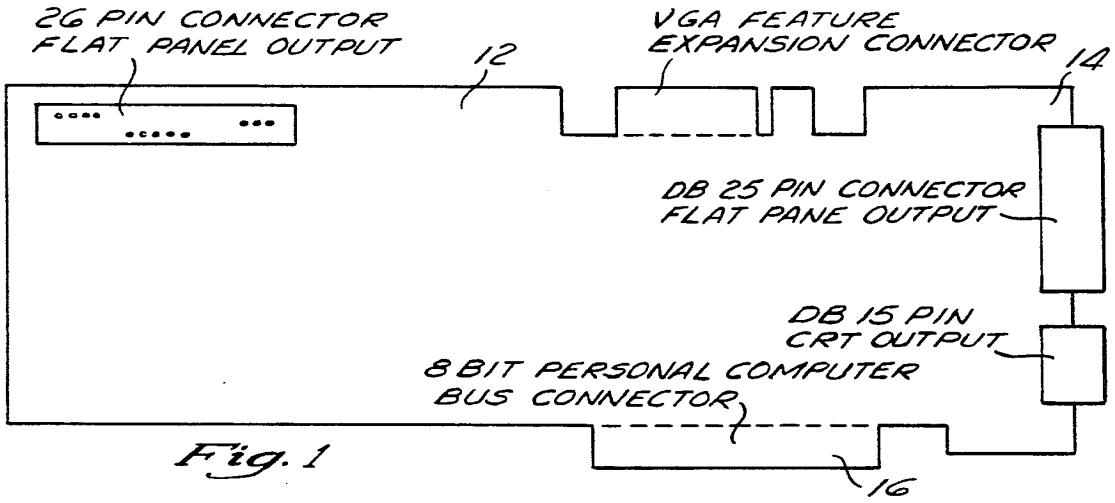

26 PIN CONNECTOR
FLAT PANEL OUTPUT
12
VGA FEATURE
EXPANSION CONNECTOR
14
DB 25 PIN CONNECTOR
FLAT PANE OUTPUT
DB 15 PIN
CRT OUTPUT
8 BIT PERSONAL COMPUTER
BUS CONNECTOR
16

Fig. 1

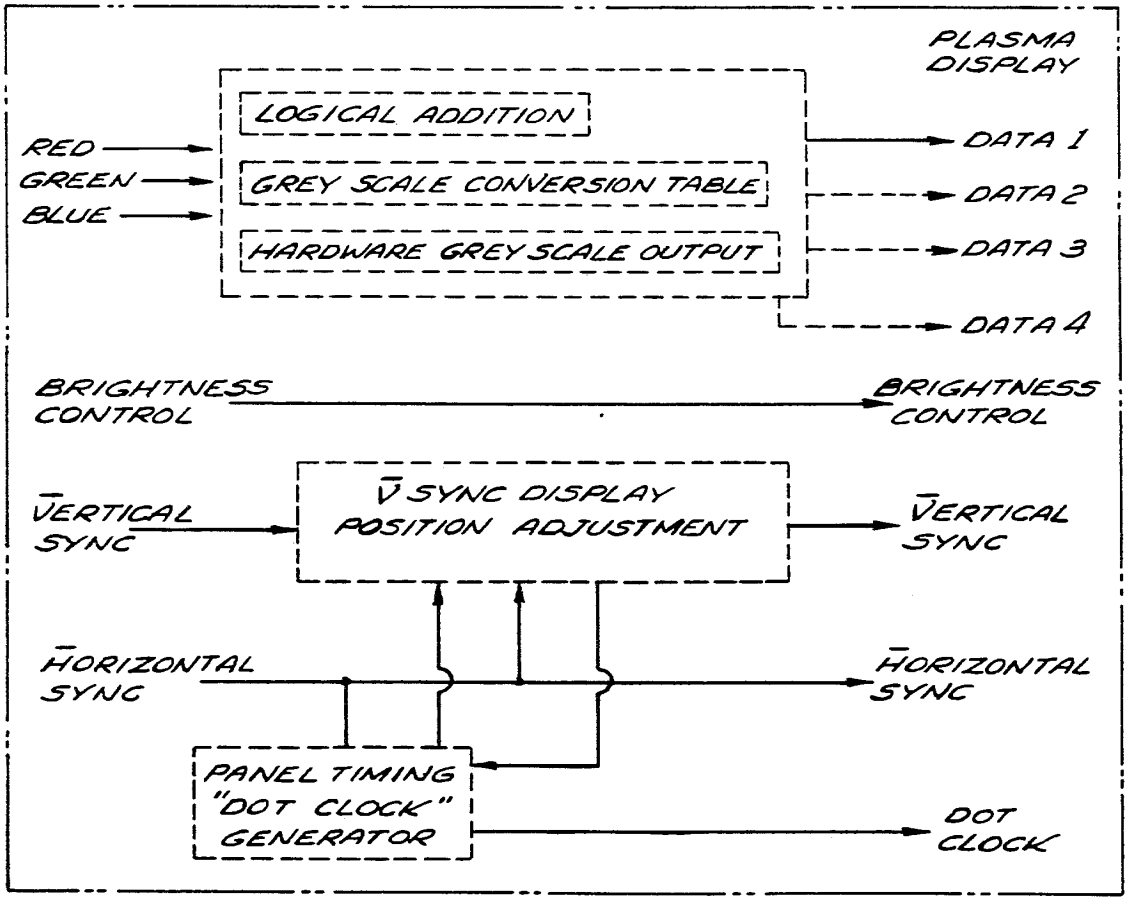

PLASMA
DISPLAY
LOGICAL ADDITION
RED
GREEN
BLUE
GREY SCALE CONVERSION TABLE
HARDWARE GREY SCALE OUTPUT
DATA 1
DATA 2
DATA 3
DATA 4
BRIGHTNESS
CONTROL
BRIGHTNESS
CONTROL
V SYNC DISPLAY
POSITION ADJUSTMENT
VERTICAL
SYNC
VERTICAL
SYNC
HORIZONTAL
SYNC
HORIZONTAL
SYNC
PANEL TIMING
"DOT CLOCK"
GENERATOR
DOT
CLOCK

Fig. 3

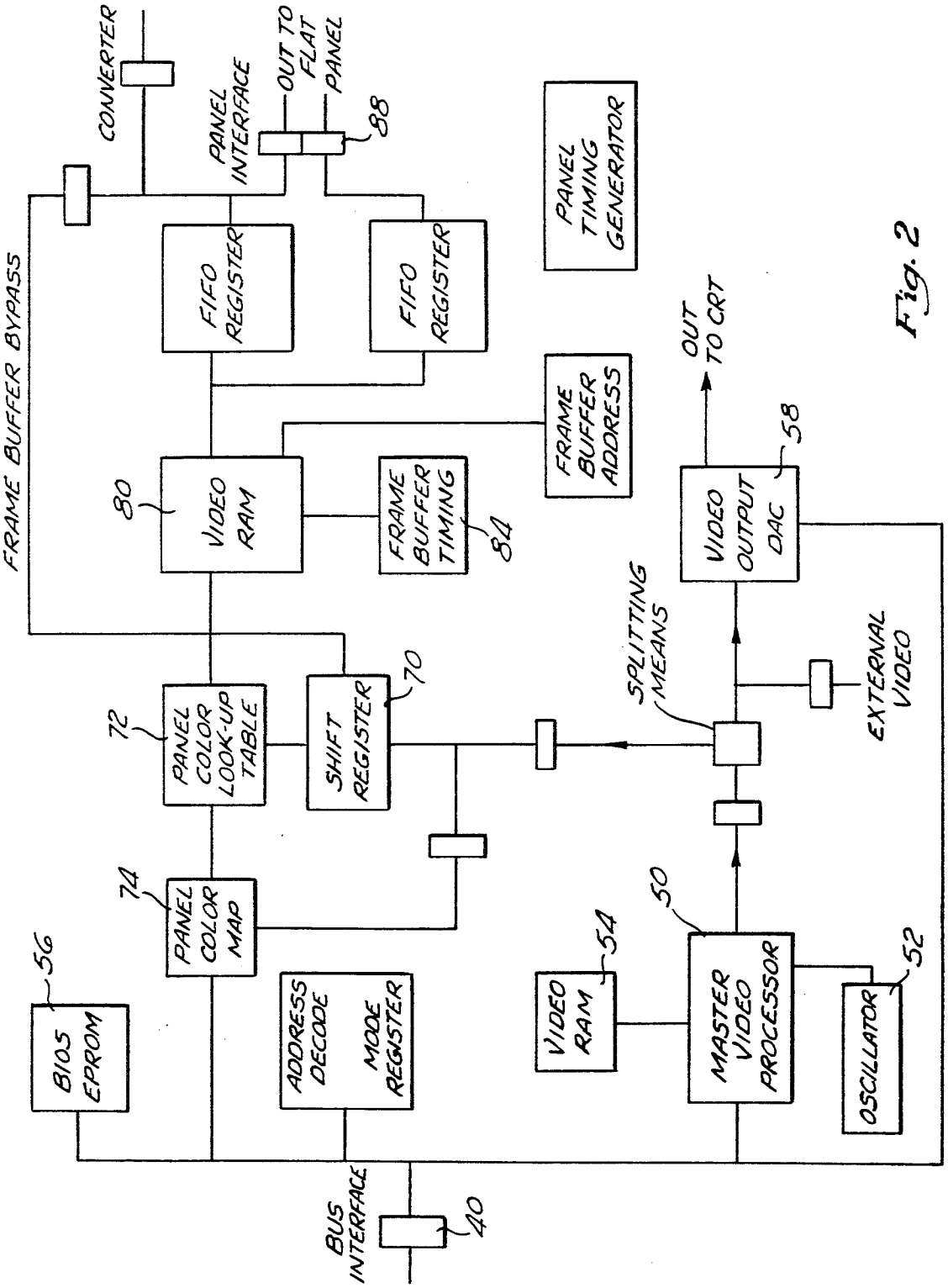

CONVERTER
PANEL INTERFACE
OUT TO FLAT PANEL
88
PANEL TIMING GENERATOR
FRAME BUFFER BYPASS
FIFO REGISTER
FIFO REGISTER
OUT TO CRT
FRAME BUFFER ADDRESS
80
VIDEO RAM
FRAME BUFFER TIMING
84
VIDEO OUTPUT DAC
58
SPLITTING MEANS
EXTERNAL VIDEO
72
PANEL COLOR LOOK-UP TABLE
SHIFT REGISTER
70
74
PANEL COLOR MAP
56
BIOS EPROM
ADDRESS DECODE
MODE REGISTER
VIDEO RAM
54
50
MASTER VIDEO PROCESSOR
52
OSCILLATOR
BUS INTERFACE
40

Fig. 2

VGA CONTROLLER CARD

BACKGROUND OF THE PRESENT INVENTION

The present invention relates generally to data processing and display systems, and more particularly to a bus mountable VGA controller card for use on IBM personal computer products namely, the IBM PC, PC/XT, PC/AT, and PS/2 and their one-hundred percent compatable clone computer products (hereinafter collectively referred to as IBM PC computers) to provide VGA (video graphic array) standard signals to drive conventional cathode ray tube (CRT) and flat panel displays. (IBM, PC/XT, and PC/AT are registered trademarks of International Business Machines).

Since initial introduction in the late-1960's, the personal computer has become the mainstay of both small and large businesses alike. With specific reference to IBM PC Computers, there has been a recent demand for enhanced video graphic capability to allow such personal computers to meet the more sophisticated demands of the marketplace. Pursuant to this demand, EGA (enhanced graphic array) graphics became the initial industry standard for business applications of personal computers which EGA standard offered a 640 by 350 pixel by 16 color resolution. By use of such EGA standards on the IBM PC computers and ther industry standard clones, such IBM personal computers were capable of providing video graphics to personal computer users.

In recognizing the substantial demand for improved video graphic capability on personal computers, International Business Machines (IBM) in 1987 introduced its PS/2 (trademark of International Business Machines) personal computer which adopted a new graphic standard, i.e. the VGA standard. Unlike the EGA standard, the VGA standard is able to both read and write hardware registers and offers increased 640×480 color resolution. The new IBM VGA standard as adopted on the IBM PS/2 computer, has been recognized as providing a substantial improvement in the art, and use of the standard is contemplated far into the future.

In view of the enhanced graphic capabilities of the VGA standard, owners of the previous PC, PC/XT and PC/AT personal computers have been faced with the decision of either purchasing a new PS/2 system which possesses the new VGA standard, or alternatively attempting to upgrade their existing PC, PC/XT, or PC/AT system to emulate the VGA standard. As will be recognized, the purchasing of the new PS/2 system proves to be a costly capital expenditure and hence is prohibitive. In relation to such upgrading to the VGA standard, VGA boards have recently been introduced into the marketplace which may be installed upon the IBM PC, PC/XT or PC/AT computers to emulate the new VGA standard. Examples of such VGA boards comprise those manufactured by Everex, Intelligent Data Systems, Paradise Systems, Sigma Designs, Tatung, Taxan, Tecmar, and Video Seven. Such VGA boards have generally failed to be completely interchangeable in functionality with the VGA standard because they typically embodied only (basic input output system) compatability and not hardware register compatability (hardware compatability) with the VGA standard. As such, the prior art VGA boards, although touting to be the functional equivalent of the VGA standard of the PS/2 system have generally failed to be completely 100% compatable with the same. As such

there exists a substantial need in the art for an improved VGA controller card or board which is 100% compatable with IBM PC computers to provide VGA standard signals to drive conventional CRT displays.

In addition, in recent years, flat panel displays have been introduced into the marketplace which serve as a dominant future substitute for conventional CRT display systems. The advantage of such flat panel displays over conventional CRT displays is their reduced power consumption, reduced physical size and reduced costs as well as improved environmental aspects such as reduced radiation exposure and/or leakage. Although the prior art VGA boards discussed above have been developed for use with conventional CRT displays, they have been completely unavailable for use on flat panel displays due the different timing frequencies and operational characteristics associated with the flat panel displays. As such, to date there is a substantial void in the prior art to allow VGA standard graphics for use with flat panel displays. Thus, there additionally exists a substantial need in the art for a VGA controller to enable use of the VGA standard on conventional flat panel displays.

Additionally, the VGA standard implemented through the PS/2 system is additionally incapable of being utilized to drive flat panel displays. Thus there exists a need in the art for a VGA controller which will enable implementation of the VGA standard on both flat panel displays and well as CRT display systems.

SUMMARY OF THE PRESENT INVENTION

The present invention specifically addresses and alleviates the above referenced deficiencies associated in the prior art. More particularly, the present invention comprises a bus mountable VGA controller card for use on IBM personal computers, namely the PC, PC/XT and PC/AT and PS/2 and their one-hundred percent compatable clone products to provide VGA standard signals to drive conventional CRT displays. In this regard, the VGA controller card of the present invention is one-hundred percent hardware compatable with the VGA standard, and hence comprises the first completely compatable VGA card for such IBM personal computers.

Additionally, the present invention comprises a VGA controller card which is specifically adapted for use to drive flat panel displays. In this regard, the present invention comprises means for preliminarily storing standard VGA signals in a register and outputting such standard VGA signals in a timed sequence sufficient for use on flat panel displays. As such, the present invention fills a significant void existing in the industry for use of VGA signals to drive flat panel displays.

In addition, the VGA controller of the present invention is specifically adapted to allow VGA signals to be independently and simultaneoustly used to drive conventional CRT and flat panel displays.

DESCRIPTION OF THE DRAWINGS

These as well as other features of the present invention will become more apparent upon reference to the drawings wherein:

FIG. **1** is a depiction of the VGA controller card of the present invention illustrating the manner in which it may be mounted upon the bus of a personal computer;

FIG. **2** is an electrical flow chart of the VGA controller card of the present invention; and

FIG. 3 is a schematic depiction of the manner in which the VGA standard signals for CRT displays are converted for driving flat panel displays.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, there is shown the VGA controller card 10 of the present invention composed generally of a printed circuit board 12 having overall dimensions dependent upon preferred implementation but typically approximately 5 inches by 8 inches and a conventional edge connector 14 suitable to allow plug in mounting upon a complementary mounting port (not shown) found on the bus of an IBM personal computer (not shown). An additional edge connector 16 is additionally provided for connection to conventional cables (not shown) extending to a conventional CRT display or flat panel display. As will become more apparent infra, a VGA controller card 10 of the present invention functions to provide VGA standard signals to drive conventional CRT displays as well as provide standard VGA signals in a time sequence sufficient for driving flat panel displays. Further, the VGA controller card 10 of the present invention is specifically adapted to allow VGA signals to be independently and simultaneously used to drive both conventional CRT and flat panel panel displays.

Referring to FIG. 2, the particular architecture of the VGA controller 10 of the present invention is depicted. As shown, the architecture includes a conventional bus interface 40 whereby display signals are communicated to a master video processor 50 which in the preferred embodiment is implemented as an Intel 82706 video graphics array processor. This particular video graphics array processor comprises a VGA compatable display controller which is one-hundred percent register compatable with all IBM VGA standard operational modes and provides software compatability at the level with EGA, CGA and MDA standards. The processor 50 includes an oscillator clock 52, video RAM 54 and bios EPROM 56 which serve to output from the processor 50 a VGA standard signal. In the preferred embodiment, the clock 52, RAM 54 and EPROM 56 are preferably implemented as conventional crystal oscillators such as MTR or Toyocom 28.322 mHz, 25.175 mHz, 32.514 mHz TTL oscillator, a 64×4 dynamic random access memory such as a Fujitsu MB 81464-10 RAM and a 256,000 byte electronically programmable read only memory such as a Fujitsu MBM 27256-20 Eprom, respectively. The output VGA signal is subsequently utilized in a video output DAC 58 such as an Inmos G 171 RAMDAC or Brooktree BT 471/478 series RAMDAC which includes a conventional color look up table. Subsequently, the signal from the video output 58 may be communicated to a conventional CRT (not shown).

As will be recognized, through the implementation of the VGA controller card 10 of the present invention as described supra, the output signal from the video output DAC 58 due to the one-hundred percent register compatible video graphics array processor 50 comprises the same VGA standard signal as generated from the IBM PS/2 system. As such, by use of the VGA controller card 10 of the present invention conventional IBM personal computers may be upgraded to the VGA standard in a simple and cost effective manner whereby VGA standard signals may be utilized to drive conventional CRT displays.

In the preferred embodiment, the VGA signal outputted from the processor 50 is split or branched such that the VGA signal is simultaneously input into the video output DAC 58 to drive a conventional CRT display in a manner described above as well as input into a flat panel display conversion circuit adapted to convert the standard VGA signal into a timed, synchronized data signal sufficient for driving conventional flat panel displays.

In this regard, as opposed to conventional CRT displays which utilize a conventional raster scanning display method, flat panel displays utilize a line scanning display method which require the VGA signal to be synchronized in time prior to output to the flat panel display. In this regard, conventional CRT display systems display pixels at a rate determined by hardware. This rate is variously known as the video bandwidth, the dot rate or the pixel rate and the oscillator that generates such a rate is conventionally known as a dot clock. Given the dot rate, differing CRT displays are programmed so that the horizontal and vertical scan frequencies sent to the CRT display are limited to frequencies the CRT display may handle. As opposed to conventional CRT display dot rates, conventional flat panel displays utilize differing dot rates which require modification, i.e. conversion of such CRT signals for timing functions suitable for driving flat panel displays.

The flat panel display conversion circuit utilize for this purpose comprises a conventional shift register 70 preferrably implemented as a Texas Instruments LS 174 Serial in Parallel out register or equivalent register which stores the VGA signal output from the processor 50. A conventional panel color look up table 72 is utilized in conjunction with a panel color map 74 which serves to identify the VGA signals in relation to the particular color map utilized for the particular flat panel display. In this regard, it will be recognized that flat panel displays although functioning in a similar manner all have particular unique operating characteristics necessitating differing color maps and look up table data. In the preferred embodiment, the panel color map 74 comprises a 64 by 4 PROM such as that manufactured by Fujitsu while the color look up table 72 is preferably implemented as a Harris CY7C122 256×4 RAM. Subsequently, the VGA signal processed by the color map data is read into a frame buffer 80 for temporary storage. A frame buffer timer 84 is provided which is utilized to adjust the frequency and timing of the VGA signal for the particular flat panel display utilized. Basically, these frame buffer timing functions are dependant upon the particular operating characteristics of the implemented flat panel display and comprises a timing equation for each of the implemented flat panel displays defined by the manufacturer of the flat panel display.

Output from the frame buffer 80 is input into a pair of first-in, first-out registers preferrably implemented as an LS244 octal buffer with signals subsequently being entered into a flat panel interface 88 for connection to a conventional flat panel display.

Referring to FIG. 3, the manipulation or conversion of the VGA signals by way of the flat panel display conversion circuit described supra is illustrated As will be recognized, the VGA signal is composed of conventional red, green and blue signals, brightness control, vertical sync and horizontal sync signals. By way of the flat panel display conversion circuit, the red, green, blue (RGB) signals are processed by logical addition, a gray scale conversion table and hardware gray scale output

to derive plural data signals suitable for driving flat panel displays. The brightness control signal is left unchanged in the conversion circuit while the vertical sync and horizontal sync are modified for display position adjustment and proper timing. As such, standard VGA signals are converted for driving flat panel displays.

With the structure defined, the operation of the VGA controller card **10** of the present invention may be described. In its first operative application, the VGA controller card **10** may be installed upon the bus of the IBM PC, PC/AT, or PC/XT computer system, whereby video signals are processed via the master video processor **50** and outputted to a video output **58** to drive a conventional CRT. Since the video processor **50** generates a VGA signal which is one-hundred percent register compatable with all IBM VGA modes and provides software compatability at bios level and EGA, CGA, and MDA the VGA card **10** of the present invention provides the first 100% hardware compatable VGA card for use on the IBM PC family computers.

In a second operative application, when installed upon the IBM PC family computer, VGA signals from the processor **50** are intercepted or divided prior to introduction into the video output **58** and are placed in a register **70** Subsequently, the panel color look up table **72** and panel color map **74** are utilized to output the VGA signal from the shift register into a frame buffer for temporary storage. Upon identifying the particular flat panel display desired to be utilized for display of the signal The frame buffer timer **84** outputs a properly synchronized VGA signal to the flat panel display As such in this second operative embodiment, the VGA controller card **10** of the present invention enables VGA graphic capability upon a flat panel display.

In a third operative embodiment, it will be recognized that the VGA controller card **10** of the present invention provides independent and simultaneous output of VGA signals to both a conventional CRT display as indicated in the first operative application discussed above, as well as flat panel displays as indicated in the second operative application discussed above. As such, the VGA card **10** of the present invention accommodates both CRT and flat panel display systems for VGA signals.

Finally, from the above description, it will be recognized that the VGA signal which is intercepted in the present invention for use in driving flat panel displays comprises the actual or same VGA standard signal generated upon the IBM PC/2 system. As such, the VGA controller card **10** of the present invention may be utilized upon an IBM PS/2 computer to enable the VGA signal generated therefrom to be processed in a manner previously described to generate a VGA signal suitable for driving flat panel displays which heretofore has been unavailable in the prior art.

Those skilled in the art will recognize that for purposes of description certain hardware implementations have been defined herein. However, modifications to such hardware specifications can be made without departing from the spirit of the present invention and such modifications are clearly contemplated herein.

What is claimed is:

1. A bus mountable VGA controller for use on personal computers comprising:

(a) a circuit board having means for interfacing said circuit board to the bus of a personal computer;

(b) a video graphics array processor for converting video signals presented on said bus to generate VGA standard signals; wherein said video graphics array processor is register compatible with VGA standard operational modes; wherein said video graphics array processor comprises an Intell 82706;

(c) means for converting said VGA standard signals to a time synchronized video signal suitable for driving a flat panel display comprising;

(i) register means for storing said VGA standard signal;

(ii) color table and map means for identifying said stored VGA standard signal in reference to the flat panel display to be utilized;

(iii) frame buffer means for storing said VGA standard signal processed by said color table and map means;

(iv) timer means to adjust the frequency and timing of said VGA standard signal stored in said frame buffer means; and

(v) first-in, first-out frame buffer means for outputting said VGA standard signal to a flat panel display; and

(vi) means for converting said standard VGA signal from a raster scan display format to a line scan display format; and

(d) a means for splitting a signal disposed between said video graphics array processor and said converting means, wherein said VGA standard signal is split into first and second VGA standard signal, said first VGA standard signal being applied to said converting means for driving a flat panel display and said second VGA standard signal being applied to an output DAC to drive a conventional CRT display.

2. The bus mountable controller for use on personal computers as recited in claim **1** wherein said register means comprises a Texas Instruments LS174 serial in, parallel-out register.

3. The bus mountable controller for use on personal computers as recited in claim **1** wherein said color table comprises a Harris CYC7C122 256×4 RAM.

4. The bus mountable controller for use on personal computers as recited in claim **1** wherein said color map comprises a Fujitsu 64×4 PROM.

5. The bus mountable controller for use on personal computers as recited in claim **1** wherein said first-in, first-out frame buffer means comprises an LS244 octal buffer.

* * * * *

EXHIBIT 1017

US005642171A

United States Patent [19]

Baumgartner et al.

[11] **Patent Number: 5,642,171**

[45] **Date of Patent: Jun. 24, 1997**

[54] **METHOD AND APPARATUS FOR SYNCHRONIZING AUDIO AND VIDEO DATA STREAMS IN A MULTIMEDIA SYSTEM**

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[73] Assignee: **Dell USA, L.P.**, Round Rock, Tex.

[21] Appl. No.: **255,604**

[22] Filed: **Jun. 8, 1994**

[51] **Int. Cl.**[6] **H04N 5/04**

[52] **U.S. Cl.** **348/515**; 395/806

[58] **Field of Search** 348/515; 395/154, 395/162–164; 345/122; 375/355; H04N 5/04, 5/12

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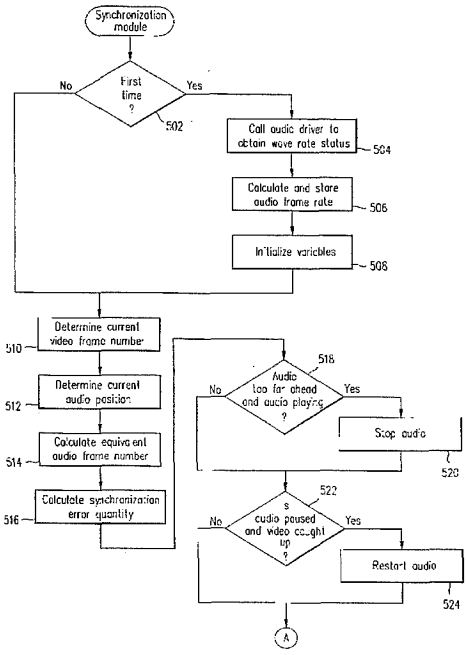
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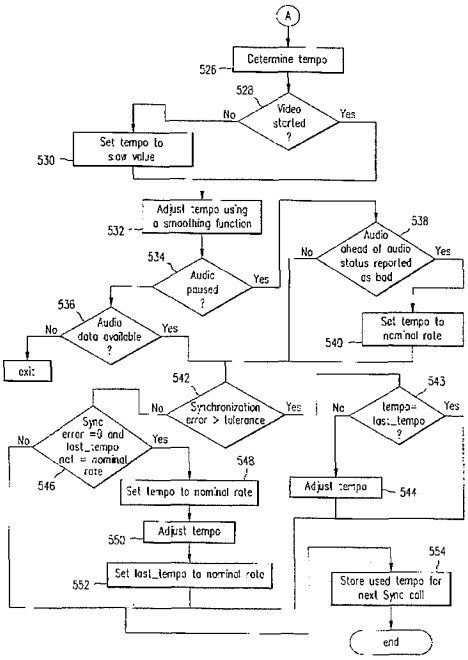
Primary Examiner—Sherrie Hsia

[57] **ABSTRACT**

A method and apparatus for synchronizing audio and video data streams in a computer system during a multimedia presentation to produce a correctly synchronized presentation. The preferred embodiment of the invention utilizes a nonlinear feedback method for data synchronization. The method of the present invention periodically queries each driver for the current audio and video position (or frame number) and calculates the synchronization error. The synchronization error is used to determine a tempo value adjustment to one of the data stream designed to place the video and audio back in sync. The method then adjusts the audio or video tempo to maintain the audio and video data streams in synchrony. In the preferred embodiment of the invention, the video tempo is changed nonlinearly over time to achieve a match between the video position and the equivalent audio position. The method applies a smoothing function to the determined tempo value to prevent overcompensation. The method of the present invention can operate in any hardware system and in any software environment and can be adapted to existing systems with only minor modifications.

40 Claims, 7 Drawing Sheets





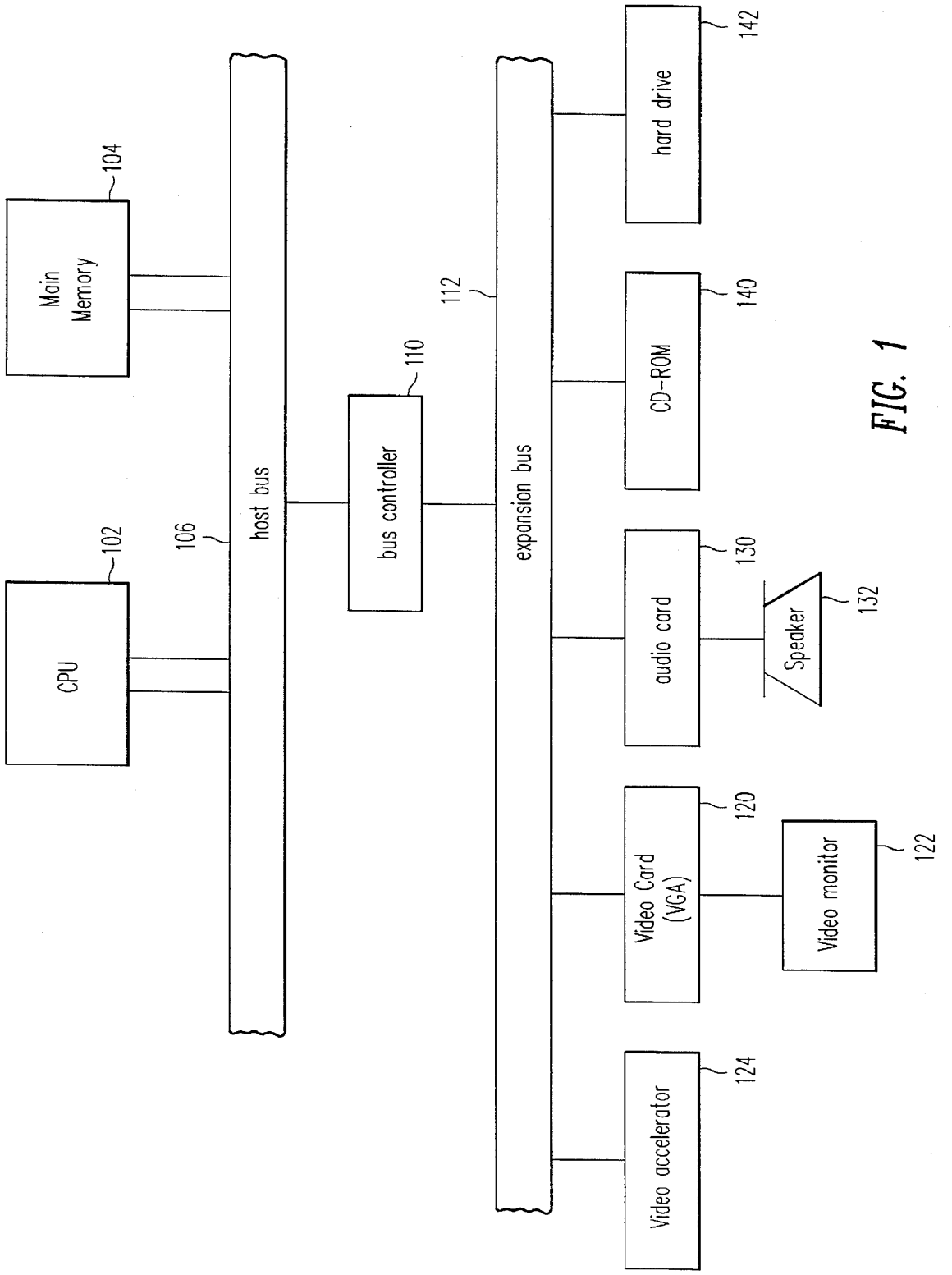

Main Memory
104
CPU
102
106
host bus
bus controller
110
112
expansion bus
hard drive
142
CD-ROM
140
audio card
130
Speaker
132
Video Card (VGA)
120
Video monitor
122
Video accelerator
124

FIG. 1

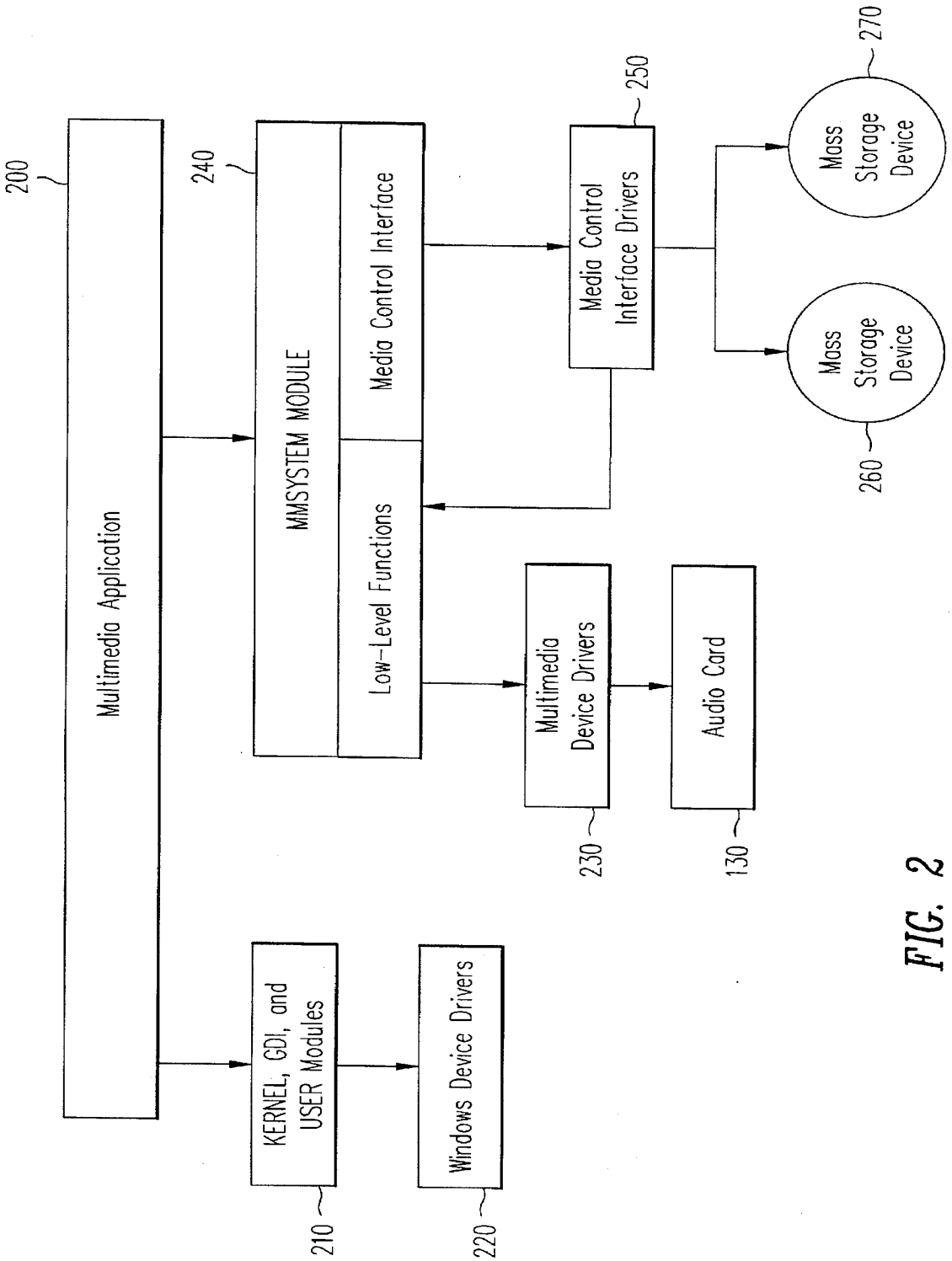

200
Multimedia Application
240
MMSYSTEM MODULE
Media Control Interface
Low-Level Functions
250
Media Control Interface Drivers
270
Mass Storage Device
260
Mass Storage Device
230
Multimedia Device Drivers
130
Audio Card
210
KERNEL, GDI, and USER Modules
220
Windows Device Drivers

FIG. 2

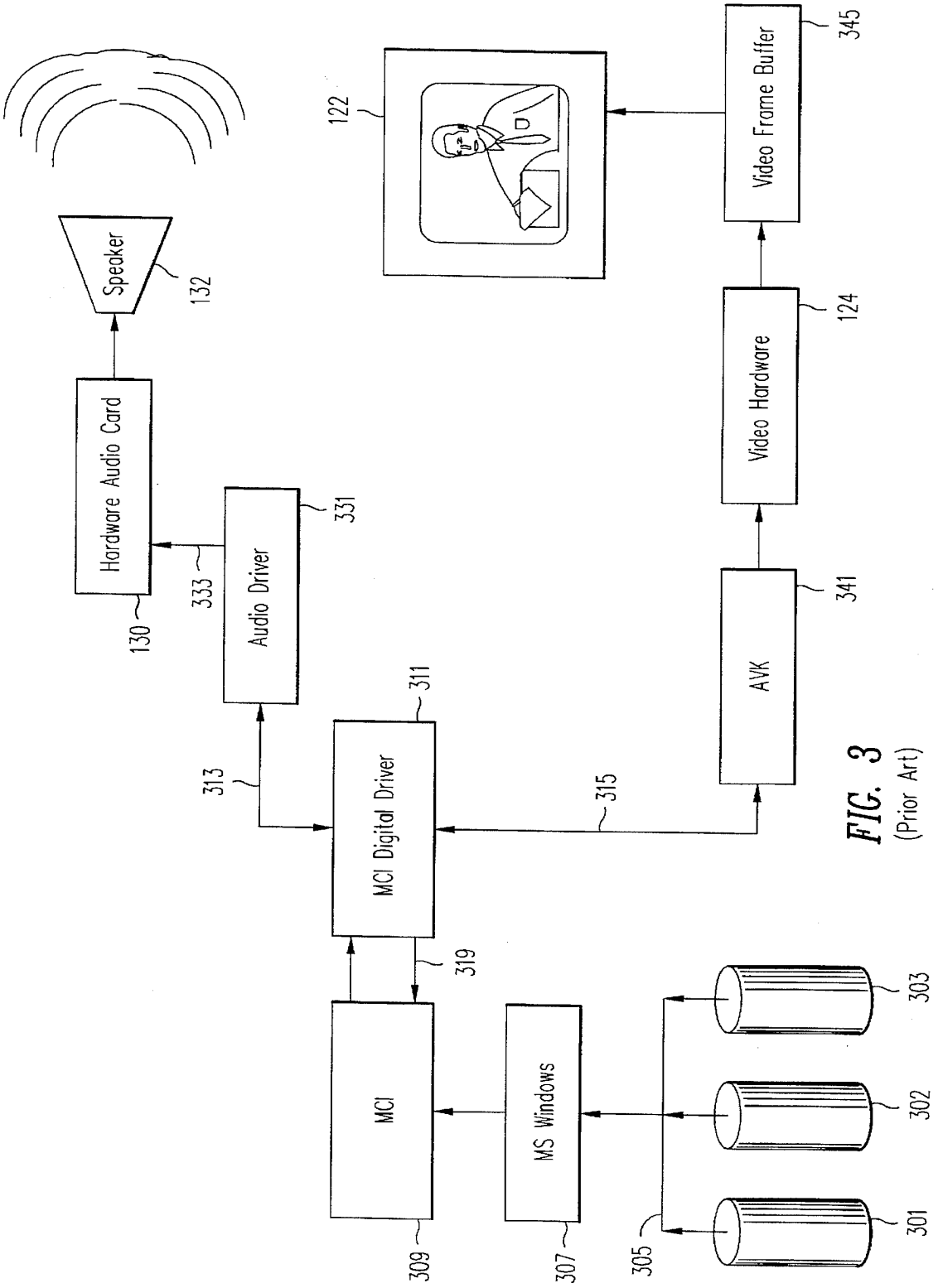


FIG. 3
(Prior Art)

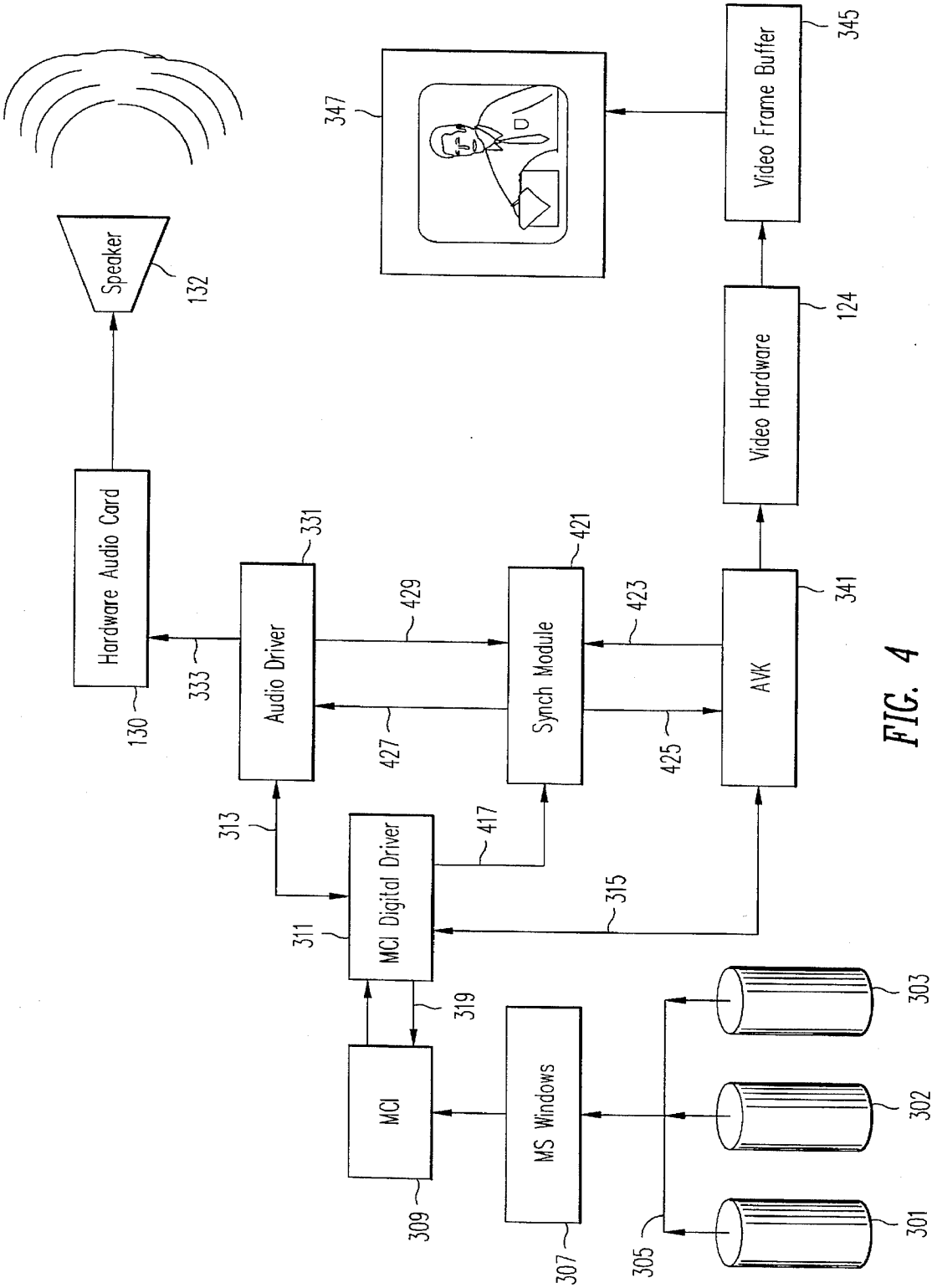

Speaker
132
347
Video Frame Buffer
345
Hardware Audio Card
130
333
Audio Driver
331
429
Synch Module
421
423
AVK
341
Video Hardware
124
427
425
313
MCI Digital Driver
311
417
315
319
MCI
309
MS Windows
307
305
303
302
301

FIG. 4

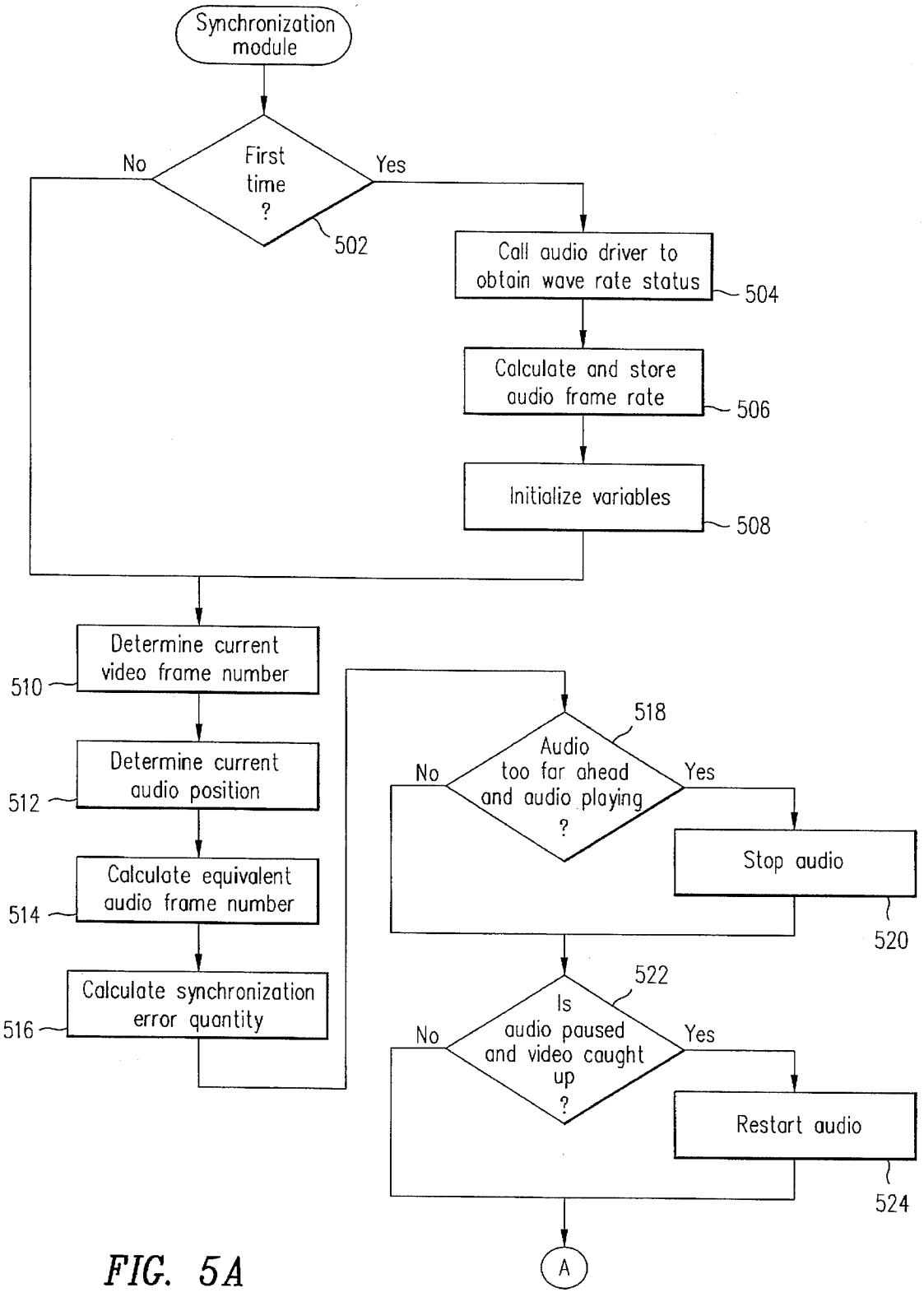
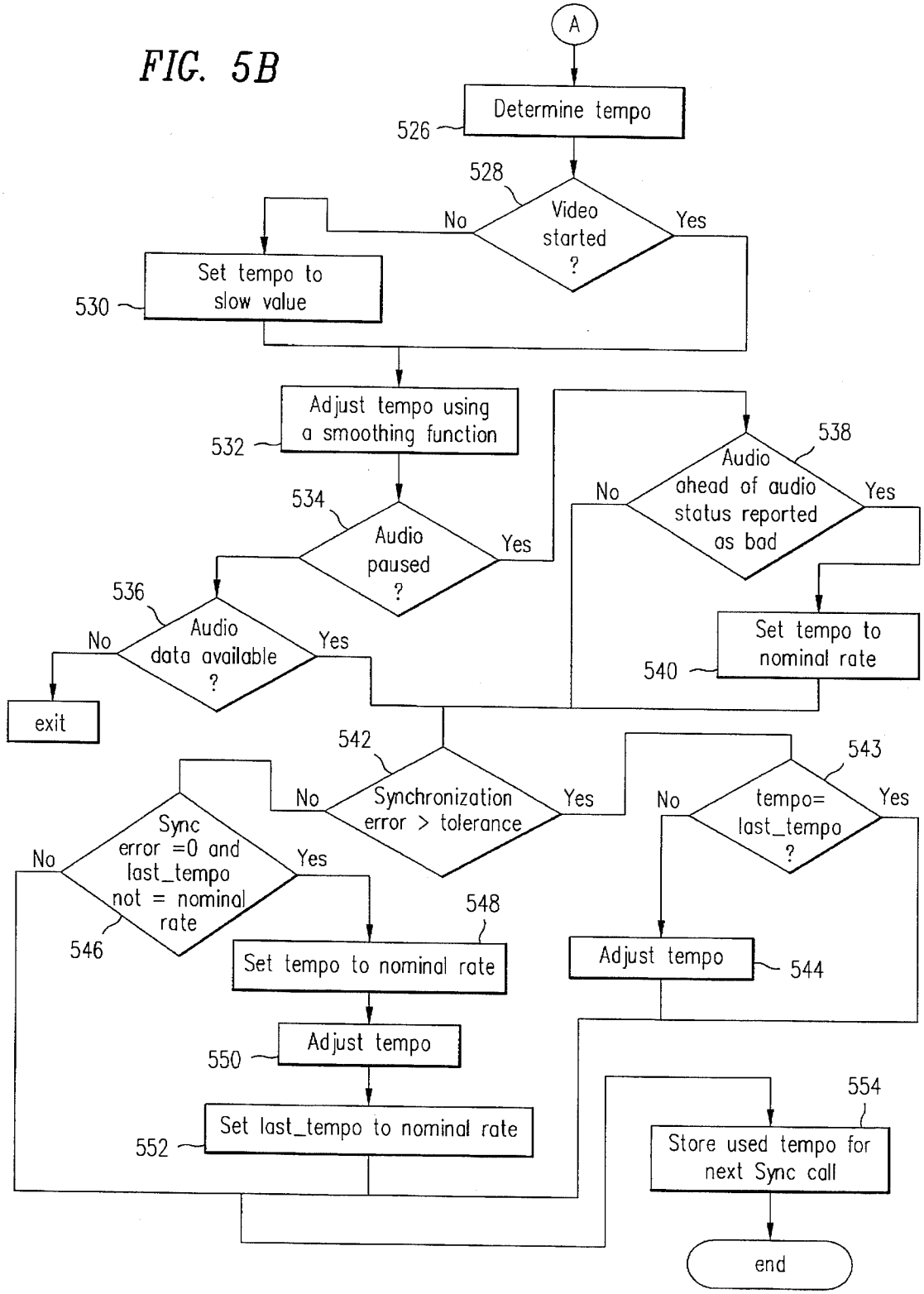

Synchronization module
First time ?
No
Yes
502
Call audio driver to obtain wave rate status
504
Calculate and store audio frame rate
506
Initialize variables
508
Determine current video frame number
510
Determine current audio position
512
Calculate equivalent audio frame number
514
Calculate synchronization error quantity
516
Audio too far ahead and audio playing ?
518
No
Yes
Stop audio
520
Is audio paused and video caught up ?
522
No
Yes
Restart audio
524
A

FIG. 5A

FIG. 5B


A
Determine tempo
526
528
Video started ?
No
Yes
Set tempo to slow value
530
Adjust tempo using a smoothing function
532
534
Audio paused ?
Yes
536
Audio data available ?
No
Yes
exit
538
Audio ahead of audio status reported as bad
No
Yes
Set tempo to nominal rate
540
542
Synchronization error > tolerance
No
Yes
Sync error =0 and last_tempo not = nominal rate
No
Yes
546
548
Set tempo to nominal rate
Adjust tempo
550
Set last_tempo to nominal rate
552
543
tempo= last_tempo ?
No
Yes
Adjust tempo
544
554
Store used tempo for next Sync call
end

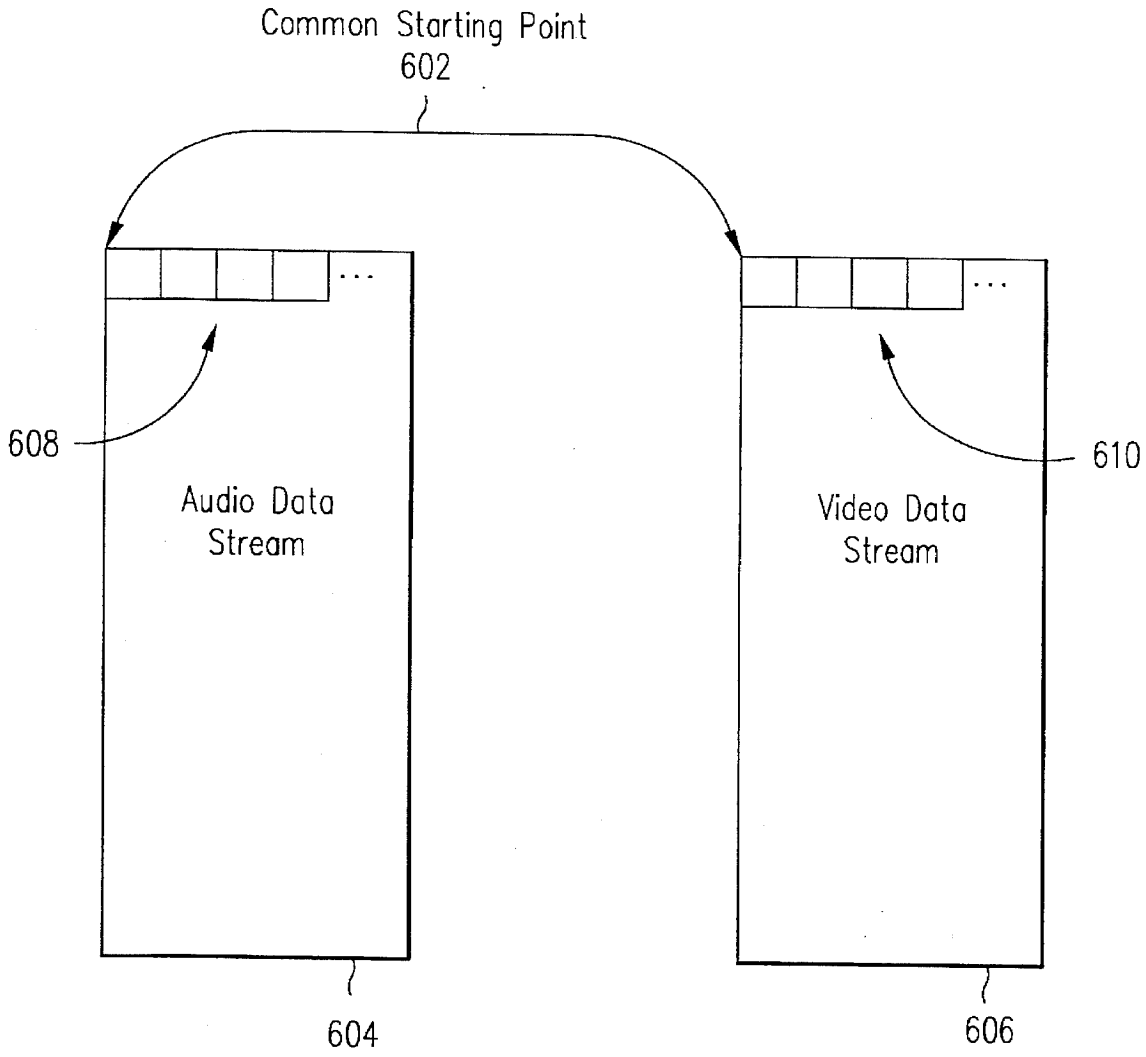

Common Starting Point
602
608
Audio Data
Stream
610
Video Data
Stream
604
606

FIG. 6

METHOD AND APPARATUS FOR SYNCHRONIZING AUDIO AND VIDEO DATA STREAMS IN A MULTIMEDIA SYSTEM

FIELD OF THE INVENTION

The present invention relates generally to multimedia computer systems, and more particularly to a method and apparatus for synchronizing video and audio data streams in a computer system during a multimedia presentation.

DESCRIPTION OF THE RELATED ART

Multimedia computer systems have become increasingly popular over the last several years due to their versatility and their interactive presentation style. A multimedia computer system can be defined as a computer system having a combination of video and audio outputs for presentation of audio-visual displays. A modem multimedia computer system typically includes one or more storage devices such as an optical drive, a CD-ROM, a hard drive, a videodisc, or an audiodisc, and audio and video data are typically stored on one or more of these mass storage devices. In some file formats the audio and video are interleaved together in a single file, while in other formats the audio and video data are stored in different files, many times on different storage media. Audio and video data for a multimedia display may also be stored in separate computer systems that are networked together. In this instance, the computer system presenting the multimedia display would receive a portion of the necessary data from the other computer system via the network cabling.

A multimedia computer system also includes a video card such as a VGA (Video Graphics Array) card which provides output to a video monitor, and a sound card which provides audio output to speakers. A multimedia computer system may also include a video accelerator card or other specialized video processing card for performing video functions, such as compression, decompression, etc. When a computer system displays a multimedia presentation, the computer system microprocessor reads the audio and video data stored on the respective mass storage devices, or received from the other computer system in a distributed system, and provides the audio stream through the sound card to the speakers and provides the video stream through the VGA card and any specialized video processing hardware to the computer video monitor. Therefore, when a computer system presents an audio-visual display, the audio data stream is decoupled from the video data stream, and the audio and video data streams are processed by separate hardware subsystems.

A multimedia computer system also includes an operating system and drivers for controlling the various hardware elements used to create the multimedia display. For example, a multimedia computer includes an audio driver or sound card driver for controlling the sound card and a video driver for controlling the optional video processing card. One example of an operating system which supports multimedia presentations is the Multimedia Extensions for the Microsoft Windows operating system.

Graphic images used in Windows multimedia applications can be created in either of two ways, these being bit-mapped images and vector-based images. Bit-mapped images comprise a plurality of picture elements (pixels) and are created by assigning a color to each pixel inside the image boundary. Most bit-mapped color images require one byte per pixel for storage, so large bit-mapped images create correspondingly large files. For example, a full-screen, 256-color image in 640-by-480-pixel VGA mode requires 307,

200 bytes of storage, if the data is not compressed. Vector-based images are created by defining the end points, thickness, color, pattern and curvature of lines and solid objects comprised within the image. Thus, a vector-based image includes a definition which consists of a numerical representation of the coordinates of the object, referenced to a corner of the image.

Bit-mapped images are the most prevalent type of image storage format, and the most common bit-mapped-image file formats are as follows. A file format referred to as BMP is used for Windows bit-map files in 1-, 2-, 4-, 8-, and 24-bit color depths. BMP files contain a bit-map header that defines the size of the image, the number of color planes, the type of compression used (if any), and the palette used. The Windows DIB (device-independent bit-map) format is a variant of the BMP format that includes a color table defining the RGB (red green blue) values of the colors used. Other types of bit-map formats include the TIF (tagged image format file), the PCX (Zsoft Personal Computer Paintbrush Bitmap) file format, the GIF (graphics interchange file) format, and the TGA (Texas Instruments Graphic Architecture) file format.

The standard Windows format for bit-mapped images is a 256-color device-independent bit map (DIB) with a BMP (the Windows bit-mapped file format) or sometimes a DIB extension. The standard Windows format for vector-based images is referred to as WMF (Windows meta file).

Compression

Full-motion video implies that video images shown on the computer's screen simulate those of a television set with identical (30 frames-per-second) frame rates, and that these images are accompanied by high-quality stereo sound. A large amount of storage is required for high-resolution color images, not to mention a full-motion video sequence. For example, a single frame of NTSC video at 640-by-400-pixel resolution with 16-bit color requires 512K of data per frame. At 30 flames per second, over 15 Megabytes of data storage are required for each second of full motion video. Due to the large amount of storage required for full motion video, various types of video compression algorithms are used to reduce the amount of necessary storage. Video compression can be performed either in real-time, i.e., on the fly during video capture, or on the stored video file after the video data has been captured and stored on the media. In addition, different video compression methods exist for still graphic images and for full-motion video.

Examples of video data compression for still graphic images are RLE (run-length encoding) and JPEG (Joint Photographic Experts Group) compression. RLE is the standard compression method for Windows BMP and DIB files. The RLE compression method operates by testing for duplicated pixels in a single line of the bit map and stores the number of consecutive duplicate pixels rather than the data for the pixel itself. JPEG compression is a group of related standards that provide either lossless (no image quality degradation) or lossy (imperceptible to severe degradation) compression types. Although JPEG compression was designed for the compression of still images rather than video, several manufacturers supply JPEG compression adapter cards for motion video applications.

In contrast to compression algorithms for still images, most video compression algorithms are designed to compress full motion video. Video compression algorithms for motion video generally use a concept referred to as inter-frame compression, which involves storing only the differ-

ences between successive frames in the data file. Interframe compression begins by digitizing the entire image of a key frame. Successive frames are compared with the key frame, and only the differences between the digitized data from the key frame and from the successive frames are stored. Periodically, such as when new scenes are displayed, new key frames are digitized and stored, and subsequent comparisons begin from this new reference point. It is noted that interframe compression ratios are content-dependent, i.e., if the video clip being compressed includes many abrupt scene transitions from one image to another, the compression is less efficient. Examples of video compression which use an interframe compression technique are MPEG, DVI and Indeo, among others.

MPEG (Moving Pictures Experts Group) compression is a set of methods for compression and decompression of full motion video images that uses the interframe compression technique described above. The MPEG standard requires that sound be recorded simultaneously with the video data, and the video and audio data are interleaved in a single file to attempt to maintain the video and audio synchronized during playback. The audio data is typically compressed as well, and the MPEG standard specifies an audio compression method referred to as ADPCM (Adaptive Differential Pulse Code Modulation) for audio data.

A standard referred to as Digital Video Interactive (DVI) format developed by Intel Corporation is a compression and storage format for full-motion video and high-fidelity audio data. The DVI standard uses interframe compression techniques similar to that of the MPEG standard and uses ADPCM compression for audio data. The compression method used in DVI is referred to as RTV 2.0 (real time video), and this compression method is incorporated into Intel's AVK (audio/video kernel) software for its DVI product line. IBM has adopted DVI as the standard for displaying video for its Ultimedia product line. The DVI file format is based on the Intel i750 chipset and is supported through the Media Control Interface (MCI) for Windows. Microsoft and Intel jointly announced the creation of the DV MCI (digital video media control interface) command set for Windows 3.1 in 1992.

The Microsoft Audio Video Interleaved (AVI) format is a special compressed file structure format designed to enable video images and synchronized sound stored on CD-ROMs to be played on PCs with standard VGA displays and audio adapter cards. The AVI compression method uses an interframe method, i.e., the differences between successive frames are stored in a manner similar to the compression methods used in DVI and MPEG. The AVI format uses symmetrical software compression-decompression techniques, i.e., both compression and decompression are performed in real time. Thus AVI files can be created by recording video images and sound in AVI format from a VCR or television broadcast in real time, if enough free hard disk space is available.

In the AVI format, data is organized so that coded frame numbers are located in the middle of an encoded data file containing the compressed audio and compressed video. The digitized audio and video data are organized into a series of frames, each having header information. Each frame of the audio and video data streams is tagged with a frame number that typically depends upon the frame rate. For example, at every 33 milliseconds (ms) or a 30th of a second, a frame number is embedded in the header of the video frame and at every 30th of a second, or 33 ms, the same frame number is embedded in the header of the audio track. The number assigned to the frames is, therefore, coordinated so that the corresponding audio and video frames are originally tagged with the same number. Therefore, since the frames are initially received simultaneously, the frames can actually be preprocessed so that tag codes are placed into the header files of the audio and the video for tracking the frame number and position of the audio and video tracks.

In the AVI format, the audio and video information are interleaved (alternated in blocks) in the CD-ROM to minimize delays that would result from using separate tracks for video and audio information. Also, the audio and video data are interleaved to synchronize the data as it is stored on the system. This is done in an attempt to synchronize the audio and video data during playback.

The Apple QuickTime format was developed by Apple for displaying animation and video on Macintosh computers, and has become a de facto multimedia standard. Apple's QuickTime and Microsoft's AVI take a parallel approach to the presentation of video stored on CD-ROMs, and the performance of the two systems is similar. The QuickTime format, like AVI, uses software compression and decompression techniques but also can employ hardware devices, similar to those employed by DVI, to speed processing. The Apple QuickTime format became available for the PC under Microsoft Windows in late 1992.

As mentioned above, the audio and video data streams in a multimedia presentation are processed by separate hardware subsystems under the control of separate device drivers. The audio and video data are separated into separate data streams that are then transmitted to separate audio and video subsystems. The video data is transmitted to the video subsystem for display, and the audio data is transmitted to the sound subsystem for broadcast. These two subsystems are addressed by separate drivers, and each driver is loaded dynamically by the operating system during a multimedia presentation. In an operating system that is multi-tasking, has multiple drivers, or has multiple windows, the time period between the servicing of drivers is indeterminate. If a driver is not serviced by the operating system in time for the next frame, a portion of the multimedia systems may stall, resulting in the audio not being synchronized with the video. When the audio and video portions of a multimedia presentation become unsynchronized, many times this lack of synchronization is noticeable to the viewer, resulting in a less pleasing display. One result of audio and video data being out of sync is that the viewer may hear words that do not match the lips of the speaker, a situation commonly called "out of lip sync."

Therefore, many times the corresponding audio and video frames of a multimedia presentation are not played synchronously together. The reasons for the audio and video data streams falling out of sync during a presentation include the inherent decoupling of the audio and video data streams in separate subsystems in conjunction with system bottlenecks and performance issues associated with the large amounts of data that are required to be manipulated during a multimedia presentation. As mentioned above, full motion video clips with corresponding audio require massive amounts of system resources to process. However, a considerably greater amount of processing is required to display the video data than is required for the audio data. First the video data must be decompressed either in software or in a codec (compression-decompression) device. If the color depth of the video is higher than that of the display, such as when an AVI file with 16 bit video is played on an 8 bit display, the computer must dither colors to fit within the display's color restrictions. Also, if the selected playback window size is inconsistent with the resolution at which the video was captured, the computer is required to scale each frame.

In addition to the greater amount of processing required for video data, the amount of video processing can vary considerably, thus further adversely affecting synchronization. For example, one variable that affects the speed of video playback is the decompression performed on the video data. The performance of software decompression algorithms can vary for a number of reasons. For example, due to the interframe method of compressing data, the number of bytes that comprise each video frame is variable, depending on how similar the prior video frame is to the current video frame. Thus, more time is required to process a series of frames in which background is moving than is required to process a series of frames containing only minor changes in the foreground. Other variables include whether the color depth of the video equals that of the display and whether the selected playback window size is consistent with the resolution at which the video was captured, as mentioned above.

In addition, a slow CPU adversely affects every stage in the processing of a video file for playback. A sluggish hard disk or CD-ROM controller can also adversely affect performance as can the performance of the display controller or video card. Also, other demands can be made on the system as a result of something as simple as a mouse movement. While the above processing is being performed on the video and audio data, and while other demands are made on system resources, it becomes very difficult to ensure that the audio and video data remain in synchronization.

Video for Windows includes a method which presumably attempts to maintain the audio and video portions of a multimedia display in sync, i.e., attempts to adapt when the computer system cannot keep up with either the video or audio portions of the display. Video for Windows benchmarks the video hardware when it first begins execution as well as every time thereafter that the default display is changed. The results of these tests are used to determine a particular system's baseline display performance at various resolutions and color depths. Video for Windows then uses this information regarding the capabilities of the video system to adjust the video frame rate to match the benchmarked performance for the default display. Video for Windows maintains the continuity of the audio at all costs because a halting audio track is deemed more distracting. When the burden of the video playback is such that the system cannot keep up, Video for Windows skips frames during playback or adjusts the frame rate continuously as the system's resource usage patterns change.

However, the method used by video for Windows in adjusting the video rate to match the benchmarked performance of the default display results in an average frame rate suitable for the benchmark determined at the time the default was last changed. Attempts to display video frames containing an unusually heavy amount of non-repetitive data will slow processing down to the point where the benchmarked frame rate is no longer useful. When this happens, video frames are skipped because the burden of processing the video data becomes too great to preserve lip-sync in the display. The result can be "jerky" movement of the images of persons speaking as noted in *Discover Windows* 3.1 *Multimedia*, by Roger Jennings (Que Corp. 1992), p. 105–106. Thus, the method used by Video for Windows has proven to be inadequate, i.e., the video and audio portions still fall out of sync or exhibit "jerky" movement during a presentation.

Shortcomings inherent in decoupled audio multimedia systems have been a problem for some time, and various efforts have been made to synchronize the audio and video portions of a presentation. There has been a recognized need in the industry for a solution to this problem. However, no satisfactory solution has been found, prior to the present invention.

Therefore, a method and apparatus is desired which provides improved synchronization between digital audio and digital video data streams in a multimedia computer system, i.e., a method is needed to assure that corresponding video and audio frames are played back together. A synchronization method is also desired that does not require the use of an encoding procedure prior to the processing of audio and video digital signals. It is also desirable to provide a multimedia synchronization system that is capable of functioning consistently whether video and audio data are delivered to the system in separate files or interleaved in one file.

SUMMARY OF THE INVENTION

The present invention comprises a method and apparatus for synchronizing separate audio and video data streams in a multimedia system. The preferred embodiment of the invention utilizes a nonlinear feedback method for data synchronization that is independent of hardware, the operating system and the video and audio drivers used. The system and method of the present invention does not require that incoming data be time stamped, or that any timing information exist in the video data stream relative to audio and video data correspondence. Further, the data is not required to be modified in any way prior to the transfer of data to the video and audio drivers, and no synchronization information need be present in the separated audio and video data streams that are being synchronized by the system and method of the present invention. The preferred embodiment of the present invention requires that there be a common starting point for the audio and video data, i.e., that them be a time index of zero where the audio and video are both in synchrony, such that the first byte of audio and video digital data are generated simultaneously.

The synchronization method of the present invention is called periodically during a multimedia display to synchronize the video and audio data streams. In the preferred embodiment, a periodic timer is set to interrupt the multimedia operating system at uniform intervals during a multimedia display and direct the operating system to invoke the synchronization method of the present invention. When the synchronization method is invoked, the method first queries the video driver to determine the current video frame position and then queries the audio driver to determine the current audio position. The current audio position is then used to compute the equivalent audio frame number. The synchronization method compares the video and audio frame positions and computes a synchronization error value, which is essentially the number of frames by which the video frame position is in front of or behind the current audio frame position.

The synchronization error is used to assign a tempo value meaningful to either the video driver or the audio driver. In the preferred embodiment, the method adjusts the video tempo to maintain video synchronization, but in an alternate embodiment the method adjusts the audio tempo to maintain synchronization. Once a video tempo value has been determined, the preferred method adjusts this video tempo value by applying a smoothing function, i.e., a weighted average of prior tempo values, to the determined tempo value. If the synchronization error is determined to be greater than a defined tolerance, i.e., if the audio and video data streams are more than a certain number of flames out of

sync, and if the tempo value is not equal to the last tempo value previously sent to the video driver, then the method adjusts the video frame speed by passing the tempo value to the video driver.

If the synchronization error is approximately 0, i.e., the audio and video data streams are substantially in sync, and the prior determined tempo value passed to the video driver was not the nominal rate, i.e., the rate intended to exactly match the audio rate, the method passes a video tempo value at the nominal rate to the video driver. In other words, if the audio and video data streams are in sync, a tempo value at the nominal rate is passed to the video driver. This removes any affects of the smoothing function, which otherwise would change the tempo value to other than the nominal rate.

The method also determines if the audio is too far ahead of the video and if the audio is playing. If so, the audio is paused to allow the video to catch up. If the method determines that the audio is paused and that the video has caught up, the method restarts the audio. The method saves the video tempo value for comparison during the next call by the periodic timer and surrenders control to the operating system until called again.

Therefore, the present invention provides an improved method of synchronizing the audio and video data streams during a multimedia presentation to provide a correctly synchronized presentation. The present invention permits the use of existing software drivers and multimedia operating systems. Further, the method of the present invention operates independently of where the audio and video data are stored as well as the type of operating system or drivers being used. Thus the present invention operates regardless of whether the audio and video data are interleaved in one file, stored on different media, or stored in separate computer systems. Also, the present invention does not require any type of time stamping or tagging of data, and thus does not require any modification of the video or audio data. Further, the present invention operates regardless of the type of compression/decompression algorithm used on the video data.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention can be obtained when the following detailed description of the preferred embodiment is considered in conjunction with the following drawings, in which:

FIG. **1** illustrates a block diagram of a multimedia computer system according to one embodiment of the invention;

FIG. **2** is a block diagram illustrating a typical multimedia control system;

FIG. **3** is a block diagram illustrating a prior art multimedia software architecture;

FIG. **4** is a block diagram illustrating a multimedia software architecture incorporating the synchronization method of the present invention; and

FIGS. **5A–B** are flowchart diagrams illustrating operation of the synchronization method of the present invention.

FIG. **6** illustrates audio and video data streams having a common starting point.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Multimedia Computer System

Referring now to FIG. **1**, a block diagram illustrating a multimedia computer system according to one embodiment of the present invention is shown. It is noted that FIG. **1** illustrates only portions of a functioning computer system, and those elements not necessary to the understanding of the operation of the present invention have been omitted for simplicity. As shown, the multimedia computer system includes a CPU **102** coupled to a host bus **106**. Main memory **104** is also coupled to the host bus **106**. The host bus **106** is coupled to an expansion bus **112** by means of a bus controller **110**. The expansion bus may be any of various types including the AT (advanced technology) bus or industry standard architecture (ISA) bus, the EISA (extended industry standard architecture) bus, a microchannel (MCA) bus, etc. A video card or video adapter such as a VGA (video graphics array) card **120** is coupled to the expansion bus **112** and is adapted to interface to a video monitor **122**, as shown. The computer system may also include a video accelerator card **124** for performing compression/decompression (codec) functions. However, in the preferred embodiment the computer system does not include a video accelerator card. An audio card or sound card **130** is also coupled to the expansion bus **112** and interfaces to a speaker **132**. The audio board **130** is preferentially a Sound Blaster II brand card made by Creative Labs, Inc. of Milpitas, Calif.

Various mass storage devices are also coupled to the expansion bus **112**, preferably including a CD-ROM **140**, and a hard drive **142**, as well as others. One or more of these mass storage devices store video and audio data which is used during presentation of a multimedia display. The audio and video data may be stored in any of a number of formats and may be stored on different media. Further, the audio and video data may be stored on media located in other computer systems that are connected to the computer system via a network. Thus the present invention can operate in a distributed environment.

It is noted that a multimedia computer system according to the present invention may be configured in any of a number of ways. For example, the video and audio card **120** and **130**, as well as one or more of the mass storage devices **140** or **142** may be coupled to a CPU local bus such as the PCI (peripheral compact interconnect) bus, or the VESA (Video Enhanced Standards Association) local bus, as desired. Various other computer configurations are also contemplated, such as a distributed system.

In the preferred embodiment of the invention, the multimedia computer system illustrated in FIG. **1** operates using the Windows 3.1 Operating System from Microsoft Corporation of Redmond, Washington. The computer system also preferably includes the Microsoft Windows multimedia extension software, including Microsoft's Media Control Interface and associated drivers. The Windows Media Control Interface (MCI) is a set of high-level commands that provide a device-independent interface for controlling multimedia devices and media files. The MCI command set is designed to provide a generic core set of commands to control different types of media devices. Because of the high level of device independence provided by the MCI command set, a programmer can use MCI commands rather than a low level API to access the multimedia capabilities of Windows. It is noted that the computer system may use other operating systems and other multimedia software, as desired.

The computer system includes video and audio drivers which interface to video and audio hardware, respectively. The audio driver interfaces between the multimedia operating system and the audio card **130**. The video driver interfaces between the operating system and the video accelerator card, if any. In the preferred embodiment, which does not

include a video accelerator **124**, the video driver does not actually interface to any video hardware, but rather performs various video data processing on the main CPU **102**. In the preferred embodiment, the video driver is comprised in the Intel Audio-Visual Kernel (AVK). The audio driver is preferably an MCI compliant WAV driver corresponding to the respective audio card **130**.

The computer system also includes a synchronization method according to the present invention which synchronizes the audio and video data streams during a multimedia presentation to ensure that the appropriate sounds are generated by the speaker **132** when the corresponding images are being displayed by the video monitor **122**.

Multimedia Software Architecture of the Preferred Embodiment

Referring now to FIG. **2**, the Microsoft Windows' Multimedia Extensions Software Architecture is illustrated. As shown in FIG. **2**, a multimedia application **200** directs a computer system to present a multimedia display by interfacing to the hardware through the operating system and various device driver layers. The block **210** includes the Windows Kernel and Graphics Device Interface (GDI), i.e., the bulk of the Windows operating system. As shown, the multimedia application **200** interfaces through the Windows operating system **210** to Windows device drivers **220**. The device drivers **220** interface to the various elements in the computer system including the printer, hard drive **142**, video monitor **122**, etc.

The block **240** comprises the Windows Multimedia Extensions Software. This translation layer isolates applications from device drivers and centralizes device-independent code. The translation layer **240** translates a multimedia function call into a set of Media Control Interface ("MCI") calls which interface to Media Control Interface drivers **250**. As shown, the Media Control Interface drivers interface to mass storage devices **260** and **270** such as the CD-ROM **140** or hard drive **142**. The Media Control Interface layer also communicates with MCI compliant multimedia device drivers **230** using a set of low level functions, as shown. The multimedia hardware device drivers **230** directly control a multimedia device such as an audio card **130** or video accelerator **124**. For more information on the Media Control Interface layer **240**, please see *Discover Windows* 3.1 *Multimedia* by Roger Jennings (Que Corp. 1992) chapters 23 and 24, which is hereby incorporated by reference. Please also see generally the *Microsoft Multimedia Programmer's Reference* and the *Microsoft Windows Multimedia Programmer's Workbook*, available from Microsoft Corporation, which are both hereby incorporated by reference.

The recording and presentation of multimedia displays is handled by the Windows Multimedia Extension Software in conjunction with the individual MCI drivers. Currently, not all multimedia drivers support MCI commands and command options. In particular, optional commands used by some devices are not supported. An example of an option command is "set," which sets the operating state of a device. Such a command would support the option "tempo 200," for example, as a means of controlling the speed of the playback device. Another example of an option command is the "pause" command, which suspends operation of a playback device, but leaves the device ready to resume playing immediately.

One embodiment of the present invention avoids use of MCI commands for querying the audio and video drivers and controlling the tempo and pausing of playback devices. In this embodiment the synchronization method of the present invention makes calls directly to the API of the audio and video drivers to obtain the necessary information and control the tempo of one of the respective data streams to maintain synchronization. The preferred embodiment of the invention uses the MCI interface to access the respective multimedia device drivers to query the drivers as well as adjust the tempo of the data streams. In alterative embodiments of the invention, the synchronization method uses MCI commands to interface to the audio driver and uses the direct API to access the video driver, or vice versa.

Multimedia storage devices can be classified as either simple devices or compound devices. Simple devices do not require a data file for playback, and videodisc players and CD audio players are examples of simple devices. Compound devices require a data file for playback and examples of compound devices include digital video players and waveform audio players. The preferred embodiment of the invention is used to synchronize audio and video data streams from compound devices.

Prior Art Multimedia System

Referring now to FIG. **3**, a prior art multimedia system that does not include the synchronizing method of the present invention is shown. As shown in FIG. **3**, audio and video data are stored in a multimedia system using one of a variety of storage devices **301**, **302**, and **303**, including the hard disk **142** or CD-ROM **140**. If the audio and video data are stored in the audio-video interleave (AVI) file format, then the audio and video data are interleaved together on the storage media in the same file. Alternatively, the audio and video data are stored on different storage media, perhaps on different computer systems connected via a network. As previously noted, the present invention operates regardless of whether the audio and video data are interleaved together, stored on separate media, or stored on separate computer systems.

The audio and video data are provided to the CPU **102**, which is preferably executing the Microsoft Windows Operating System **307**, as well as the Microsoft Multimedia Extension software. The Multimedia Extension software invokes the media control interface (MCI) layer software **309**, which in turn invokes respective MCI digital drivers **311** to provide the respective data streams to the respective hardware subsystems. As shown, the MCI digital driver **311** communicates with the video driver in the Intel audio-video kernel (AVK) **341**. The video driver in the AVK performs various processing on the video data and interfaces to video accelerator hardware **124**, if any. The video driver in the AVK **341** also monitors the frame number of the video frame being played. The video data is then provided to the video frame buffer **345** in the video adaptor (VGA card) **120** where it is then displayed on the video monitor **122**. The MCI digital driver **311** also communicates with the audio driver **331** to provide the audio data **313** to the respective hardware audio card **130** to the speaker **132**. The audio driver **331** is preferably an MCI-compliant driver. Thus, audio data is read from the respective storage device and provided to the audio card **130** by the MCI driver **311** and the audio drivers **331** executing on the CPU **102**. The audio driver **331** monitors the number of bytes of audio data processed from the start of a particular set of data.

As discussed in the background section, prior art multimedia systems provide generally unsynchronized audio and video outputs during a multimedia presentation due to the

inherent difficulty of synchronizing separate audio and video data streams passing through separate audio and video subsystems and controlled by separate audio and video drivers. Numerous factors can affect the playback of the audio and video data streams, including the greater amount and more variable amount of processing required for the video data as well as other demands that can be made on the system.

As discussed above, a large amount of processing may be required before the video data can be displayed on the video monitor **122**. For example, if the video's color depth is higher than the display's, as when an AVI file is played with 16-bit video on an 8-bit display, colors must be dithered to fit within the display's color restrictions. Also, if the playback window size differs from the resolution at which the video was captured, each frame must be scaled. Video and audio data processing can be adversely affected by a number of other factors, including a slow hard disk, a slow CD-ROM controller, and a slow display controller or audio card. During this process, it becomes virtually impossible for the environment to maintain the audio and video data properly synchronized while managing other critical tasks. As discussed in the background section, prior art methods, to the extent there are any, have proved inadequate in maintaining synchronization between video and audio data streams.

Multimedia Software Architecture Including the Preferred Embodiment of the Present Invention

Referring now to FIG. **4**, operation of the preferred embodiment of the present invention is illustrated. Logical blocks in FIG. **4** that are similar to those shown in FIG. **3** are designated with the same reference numeral for convenience. As discussed above, the preferred embodiment uses an MCI compatible interface to perform the synchronization method of the present invention. The preferred embodiment also uses the video driver in the Intel Audio Video Kernel (AVK) **341**. Because of the high level of device independence provided by the MCI interface, the multimedia capabilities of Microsoft Windows can be accessed through MCI protocols, rather than through low-level Application Program Interfaces (API). The preferred embodiment uses the MCI protocol and commands to interface with the video and audio drivers. These protocols are found in the *Microsoft Windows Software Development Kit, Multimedia Programmer's Guide*, Document Number PC30253-0492 which can be obtained from Microsoft Corporation of Redmond, Washington. (facsimile number 206-936-7329). In an alternative embodiment of the present invention, as mentioned above, the method of the present invention avoids the MCI layer and instead communicates directly with the API of the video and audio drivers. Bypassing the MCI interface layer results in a slight speed increase due to the decreased overhead. The source code listing following this description implements an embodiment of the invention that bypasses the MCI layer and instead communicates directly with the API of the audio and video drivers.

As shown in FIG. **4**, video data and commands pass from the MCI digital driver **311** to the video driver in the AVK **341** via the data path **315**. The AVK in turn provides data to the video hardware **124**, if any, which in turn provides the video data to the video frame buffer **345** in the video adaptor **120**.

Audio data and commands are transferred from the MCI digital driver **311** to the audio driver **331** via data path **313**. The audio driver **331** in turn provides the data to the audio card **130** via data path **333**, and the speaker **132** produces sound corresponding to the audio data.

The synchronization method of the present invention is performed by synchronization module block **421**. The synchronization module **421** comprises a method that is preferably implemented in software, and a source code listing of one embodiment of this method is located at the end of this specification. As noted above, the source code listing at the end of this specification operates by interfacing directly to the API of the audio and video drivers rather than going through the MCI interface layer. Otherwise the source code listing is similar to the preferred method. The MCI digital driver **311** provides a signal to the synchronization module **421** over path **417**. The computer system includes a timer which periodically interrupts the MCI layer **309** and MCI driver **311** and directs the MCI layer **309** to invoke the synchronization module **421** of the present invention. When the synchronization module **421** is invoked, the synchronization method queries the audio and video drivers **331** and **341** for the current position of the audio and video data. The synchronization module **421** is shown connected to the AVK video driver **341** and the audio driver **331**. As noted above, the synchronization module **421** of the preferred embodiment of the invention interfaces to the AVK video driver **341** and the audio driver **331** through the MCI interface layer. In contrast, the source code listing at the end of this specification implements an embodiment that accesses the AVK video driver **341** and audio driver **331** directly via the API of the respective drivers.

The audio driver **331** provides audio position information to the synchronization module **421** over path **429**. The AVK video driver **341** provides video frame position data over signal path **423** to the synchronization module **421**. The synchronization module **421** uses the audio and video frame rate information to compute a video tempo value that is provided to the AVK video driver **341**. Video tempo and pause commands are conveyed from the synchronization module to the AVK **341** over signal path **425**, preferably routed through the MCI layer **309** as discussed above. Also, in the preferred embodiment, the synchronization module **421** provides a pause command to the audio driver **331**. In an alternate embodiment, the present invention maintains synchronization by adjusting the audio tempo, and the synchronization module **421** generates an audio playback tempo command that is conveyed to the audio driver **331** over signal path **427**.

Synchronization Method—Flowchart

Referring now to FIGS. **5A** and **5B**, a flowchart diagram illustrating operation of the synchronization method performed by the synchronization module **421** according to the present invention is shown. The main portion of the synchronization method is located at lines **151–327** of the source code listing at the end of this specification. The synchronization method makes a function call to a function referred to as audframe_decupl_aud_dev, which computes the audio frame number from the audio position. This function is located generally at lines **1–150** of the source code listing.

When the synchronization method is invoked, in step **502** the method determines if this is the first time the method has been invoked. If so, then in step **504** the method calls the audio driver to obtain the wave rate, i.e., how many kilohertz at which the audio is operating. In step **506** the method calculates and stores the number of bytes that are in an audio frame that is equivalent to a corresponding video frame. The method obtains the wave rate at which the audio is playing, determines how many bytes of audio are played each second, then calculates the equivalent number of bytes for

each video frame using the known video frame rate. The equation used in this calculation is:

```
bytes_per_frm_x100000=Avio->AudStrms[0]
    .SamplesPerSecond*Avio->AudStrms[0].FrameRate/10 UL;
```

In step **508** the synchronization method initializes other variables. For example, the method initializes a previous tempo variable to a starting value, preferably a nominal value. As discussed further below, this previous tempo variable is used to record the prior tempo variable provided to the video driver the last time the synchronization module was invoked. Other variables can be initialized as desired. If the synchronization module is not being called for the first time in step **502**, then operation proceeds directly to step **510**.

It is noted that the preferred embodiment of the invention operates as shown in FIG. **5**A in steps **502–508**. However, in an alternate embodiment, steps **502–508** are performed elsewhere, such as in the audio driver **331** or the MCI layer **309**. It is also noted that steps **502–508** are not included in the source code listing at the end of this specification.

In step **510** the method determines the current video frame number. The synchronization method of the present invention calls the respective video driver **341** controlling the video hardware (if any) to determine what video frame number is currently being played. This call preferably uses MCI interface commands. In step **512** the method calls the respective audio driver to determine the current audio position, i.e., which audio byte is currently being played. This call also preferably utilizes MCI commands. In an alternate embodiment, the call to the video driver is made directly to the API of the video driver, and the call to the audio driver involves a call directly to the API of the .WAV audio driver **331** to determine what audio byte is currently being played. In step **514** the method then calculates the equivalent audio frame number being played using the audio frame rate value calculated and stored in step **506**. As shown in the source code listing at the end of this specification, step **514** invokes a function referred to as audframe_decupl_aud_dev. This function calculates the current audio frame number using a fraction representing the number of bytes per equivalent audio frame to determine the audio frame number. This function preferably does not use floating point numbers in the calculation due to the perceived unreliability of floating point numbers in some programming environments.

Referring to FIGS. **5**A and **5**B and **6**, the preferred embodiment of the present invention requires that there be a common starting point for the audio and video data. FIG. **6** illustrates an audio data stream **604** and a video data stream **606** having a common starting point **602**. Each audio data stream **604** includes audio frames **608** having audio data, and each video data stream **606** includes video frames **610** having video data. There is a time index of zero where the audio data stream **604** and video data stream **606** are both in synchrony, such that a first byte of the audio data stream **604** and a first byte of the video data stream **606** are generated simultaneously.

In step **516** the method then calculates the synchronization error quantity. Clearly, because audio data stream **604** and video data stream **606** have a common starting point **602**, calculating the synchronization error quantity essentially involves subtracting the current video frame number from the current audio frame number to determine the number of frames by which the audio and video are out of sync.

In step **518** the method determines if the audio is too far ahead of the video and if the audio is still playing. In the preferred embodiment the method determines if the audio is more than 5 frames ahead of the video in step **518**. If the audio is determined to be too far ahead and is also playing in step **518**, then the method stops the audio in step **520** and then advances to step **522**. If the audio is either not too far ahead, i.e., not more than 5 frames ahead, or the audio is not playing, then operation advances directly to step **522**. It is noted that if the audio is determined to be too far ahead in step **518**, i.e. more than 5 frames ahead of the video, then the synchronization method of the present invention may not be working, i.e., the video tempo is not being set properly. Another possibility is that the synchronization method is not being called often enough. It is noted that if the video advances too far ahead of the audio, then the video is simply slowed down using a lower video tempo.

In step **522** the method determines if the audio is paused and the video has caught up to the audio. In the preferred embodiment, the video is considered to have caught up to the audio if the audio is less than 2 frames ahead of the video. If the audio is paused and the video is determined to have caught up to the audio, then the audio is restarted in step **524**. Operation then advances to step **526** (FIG. **5**B). If either the audio is not paused or the video has not caught up to the audio, then operation proceeds directly to step **526**.

In step **526** the method selects a synchronization adjustment factor, referred to as a tempo value, for the video driver using a lookup table. In the source code listing at the end of this specification, the video tempo value is actually selected from a case statement. As noted above, in the preferred embodiment the synchronization method adjusts the video frame rate or video tempo to maintain the audio and video data streams in sync. However, it is noted that in the present invention either the audio or video stream rates can be adjusted as desired. For example, the method could slow down or speed up the video frame rate or slow down or speed up the audio frame rate as desired to maintain the respective audio and video data streams in sync. It is noted that adjusting the audio data stream may be a simpler procedure than adjusting the video data stream. The audio data stream was not adjusted in the preferred embodiment because of concerns that the user might be able to hear the audio adjustments. However, experimentation has shown that adjustments to the audio data stream would generally not be detectable by the user if the synchronization method of the present invention was invoked a sufficient number of times each second.

In step **528** the method determines if the video has started to play. If not, then the method sets the video tempo value to a slow value. This is done merely to begin the video portion of the presentation at a slow rate. If the video has started to play, operation proceeds directly to step **532**. In step **532** the method adjusts the video tempo value using a smoothing or dampening function. The preferred embodiment uses a smoothing formula which combines one half of the current tempo value plus one half of the previous tempo value. This smoothing function operates to prevent overcompensation and to add stability to the synchronization method, thus allowing for smoother synchronization. The adjustment performed in step **532** is similar to a damping function.

In step **534** the method determines if the audio is paused. If the audio is determined to not be paused in step **534**, then in step **536** the method determines if audio data is available. If audio data is determined to not be available in step **536**, then it is assumed that the multimedia presentation does not

include any audio data. In this case the method exits since it not necessary to adjust the video playback speed or tempo if there is no audio component. If audio data is determined to be available in step **536**, then operation advances to step **542**.

If the audio is determined to be paused in step **534**, then in step **538** the method determines if the audio is ahead of the video or if the audio status is reported as bad. If the audio is determined to be equal to or behind the video in step **538**, then operation advances to step **542**. If the audio is determined to be ahead of the video in step **538** or if the audio status is reported as bad, then the method sets the video tempo to a nominal rate, i.e. , a rate which is calculated to be equal to the average speed of the audio playback. The video tempo is set to the nominal rate in step **540** because it is not necessary to set the video rate to large (fast) tempos if the audio is paused and the audio is ahead of the video. In cases where the audio is paused and is ahead of the video, this typically means that the user has either clicked on the PAUSE or STEP button during the presentation, or that the audio has been halted because the audio and video were too far out of sync.

In step **542** the method determines if the synchronization error calculated in step **516** is greater than a set tolerance. In the preferred embodiment the tolerance is set to 1 frame. Thus the synchronization method does not adjust the video tempo unless the audio and video are at least a certain amount out of sync. If the audio and video are in sync or are relatively close to being in sync, then the tempo is not adjusted. This avoids having to call the video driver to adjust the tempo and thus reduces the overhead caused by synchronization. If the synchronization error is greater than the tolerance in step **542**, then in step **543** the method determines if the tempo value is equivalent to the last_tempo value, i.e., the tempo value sent to the video driver the last time the synchronization method was executed. If the current tempo value equals the last_tempo value, then operation advances to step **554**. In this instance the video driver is already operating at this tempo, and thus there is no need to call the video driver to set the tempo value to the same value. This also serves to reduce the overhead of the synchronization method. If the tempo value does not equal the last_tempo value in step **543**, then in step **544** the method adjusts the video frame rate using the tempo value determined in step **526** and adjusted in step **532**. As noted above the method preferably adjusts the video frame rate using MCI interface calls. In an alternate embodiment, as shown in the source code listing, the synchronization method passes the video frame rate or tempo value directly to the video driver, using the AvkGrpTempo function call. The video driver uses the received number to adjust the video frame rate. Operation then advances to step **554**.

If the synchronization error is determined to not be greater than the tolerance in step **542**, then in step **546** the method determines if the synchronization error is 0 and if the previous tempo was not set to the nominal rate. If either the synchronization error is not 0 or the previous tempo was set to the nominal rate, then operation advances to step **554**. In this instance it is not necessary to adjust the tempo because the synchronization error was determined to be less than the tolerance in step **542**. If the synchronization error is **0** and the last tempo is not equal to the nominal rate, then an extra stabilizing effect is added. This extra stabilizing effect is referred to as a "lock-down" function. In step **548** the method sets the tempo to the nominal rate and in step **550** the method adjusts the video frame rate by making the appropriate MCI interface call to the video driver. In step **552** the method sets the last_tempo variable to the nominal rate to prevent steps **548–552** from being performed the next time the synchronization method is called.

As noted above, steps **548–552** are performed when the synchronization error is **0** but the prior tempo was not set to the nominal rate. Here it is desirable to eliminate the effects of the smoothing function applied in step **532**. If the audio and video data streams are in sync, the tempo value produced by the smoothing function in step **532** will suggest that the two streams are out of sync because part of the tempo value calculation is the weighted average of the previous tempo value with the current value. Thus, if the current tempo value is zero, but a previous adjustment was required, the synchronization method would report that a tempo adjustment is necessary. Therefore, in this instance the tempo is set to the nominal rate just as if the smoothing function had not been applied.

Thus, this lock-down function ensures that the synchronization method does not overcompensate when the audio and video are in sync. In other words, this function adds stability by locking on a point where the audio and video are in sync to prevent overcompensation from occurring, i.e., primarily to prevent the smoothing function applied in step **532** from pushing the audio and video out of sync. Without this lock-down function, if the audio and video data streams were in sync, the smoothing function would cause the streams to fall out of sync, i.e., would cause the video data stream to oscillate between being ahead of or behind the audio stream.

In step **554** the method saves the tempo value for the next call by the periodic timer. The synchronization method then completes.

Conclusion

Therefore, a method and apparatus for synchronizing the audio and video portions of a multimedia display is shown. This method provides superior synchronization over methods found in the prior art.

Although the method and apparatus of the present invention has been described in connection with the preferred embodiment, it is not intended to be limited to the specific form set forth herein, but on the contrary, it is intended to cover such alternatives, modifications, and equivalents, as can be reasonably included within the spirit and scope of the invention as defined by the appended claims.

We claim:

1. A method for synchronizing audio and video data streams having a common starting point during a multimedia presentation, comprising the steps of:

determining a current position of the video data stream relative to the common starting point;

determining a current position of the audio data stream relative to the common starting point;

calculating a synchronization error related to a difference between the respective video data stream and audio data stream current positions using the current positions of the audio and video data streams;

adjusting a tempo of one of the data streams based on the synchronization error if necessary to place the audio and video data streams in synchrony;

repeating the determining steps and the steps of calculating and adjusting during the multimedia presentation to maintain the audio and video data streams in synchrony.

2. The method of claim **1**, further comprising:

determining if the synchronization error is greater than a tolerance value after the step of calculating and prior to the step of adjusting, and

wherein the step of adjusting the tempo is performed only if the synchronization error is greater than the tolerance value.

3. The method of claim 1, further comprising:

determining a tempo value from the synchronization error calculated in the step of calculating prior to the step of adjusting; and

wherein the step of adjusting comprises adjusting the tempo of one of the data streams using the determined tempo value.

4. The method of claim 3, further comprising:

storing the determined tempo value;

calculating a second synchronization error by repeating at a subsequent time the steps of determining a current position of the video data stream, determining a current position of the audio data stream, and calculating a synchronization error;

determining a second tempo value from the second synchronization error; and

repeating the step of adjusting based on the second synchronization error if the second determined tempo value does not equal the stored determined tempo value.

5. The method of claim 4, further comprising:

applying a smoothing function to the second determined tempo value using the stored determined tempo value and second determined tempo value prior to the step of adjusting, wherein the smoothing function prevents overcompensating the tempo adjustment and adds stability to the synchronizing method.

6. The method of claim 5, further comprising:

determining if the synchronization error is 0 and if the immediately prior tempo value was not equal to a nominal rate prior to the step of adjusting; and

wherein the step of adjusting the tempo comprises setting the tempo to the nominal rate if the synchronization error is 0 and the immediately prior tempo value was not equal to a nominal rate.

7. The method of claim 1, wherein the step of adjusting the tempo comprises adjusting the tempo of the video data stream.

8. The method of claim 1, wherein the step of adjusting the tempo comprises adjusting the tempo of the audio data stream.

9. The method of claim 1, further comprising:

determining if the audio data stream is far ahead of the video data stream and if the audio is playing after the steps of determining respective current positions; and

halting playback of the audio data steam if the audio data steam is far ahead of the video data steam and the audio is playing.

10. The method of claim 9, further comprising:

determining if the audio playback is paused and if the video data stream has approximately caught up to the audio data stream; and

restarting the audio playback if the audio playback is paused and the video data stream has approximately caught up to the audio data stream.

11. The method of claim 1, wherein the video data stream is processed in a video subsystem and the audio data stream is processed in an audio subsystem such that the video data stream is decoupled from the audio data stream.

12. The method of claim 13, wherein each video frame has a video frame number relative to the common starting point, wherein the step of determining the current position of the video data stream comprises determining a current video frame number being played.

13. The method of claim 1, wherein at any point in time during the multimedia presentation an audio frame and a video frame are being played and the step of determining the current position of the audio data stream includes the steps of:

determining which audio byte is currently being played;

obtaining a frequency at which the audio is being played;

determining how many bytes of audio are being played per unit of time;

determining a number of bytes per audio frame equivalent to a number of bytes per video frame: and

determining an equivalent audio frame number being played relative to the common starting point.

14. The method of claim 12, wherein the step of calculating a synchronization error comprises calculating a difference between the current video frame number and the determined equivalent audio frame number.

15. The method of claim 1, wherein the synchronizing method is periodically performed each time after the expiration of a predetermined time interval.

16. A computer system which synchronizes audio and video data streams, having respective audio and video data, during an audio-visual display, comprising: one or more storage devices for storing the audio and video data for the audio-visual display;

a video monitor coupled to the one or more storage devices for generating a video display corresponding to the video data in the video data stream;

a speaker coupled to one or more storage devices for generating sounds corresponding to the audio data in the audio data stream;

one or more data paths for transmitting the audio and video data streams corresponding to the audio and video data from the one or more storage devices to the speaker and the video monitor, respectively;

means coupled to the one or more storage devices, the one or more data paths, the video monitor and the speaker for obtaining a current position of the video data stream relative to a common starting point of the audio and video data streams;

means coupled to the one or more storage devices, the one or more data paths, the video monitor and the speaker for obtaining a current position of the audio data stream relative to the common starting point;

means coupled to both the means for obtaining for calculating a synchronization error related to a difference between the respective video data stream and audio data stream current positions using the current positions of the audio and video data streams; and

means coupled to the one or more data paths and the synchronization error calculating means for adjusting a tempo of one of the data streams based on the synchronization error if necessary to place the audio and video data streams in synchrony; and

wherein the means for obtaining, means for calculating, and means for adjusting repeat their respective functions during the audio-visual display to maintain the audio and video data streams in synchrony.

17. The computer system of claim 16, further comprising:

means coupled to the calculating means for determining if the synchronization error is greater than a tolerance value;

wherein the means for adjusting the tempo adjusts the tempo only if the synchronization error is greater than the tolerance value.

18. The computer system of claim 16, further comprising:

means for determining a tempo value from the synchronization error calculated by the means for calculating;

wherein the means for adjusting adjusts the tempo of one of the data streams using the determined tempo value.

19. The computer system of claim 18, further comprising:

means coupled to the tempo value determining means for storing the determined tempo value, wherein the stored determined tempo value is used as a prior tempo value the next time the synchronizing method is performed;

means coupled to the tempo value determining means and the storing means for determining if the determined tempo value equals the prior tempo value;

wherein the means for adjusting is not executed if the determined tempo value equals the prior tempo value.

20. The computer system of claim 18, further comprising:

means coupled to the tempo value determining means for storing the determined tempo value;

means coupled to the tempo value determining means and the storing means for applying a smoothing function to the determined tempo value using a tempo value stored by the means for storing, wherein the smoothing function prevents the means for adjusting the tempo from overcompensating the tempo adjustment and adds stability to the tempo adjustment.

21. The computer system of claim 20, further comprising:

means coupled to the calculating means for determining if the synchronization error is 0 and if the immediately prior tempo value was not equal to a nominal rate; and

wherein the means for adjusting the tempo comprises means for setting the tempo to the nominal rate if the synchronization error is 0 and the immediately prior tempo value was not equal to a nominal rate.

22. The computer system of claim 16, wherein the means for adjusting the tempo adjusts the tempo of the video data stream.

23. The computer system of claim 16, wherein the means for adjusting the tempo adjusts the tempo of the audio data stream.

24. The computer system of claim 16, further comprising:

means coupled to the one or more data paths for determining if the audio data stream is far ahead of the video data stream and if the audio is playing; and

means for halting playback of the audio data stream is the audio data stream is far ahead of the video data stream and the audio is playing.

25. The computer system of claim 24, further comprising:

means coupled to one or more data paths for determining if the audio playback is paused and if the video data stream has approximately caught up to the audio data stream;

means coupled to the one or more data paths for restarting the audio playback if the audio playback is paused and the video data stream has approximately caught up to the audio data stream.

26. The computer system of claim 16, wherein the one or more data paths comprises an audio data path for transmitting the audio data stream and a video data path for transmitting the video data stream.

27. The computer system of claim 28, wherein the means for obtaining the current position of the video data stream comprises means for obtaining a current video frame number.

28. The computer system of claim 16, wherein the audio data stream and the video data stream include audio frames and video frames, respectively, each audio and video frame includes a respective frame number relative to the common starting point, the means for obtaining the current position of the audio data stream further comprising:

a means for determining which audio byte is currently being played;

wherein said means for obtaining the current position of the audio data stream includes means for calculating an equivalent audio frame number relative to the common starting point using the audio byte currently being played, an audio play frequency, using a number of bytes of audio played per unit of time, and using a number of bytes per audio frame equivalent to a number of bytes per video frame.

29. The method of claim 27, wherein the means for calculating a synchronization error calculates a difference between the current video frame number and the calculated equivalent audio frame number.

30. The method as in claim 1 wherein the common starting point is a time index of zero where the audio and video data streams are both in synchrony, such that a first byte of audio data and a first byte of video data are generated simultaneously.

31. The method as in claim 1 wherein the multimedia presentation utilizes a computer system having a video driver, and wherein the video data stream includes video frames, and wherein the video data stream current position determining step comprises querying the video driver to determine a current video frame number being played, the method further comprising:

determining a tempo value using the synchronization error;

wherein the tempo adjusting step comprises passing the tempo value to the video driver.

32. The method as in claim 1 wherein the multimedia presentation utilizes a computer system having an audio driver and the audio data stream current position determining step comprises the step of:

querying the audio driver to determine the current audio data stream position.

33. The method as in claim 1 wherein the video data stream and the audio data stream are respectively free from time stamps, and the video data stream is free from any timing information relative to the audio and video data stream correspondence.

34. The method as in claim 1 wherein the tempo is a rate of one of the data streams.

35. The method as in claim 5 wherein the smoothing function combines one half of a current tempo value plus one half of the prior tempo value.

36. The computer system as in claim 16 wherein the current position of the video data stream is represented by a video frame number, the computer system further comprising:

a video driver means, coupled to the means for obtaining a current position of the video data stream, for passing the video frame number to the means for obtaining a current position of the video data stream.

37. The computer system as in claim 16 wherein the current position of the audio data stream is represented by an audio frame number, the computer system further comprising:

an audio driver means, coupled to the means for obtaining a current position of the audio data stream, for passing the audio frame number to the means for obtaining a current position of the audio data stream.

38. The computer system as in claim **16** wherein the common starting point is a time at which a first byte of the audio data and a first byte of the video data are in synchrony.

39. The computer system as in claim **16** wherein the tempo is a rate of one of the data streams.

40. The computer system as in claim **20** wherein the smoothing function combines one half of a current tempo value plus one half of the prior tempo value.

* * * * *

EXHIBIT 1019

United States Patent [19]

Kinoshita

[11] **Patent Number: 4,740,828**

[45] **Date of Patent: Apr. 26, 1988**

[54] **IMAGE SENSING APPARATUS HAVING A LOW-RESOLUTION MONITOR, MEANS FOR REDUCING THE AMOUNT OF INFORMATION IN AN IMAGE SIGNAL, AND SWITCHING MEANS FOR REDUCING POWER CONSUMPTION IN VARIOUS OPERATING MODES**

[75] Inventor: **Takao Kinoshita**, Tokyo, Japan

[73] Assignee: **Canon Kabushiki Kaisha**, Tokyo, Japan

[21] Appl. No.: **682,936**

[22] Filed: **Dec. 18, 1984**

[30] **Foreign Application Priority Data**

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Dec. 24, 1983 [JP] Japan 58-245848
Dec. 28, 1983 [JP] Japan 58-251736
Dec. 28, 1983 [JP] Japan 58-251737

[51] **Int. Cl.**[4] **H04N 9/077**; H04N 3/15; H04N 5/335; H04N 9/04

[52] **U.S. Cl.** **358/48**; 358/41; 358/44; 358/213.1; 358/213.13; 358/213.26; 358/213.29; 358/224; 358/906; 358/909

[58] **Field of Search** 358/906, 183, 287, 224, 358/44, 213, 909, 41, 213.11, 213.13, 213.22, 213.23, 213.25, 213.26, 213.27, 213.28, 213.29; 360/9.1, 33.1

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Primary Examiner—James J. Groody
Assistant Examiner—Randall S. Svihla
Attorney, Agent, or Firm—Toren, McGeady & Associates

[57] **ABSTRACT**

An image sensing apparatus is provided with an image sensor having picture elements; an electronic monitor having a number of scanning lines fewer than the vertical picture elements of the image sensor; and a driving circuit for reading from the image sensor a fewer scanning lines when the apparatus is in a monitor mode than when the apparatus is in an image sensing mode. The driving circuit reads the image sensor in a non-interlacing manner in the monitor mode. A switching circuit shuts off power to unused circuits when the apparatus is in various operating modes.

17 Claims, 11 Drawing Sheets

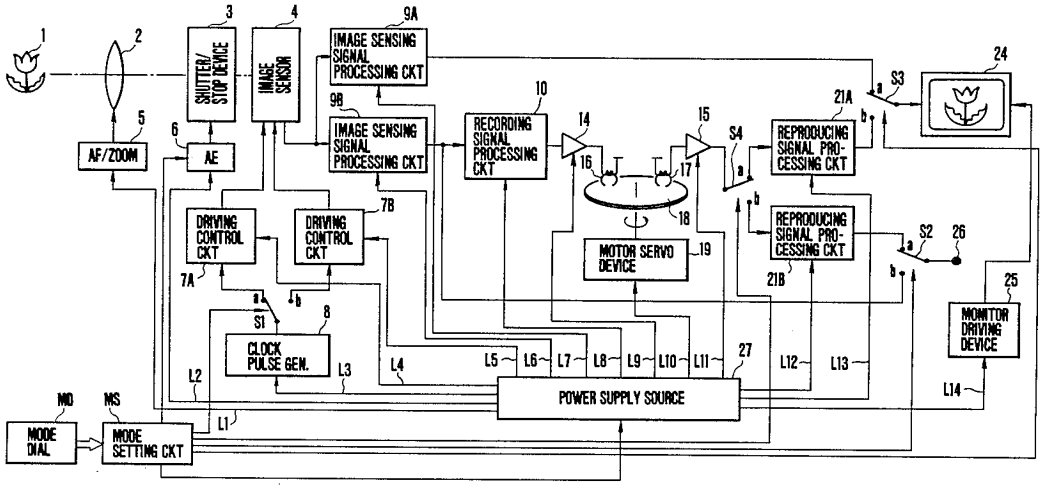


FIG. 1

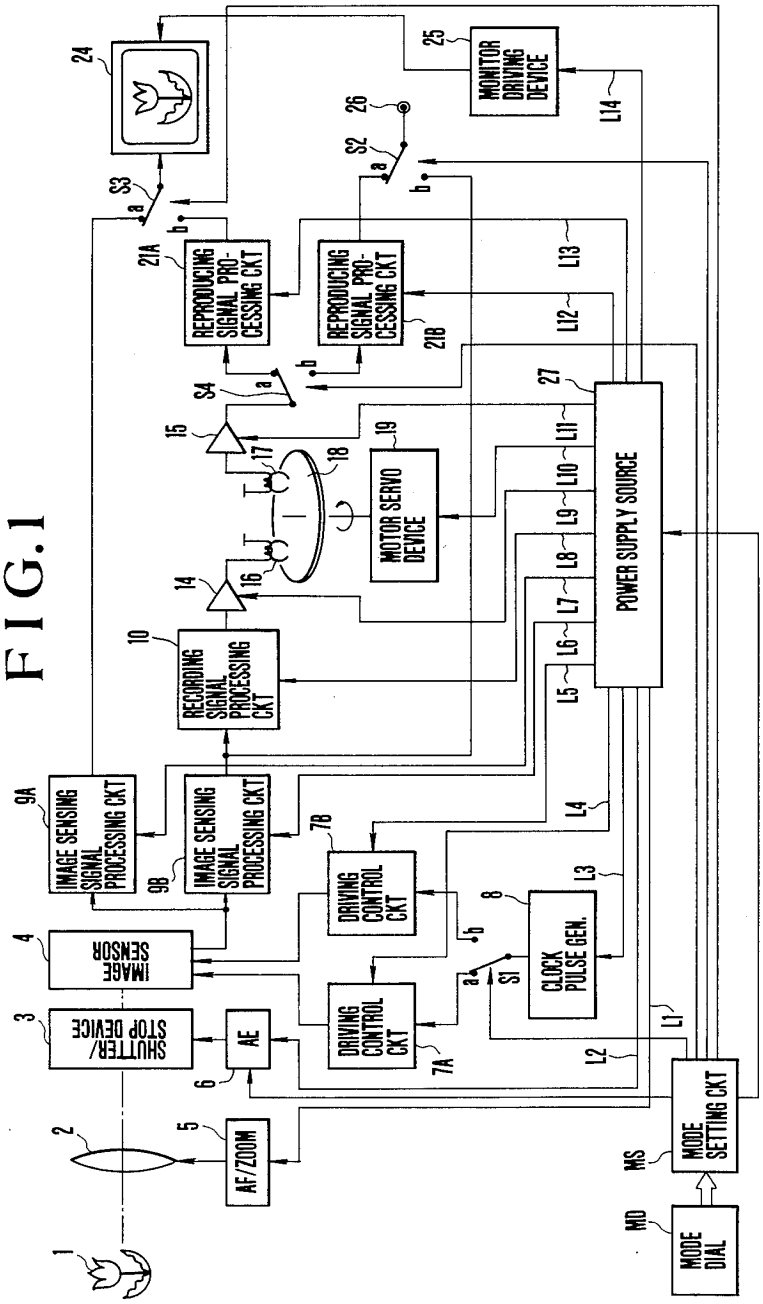

1
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9A
9B
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26
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S1
S2
S3
S4
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12
L13
L14
MS
MD
LENS
SHUTTER/ STOP DEVICE
IMAGE SENSOR
AE
AF/ZOOM
IMAGE SENSING SIGNAL PROCESSING CKT
IMAGE SENSING SIGNAL PROCESSING CKT
RECORDING SIGNAL PROCESSING CKT
DRIVING CONTROL CKT
DRIVING CONTROL CKT
CLOCK PULSE GEN.
MOTOR SERVO DEVICE
REPRODUCING SIGNAL PROCESSING CKT
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MONITOR DRIVING DEVICE
POWER SUPPLY SOURCE
MODE SETTING CKT
MODE DIAL

FIG.2

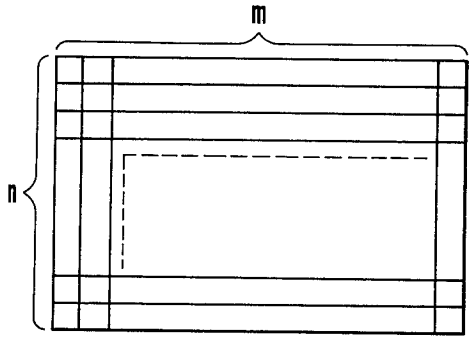


FIG.3(a)

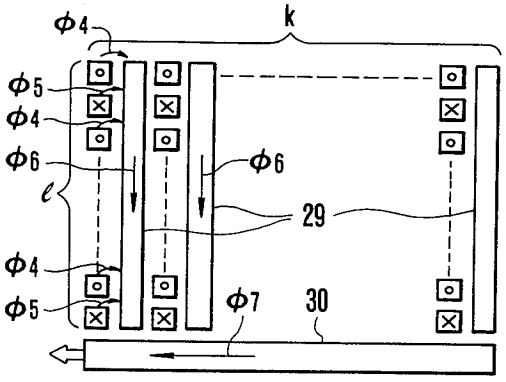


FIG.3(b)

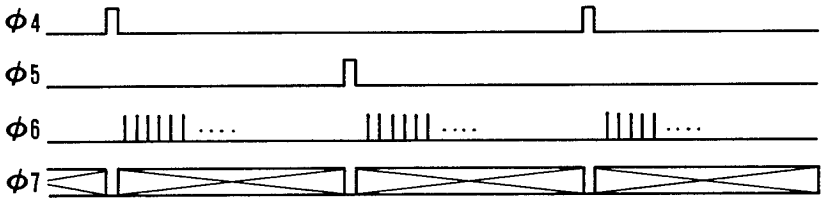


FIG.3(c)

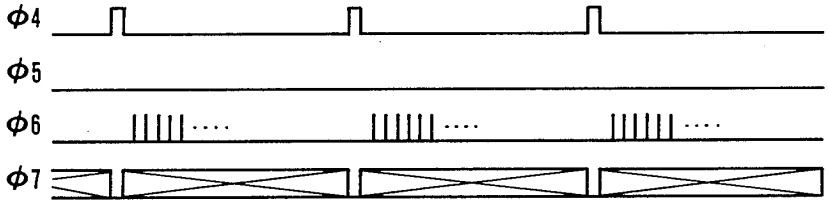


FIG.3(d)

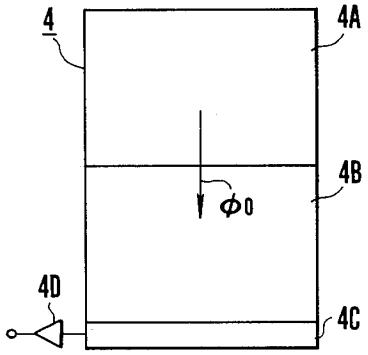


FIG.3(e)

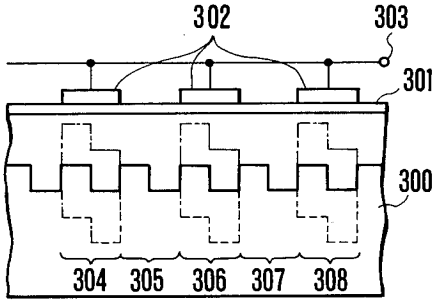


FIG.3(f)

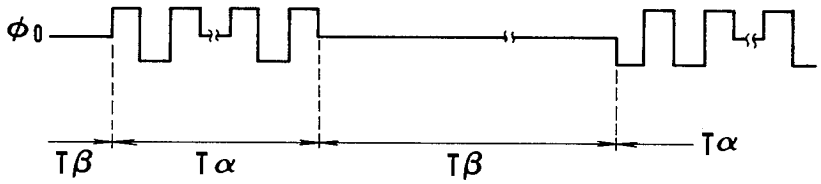


FIG.3(g)

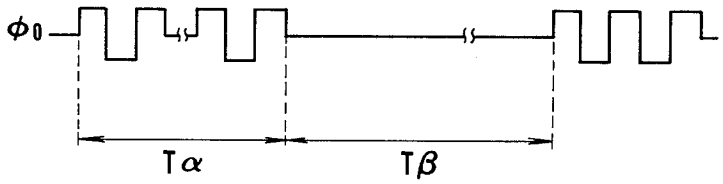


FIG.4

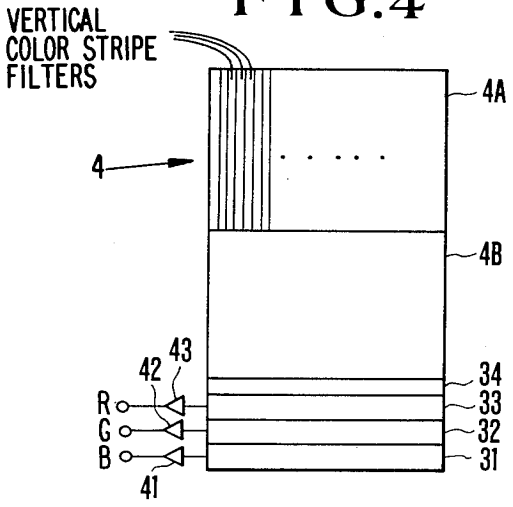


FIG.5

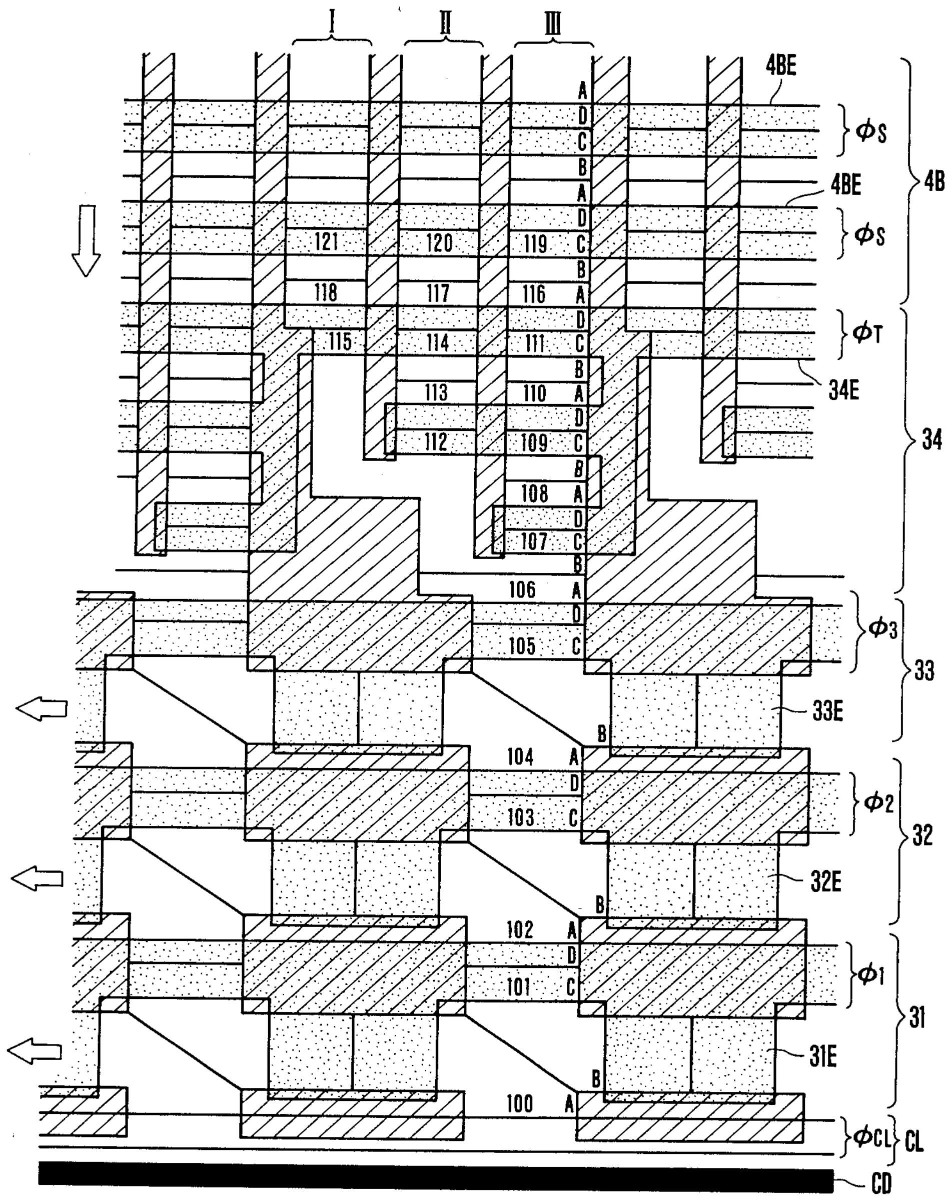
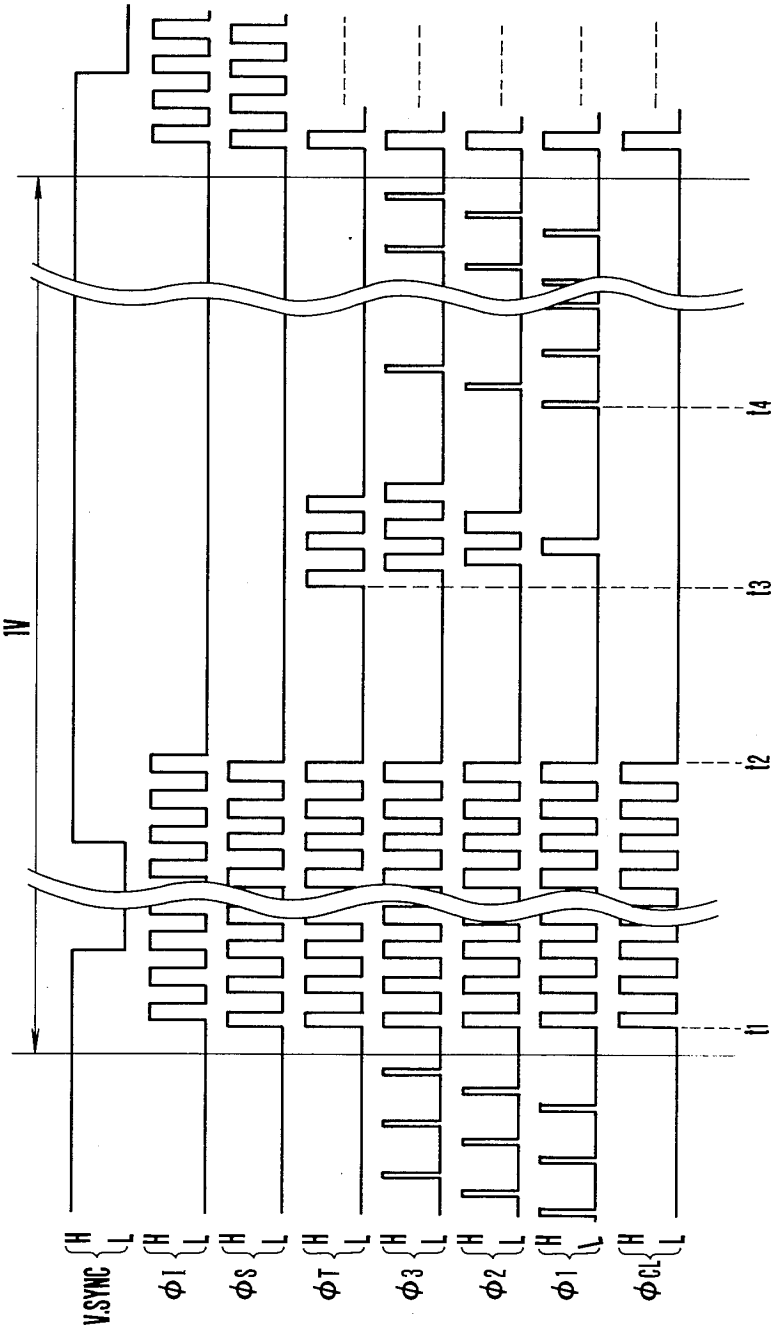

I
II
III
4BE
A
D
C
B
φs
4B
121
120
119
118
117
116
φT
115
114
111
34E
113
110
112
109
34
108
107
106
105
φ3
33
33E
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φ2
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32E
102
101
φ1
31
31E
100
φCL
CL
CD

FIG.6(a)



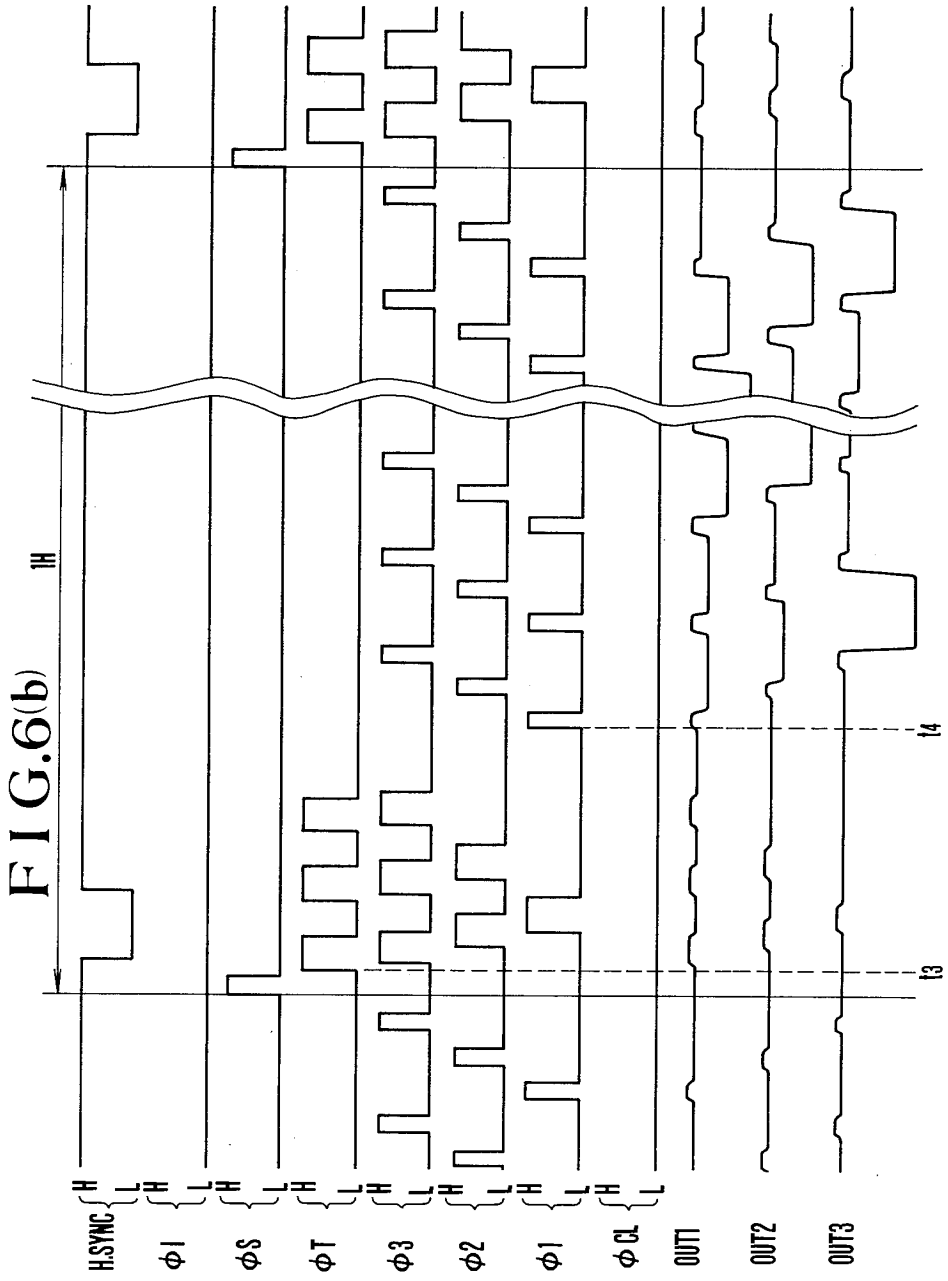


FIG.6(b)

FIG.7(a)

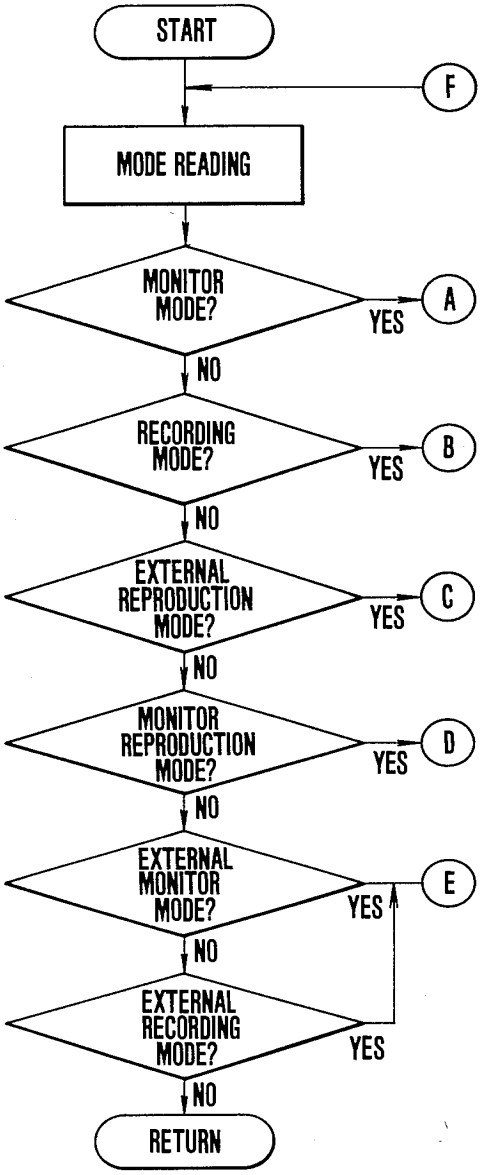

START
F
MODE READING
MONITOR MODE?
YES
A
NO
RECORDING MODE?
YES
B
NO
EXTERNAL REPRODUCTION MODE?
YES
C
NO
MONITOR REPRODUCTION MODE?
YES
D
NO
EXTERNAL MONITOR MODE?
YES
E
NO
EXTERNAL RECORDING MODE?
YES
NO
RETURN

FIG.7(b)

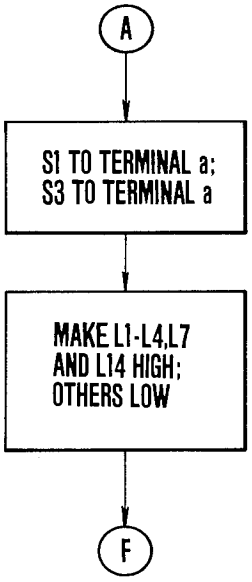

A
S1 TO TERMINAL a;
S3 TO TERMINAL a
MAKE L1-L4,L7
AND L14 HIGH;
OTHERS LOW
F

FIG.7(c)

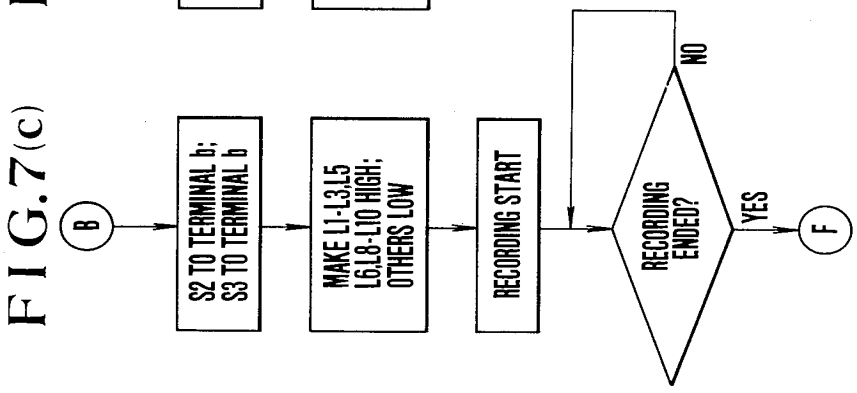


FIG.7(d)

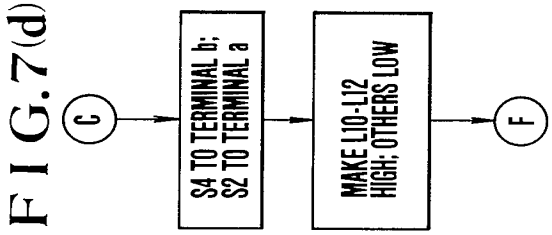


FIG.7(e)

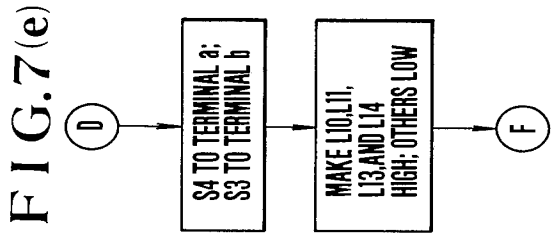
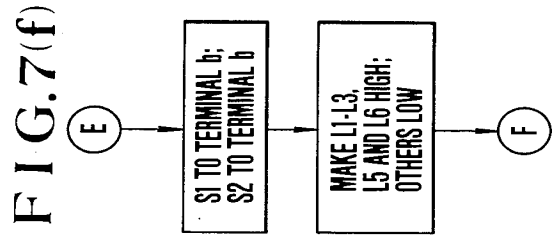


FIG.7(f)



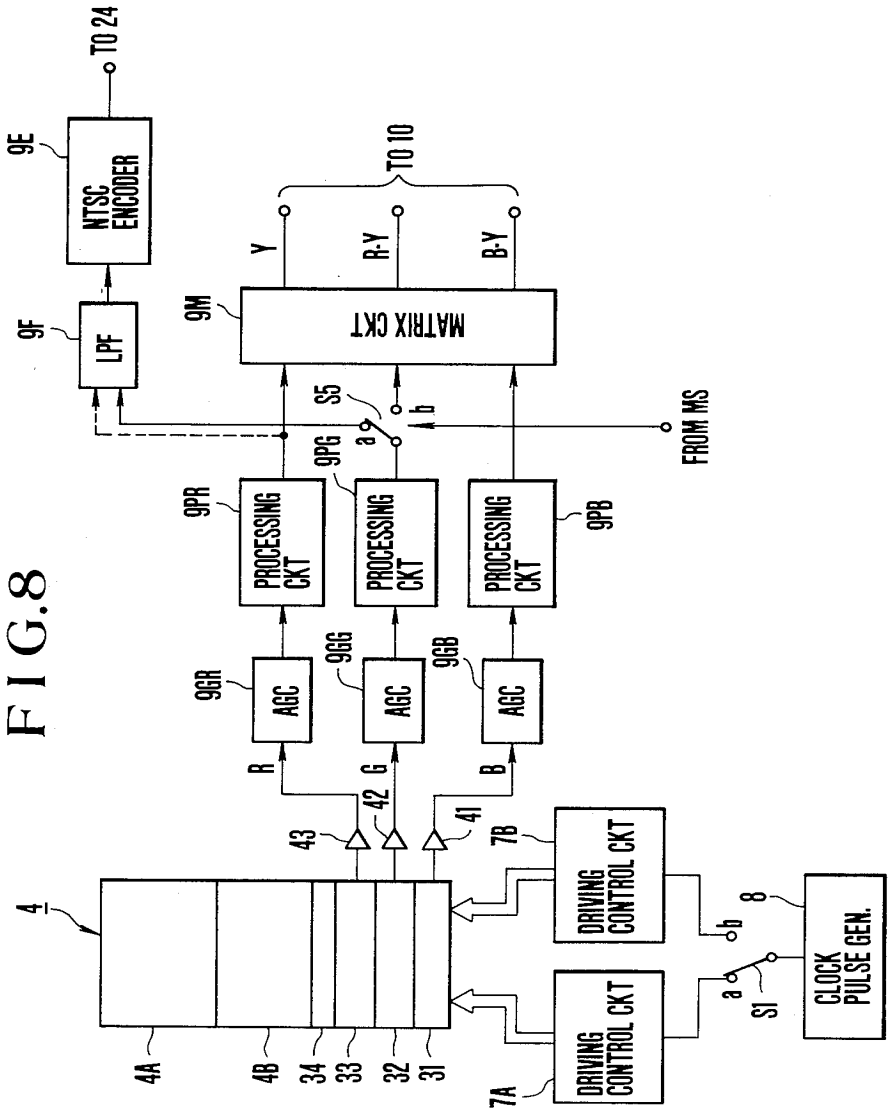

TO 24
9E
NTSC ENCODER
9F
LPF
TO 10
Y
R-Y
B-Y
9M
MATRIX CKT
S5
a
b
FROM MS
9PR
PROCESSING CKT
9PG
PROCESSING CKT
9PB
PROCESSING CKT
9GR
AGC
9GG
AGC
9GB
AGC
R
G
B
43
42
41
7B
DRIVING CONTROL CKT
7A
DRIVING CONTROL CKT
4
4A
4B
34
33
32
31
8
S1
CLOCK PULSE GEN.

FIG.8

FIG.9

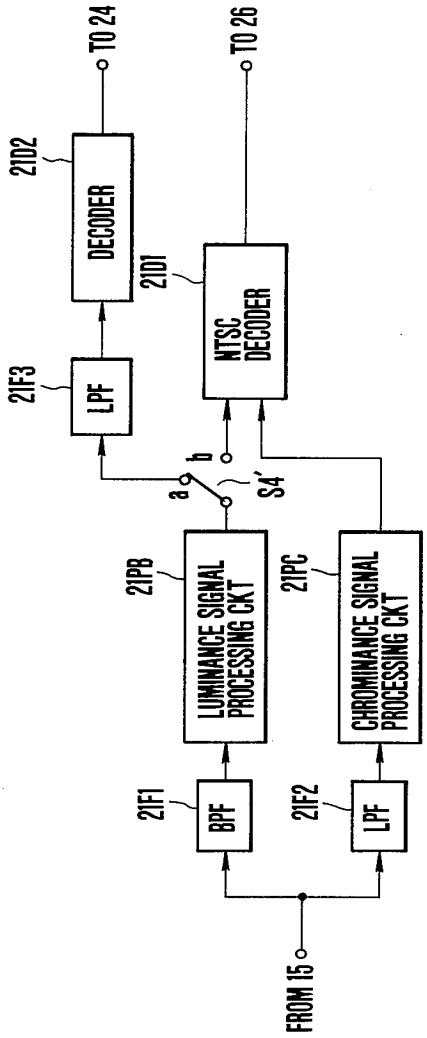

TO 24
TO 26
21D2
DECODER
21D1
NTSC DECODER
21F3
LPF
a
b
S4'
21PB
LUMINANCE SIGNAL PROCESSING CKT
21PC
CHROMINANCE SIGNAL PROCESSING CKT
21F1
BPF
21F2
LPF
FROM 15

IMAGE SENSING APPARATUS HAVING A LOW-RESOLUTION MONITOR, MEANS FOR REDUCING THE AMOUNT OF INFORMATION IN AN IMAGE SIGNAL, AND SWITCHING MEANS FOR REDUCING POWER CONSUMPTION IN VARIOUS OPERATING MODES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an image sensing apparatus having an electronic monitor and means for changing the manner in which an image sensor, etc. are driven and the manner in which power is supplied to peripheral circuits when the apparatus is in a monitor mode.

2. Description of the Prior Art

Image sensing apparatus such as electronic cameras are highly promising apparatus capable of replacing cameras using silver halide. However, they have some basic problems. The first of such problems relates to power consumption. In intermittently taking still pictures, the power consumption presents no serious problem. However, in cases where an electronic monitor is connected to or mounted on the camera, an image sensing system or a reproducing system must be continuously driven for continuous monitoring or play back. Such a requirement then presents a grave problem in connection with power consumption.

A second problem relates to the performance of the electronic monitor, such as the resolving power of the monitor. Insufficient resolving power of the monitor would bring about a spurious resolution or the like when an image signal is monitored through the same signal processing arrangement as in recording or reproduction. Furthermore, if the monitor does not possess adequate power in relation to the image sensing or recording power, that is, where the monitor is for a black-and-white signal while the image sensing or recording signal is a color signal or where the reproduction bandwidth of the monitor is narrower than the image sensing or recording bandwidth, there is a loss of electric energy and degradation of picture quality.

A third problem with the prior art apparatus lies in the relation between the resolving power of the monitor and the manner in which the image sensor is driven. Heretofore, a monitoring image signal has been obtained by driving an image sensor in the same manner as in recording or reproduction. A monitor device is thus required to have a high degree of performance. Particularly, the resolving power in the vertical direction of the monitor must be equal to that of the image sensor. The monitor arrangement of the prior art thus has resulted in a high cost.

No particular attention has been paid to these problems in the image sensing apparatus of the prior art such as electronic cameras, facsimile devices, copying machines, etc.

SUMMARY OF THE INVENTION

It is an object of this invention to provide an image sensing apparatus whereby the above-stated third problem of the prior art can be solved by adoption of means for having a monitoring function adequately performed with a low-cost, simple electronic monitor having a number of scanning lines which is fewer than the number of vertical picture elements of an image sensor.

It is another object of this invention to provide an image sensing apparatus wherein an electronic monitor, which has a number of scanning lines fewer than the number of vertical picture elements of an image sensor, is in combination with means for preventing degradation of sensitivity due to a difference in the number of scanning lines for driving the image sensor.

It is a further object of this invention to provide an image sensing apparatus whereby the first of the above-stated problems of the prior art is solved by using a built-in electronic monitor in combination with power saving means which reduces electric energy consumption of the apparatus when it is in a monitor mode or a reproduction mode using the built-in electronic monitor.

It is a still further object of this invention to provide an image sensing apparatus wherein, in the event that a built-in electronic monitor of a low resolving power is used for the apparatus, the second of the above problems of the prior art is solved with the monitor capable of adequately suppressing a spurious resolution when the apparatus is in a monitoring or reproduction mode using the built-in electronic monitor.

An embodiment of this invention is provided with means for driving the image sensor with a fewer number of scanning lines when the apparatus is in a monitor mode than in an image sensing mode, so that monitoring can be adequately accomplished even with an electronic monitor having a number of scanning lines fewer than the number of vertical picture elements of the image sensor.

Furthermore, another embodiment of this invention is provided switching means which change an image sensor driving operation to have electric signal charges of picture elements added together when the apparatus is in a monitor mode using an electronic monitor. Therefore, monitoring can be adequately accomplished even in the event that the electronic monitor used has the picture elements thereof arranged in a way different from those of the image sensor. This embodiment is especially advantageous in that, where an electronic monitor having a number of scanning lines fewer than the number of vertical picture elements of the image sensor is used, degradation in sensitivity due to a difference in the number of scanning lines driving the image sensor can be prevented by virtue of the switching means.

A further embodiment of the invention is provided with power saving means which brings the operations of parts not required for monitoring to a stop or shuts off the power supply to such unnecessary parts when the apparatus is in a monitor mode using a built-in electronic monitor, so that electric energy can be saved to a great extent.

A still further embodiment of this invention is provided with power saving means which brings the operations of parts not required for reproducing to a stop or cuts down the power supplied to such unnecessary parts when the apparatus is in a reproducing mode using a built-in electronic monitor, so that electric power consumption of the apparatus as a whole can be greatly lowered.

A combination of these embodiments possibly saves $\frac{1}{3}$ to $\frac{1}{2}$ the power consumption of the whole apparatus. The independent or combined application of the above-stated features of the invention permits simplification of the power supply arrangement of the apparatus. For example, the capacity of a DC-to-DC converter can be lessened.

Futhermore, in an embodiment of this invention, there is provided switching means for shifting the image-sensing-system signal processing method of the apparatus to a method suited for a monitor mode using a built-in monitor when the apparatus is brought into the monitor mode, so that spurious resolution in the monitor mode can be sufficiently prevented even in the event of low resolving power of the built-in electronic monitor.

In another embodiment of this invention, there is provided switching means for shifting the reproduction-system signal processing method of the apparatus to a method suited for reproduction by a built-in electronic monitor when the apparatus is brought into the reproduction mode using the monitor, so that spurious resolution during reproduction with the monitor can be sufficiently prevented even in the event of low resolving power of the monitor.

These and further objects and features of the invention will become apparent from the following detailed description of preferred embodiments thereof taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing an electronic camera to which this invention is applied in an embodiment thereof.

FIG. **2** is an illustration of the arrangement of the picture elements of an electronic monitor included in the electronic camera of FIG. **1**.

FIGS. **3**(*a*)–**3**(*g*) are illustrations of the mode of driving an image sensor of the same electronic camera.

FIG. **4** is a schematic illustration of the arrangement of the image sensor included in the same electronic camera in which an electric signal charge is added by means of a horizontal shift register.

FIG. **5** is a detailed illustration of the electrode arrangement of the image sensor of FIG. **4**.

FIGS. **6**(*a*) and **6**(*b*) are charts respectively showing clock timing for the vertical and horizontal transfer operations of the image sensor of FIG. **4**.

FIGS. **7**(*a*)–**7**(*f*) illustrate a control operation on a power supply system within the electronic camera of FIG. **1**. Of these drawings, FIG. **7**(*a*) is a main routine flowchart; and FIGS. **7**(*b*), **7**(*c*), **7**(*d*), **7**(*e*) and **7**(*f*) are sub-routine flowcharts respectively for a monitor mode, a recording mode, an external reproduction mode, a monitor reproduction mode and an external monitor mode (or an external recording mode).

FIG. **8** is a block diagram showing, by way of example, the specific arrangement of the image sensor of FIG. **1** and the details of an image sensing signal processing circuit of FIG. **1**.

FIG. **9** is a block diagram showing the details of a reproduction signal processing circuit shown in FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following description shows the arrangement made for attaining the above-stated objects of the invention with reference to the accompanying drawings:

FIG. **1** shows the whole arrangement of an electronic camera which represents an example of the image sensing apparatus according to this invention in an embodiment thereof. An optical image of an object **1** to be photographed reaches the surface of an image sensor **4** through an image sensing optical system **2**, such as a lens system, and a shutter/stop device **3**. The image sensor **4** may be a solid-state image sensor, such as a two- or one-dimensional CCD, or a camera tube. This embodiment, however, uses a two-dimensional CCD as the image sensor **4**. An automatic focusing (AF)/zoom drive control device **5** controls the focal point, focal length, etc. of the image sensing optical system **2**. A shutter/stop drive control device **6** drives and controls the shutter/stop device **3** for automatic exposure control (AE). The arrangment and the functions of these elements and devices are well known and thus require no detailed description herein.

The embodiment is provided with driving control circuits **7A** and **7B** for driving the image sensor **4**. These circuits **7A** and **7B** control impedance, the level and the rise and fall time of pulses. The circuit **7A** is for a monitor mode which will be described later herein and the other circuit **7B** is for an image sensing mode which will also be described later. With a selector **S1** operated, clock pulses generated by a clock pulse generator **8** are supplied to either of these driving control circuits **7A** and **7B** based on which one of the above-stated modes is selected. To facilitate understanding, the driving control circuits **7A** and **7B** are separately shown in different blocks. However, they may have some of their component parts arranged in common. Furthermore, they may be in one circuit in order to have all the component parts arranged in common with the circuit constant being mechanically or electrically variable. Similar modifications or variations also apply to image sensing signal processing circuits **9A** and **9B** and reproduction signal processing circuits **21A** and **21B**, which will be described later. The above-stated image sensing mode includes a recording mode; an external recording mode or an external monitor mode using an external monitor of a high resolving power; and any other mode in which the image sensor **4** is driven for the image sensing purpose.

The output of the image sensor **4** is supplied to both of the image sensing signal processing circuits **9A** and **9B**, which selectively process the output of the sensor **4** based on whether the camera is set in the monitor mode or in the recording mode. The output terminal of the processing circuit **9A** is connected to a terminal "a" of a selector **S3**. Meanwhile the output terminal of the other processing circuit **9B** is connected to the input terminal of a recording signal processing circuit **10** and also to a terminal "b" of a selector **S2**. The recording signal processing circuit **10** converts the output of the image sensing signal processing circuit **9B** into a signal suited for recording. The output of the circuit **10** is supplied via a recording amplifier **14** to a recording head **16** to be recorded thereby on a magnetic disc **18**, which is a record bearing medium. Although the disc **18** is shown in FIG. **1**, a magnetic tape or any of other record bearing medium adapted for optical recording, photo-magnetic recording, magnetic bubble memory recording, etc., may be employed as the record bearing medium in place of the magnetic disc **18**. Furthermore, the recording head **16** may also serve as a reproducing head in place of a reproducing head **17** which will be described later. The magnetic disc **18** is driven and controlled by a motor servo device **19**.

A signal, which is recorded or has previously been recorded on the magnetic disc **18**, is read out by the reproducing head **17** via a readout amplifier **15**. The signal thus read out is supplied either to the reproduction signal processing circuit **21A** or the other reproduction signal processing circuit **21B** based on the posi-

tion of a selector S4. The processing circuit 21A and 21B supply the reproduced signal to a built-in monitor 24 and to an external monitor (not shown). Their output terminals are respectively connected to a terminal "b" of the selector S3 and a terminal "a" of the selector S2. The monitor 24 is composed of, for example, a liquid crystal display device (LCD), an electro-chrominance display device (ECD), a cathode-ray display tube, or the like. A monitor driving device 25 drives and controls the monitor 24. An external video output terminal 26 is connected to a common terminal of the selector S2. A power supply source 27 supplies power to each of the above-stated circuits and devices via connection lines L1–L14.

In this embodiment, the number of scanning lines of the built-in monitor 24 of the electronic camera is fewer than the number of vertical picture elements of the image sensor 4. The image sensor 4 is therefore driven with fewer scanning lines when the camera is in the monitor mode than in the image sensing mode in such a way as to make the monitor 24 compatible with the image sensor 4.

The electronic camera shown in FIG. 1 can be set in each of the different modes including the monitor mode, the recording mode, the monitor reproduction mode, the external monitor mode, the external recording mode and the external reproduction mode by setting the selectors S1–S4 in the following manner:

(1) In the monitor mode, the selector S1 is connected to the terminal "a" thereof while the selector S3 is connected to the terminal "a" thereof.

(2) In the recording mode, the selector S1 is connected to the terminal "b" thereof while the selector S3 is connected to the terminal "b" thereof.

(3) In the monitor reproduction mode, the selector S4 is connected to the terminal "a" thereof while the selector S3 is connected to the terminal "b" thereof.

(4) In the external monitor mode and external recording mode, the selector S1 is connected to the terminal "b" and the selector S2 to the terminal "b" thereof.

(5) In the external reproduction mode, the selector S4 is connected to the terminal "b" thereof and the selector S2 to the terminal "a" thereof.

In each of the above-stated external modes, each signal is supplied via the external video output terminal 26 to each applicable external device.

The selectors S1–S4 which serve as mode selection switches are operated in response to a release operation. These selectors S1–S4 are under the control of the output of a mode setting circuit MS which forms a code signal in response to the operation of a mode dial MD. Furthermore, the selector S3 may be connected to the terminal "a" instead of the terminal "b" in the recording mode. In addition to that modification, the above-stated arrangement for switch-over from one circuit to the other of FIG. 1 may be arranged in different manners. When one of the above-stated modes is selected with the selectors S1–S4 set in their positions as mentioned above, power supplied from the power supply source 27 to parts (circuits or devices) of the electronic camera of FIG. 1, which are not necessary for the selected mode, is either cut off or cut down in a manner as will be described later herein.

When the driving control circuits 7A and 7B are switched over from one position or terminal to the other the details of the scanning and signal reading operations on the image sensor 4 are as follows: The built-in electronic monitor 24 of the electronic camera is assumed to have a number "n" of vertical display lines and a number "m" of horizontal display lines, as shown in FIG. 2. The image sensor 4 is assumed to have a number "l" of vertical picture elements and a number "k" of columns of vertical registers 29, as shown in FIG. 3(*a*). The following relations are obtained: $l>n$ and $k>m$. The image sensor 4 is assumed to be an interline CCD (the same applies to other kinds of solid-state photo sensors or a camera tube). Referring to FIG. 3(*a*), the signals of picture elements indicated by marks "o" and "x" are transferred to the vertical shift registers 29 by means of pulses $\phi 4$ and $\phi 5$. The signals within the registers 29 are then transferred downward by pulses $\phi 6$, as viewed in the drawing, to a horizontal shift register 30. Furthermore, the signals within the horizontal shift register 30 are transferred to the left by means of pulses $\phi 7$, as viewed in the drawing, and are then read out as an image signal.

When the embodiment is in the monitor mode, the clock signal produced from the clock pulse generator 8 is supplied to the driving control circuit 7A. The circuit 7A then produces driving pulses as shown in FIG. 3(*c*).

Meanwhile, in the image sensing mode, which is not in combination with the monitor mode, the driving control circuit 7B produces pulses as shown in FIG. 3(*b*).

In the image sensing mode, the pulses $\phi 4$ are produced at a rate of one for every two fields in synchronization with a vertical synchronizing signal. The pulses $\phi 5$ differ in phase by 180 degrees from that of the pulses $\phi 4$ and are supplied at the same period as that of the pulses $\phi 4$. The pulses $\phi 6$ are supplied within a horizontal blanking period at every horizontal period (1H). Meanwhile, the pulses $\phi 7$ are produced to constantly drive the horizontal shift register 30 at a high speed while the pulses $\phi 4$ and $\phi 5$ are at a low level. In the image sensing mode, therefore, each of the picture elements marked "o" and "x" accumulates electric charge for two fields and their signals are alternately read out at every field.

Next, in the monitor mode, the pulses $\phi 4$ alone are produced at every field while the pulses $\phi 5$ are not supplied. Therefore, a signal accumulated by each of the picture elements marked "o" for one field period alone is read out at every field.

In other words, while interlacing is performed in the image sensing mode, no interlacing is performed in the monitor mode.

In accordance with the above driving method employed in this embodiment, the effective accumulation time of the sensor 4 decreases by half and thus results in a lowered sensitivity. However, flickering (or vertical vibrations) of the image on the monitor 24 disappears. In the monitor mode using the built-in monitor 24, the image sensor 4 is driven in a non-interlacing manner. However, in the external monitor mode using an external monitor of a high vertical resolving power, the image sensor 4 is, of course, driven in a normal interlacing manner.

As mentioned above, in the monitor mode, the mere arrangement to drive the image sensor 4 with a number of scanning lines fewer than the scanning lines used in the image sensing mode results in lowered sensitivity. This problem can be solved by shifting the image sensor driving operation to a driving operation in which electric signal charges are added together. For example, the electric signal charge is added within the vertical shift registers 29 as mentioned in the foregoing. However,

the image sensor **4** is still driven in the non-interlacing manner as long as the pairs of picture elements to which the adding up arrangement applies are not changed for every field. This arrangement effectively prevents degradation of sensitivity as well as flickering of the image. FIGS. **3**(*d*)–**3**(*g*) show a second embodiment of this invention which is arranged in this manner.

In the second embodiment a frame transfer type CCD is employed as the image sensor **4**. Referring to FIG. **3**(*d*), the image sensor **4** consists of an image sensing part **4A**; a memory part **4B**; a horizontal shift register **4C**; and an output amplifier **4D**. A reference symbol ϕ**0** denotes pulses for vertically transferring the electric charges within the image sensing part **4A** and the memory part **4B**.

Referring to FIG. **3**(*e*) which is a schematic sectional view of the image sensing part **4A**, the image sensing part **4A** consists of a semiconductor substrate **300** which is of, for example, the P type; an insulation layer **301**; transparent electrodes **302**; and a lead wire **303** which has the above-stated pulses ϕ**0** impressed thereon. Within each of areas **304**, **306** and **308** which are beneath the electrodes **302** and within other areas **305**, **307** and **309**, a stepwise potential difference results from ion injection. The potential is indicated by a broken line in the drawing when the pulse ϕ**0** is impressed at a high level on the electrode **302** and is indicated by a one-dot-chain line when the pulse is impressed at a low level. Furthermore, the drawing shows the potential as viewed in terms of electrons. The probability of existence of electrons increases as the potential level decreases.

Referring to FIG. **3**(*f*) which shows the vertical transfer pulses ϕ**0** as in the image sensing mode, a vertical transfer period Tα appears alternately with an accumulation period Tβ. In the first field after the accumulation period Tβ, the pulse ϕ**0** rises to have the electric charges accumulated in the areas **305** and **306** added up in the area **306** and those of the areas **307** and **308** added up in the area **308** to form line information. In the second field after the accumulation period Tβ, the pulse ϕ**0** falls adding up the electric charges of the areas **304** and **305** in the area **305** and those of the areas **306** and **307** are added up in the area **307**, respectively. Interlacing is performed for every field in this manner.

Whereas, in the monitor mode in this embodiment, the pulses ϕ**0** have the same wave form both in the first and second fields as shown in FIG. **3**(*g*). Therefore, interlace driving is carried out with the same pairs of electric charges and thus added up for the signals of these fields. The sensitivity never decreases.

The addition or summing of electric charges may be carried out in a different way. For example, in shifting the electric signal charges to the horizontal register **30** shown in FIG. **3**(*a*), the vertical electric charges may be subjected to addition, increasing them two times, three times, or the like. It is also possible to carry out addition of the electric charges at an output stage for an increase in sensitivity by lowering the reset pulse driving frequency for the output amplifier of the image sensor **4**. These methods are advantageous in cases where the monitor **24** possesses a low resolving power in the horizontal direction.

In driving the image sensor **4** to give a signal of fewer picture elements in the monitor mode than in the image sensing mode, the electric signal charge adding up arrangement of the second embodiment effectively increases the sensitivity of the sensor **4** to make up for decreased resolving power, so that the performance of the monitor **24** (viewfinder) can be enhanced.

FIGS. **4**–**6**(*a*) and **6**(*b*) show a third embodiment of this invention. In this embodiment, the image sensor **4** has a plurality of horizontal shift registers **31** to **33**; the sensitivity of the sensor **4** is increased by changing the sensor driving operation in such a way as to consolidate the horizontal shift registers **31** to **33** into one; and the number of bits in the horizontal direction is decreased. In this case, a black-and-white signal is processed in the monitor mode while a color signal is processed in the image sensing mode.

The arrangment of the image sensor **4** of this embodiment is schematically shown in FIG. **4**. This sensor **4** is a frame transfer type solid-state image sensor. A plurality of vertical color stripe filters for color separation are applied to the front side of the image sensing part **4A** in positions according to picture elements. These filters include, for example, R, G and B filters. The sensor **4** includes horizontal shift registers **31**–**33** corresponding to B, G and R signals; a separating input part **34**; and electric charge-to-voltage conversion amplifiers **41**–**43** for the B, G and R signals. The three horizontal shift registers **31**–**33** provide reading transfer routes for different kinds of chrominance signals to be obtained. The electric charges corresponding to each different color B, G, R are respectively supplied to the applicable horizontal shift register **31**–**33** for reading out. Accordingly, the signal of each color B, G, R is substantially sampled at the horizontal register **31**, **32** or **33**. Then, each color or chrominance signal B, G, R is separated from the other and is produced from a respective one of these amplifiers **41**, **42** and **43**.

FIG. **5** shows the arrangement of electrodes in the essential parts of the image sensor **4** of FIG. **4**. The illustration in FIG. **5** includes the lower end portion of the memory part **4B** and the details of the three horizontal shift registers **31**, **32** and **33**.

While it is not shown in FIG. **4**, an electric charge clearing gate CL is disposed in the lowest part of the image sensor **4** of this embodiment and right below the lower side of the horizontal shift register **31**. An electric charge clearing drain CD is arranged via the electric charge clearing gate CL and is connected to a power supply. In between the memory part **4B** and the three horizontal shift registers **31**–**33** is interposed the separating input part **34** which performs a parallel-series converting operation. In other words, information signals on the three colors B, G, R contained in the last horizontal line of the memory part **4B** are separated and supplied from this part **34** to these three horizontal shift registers **31**, **32**, **33** as applicable.

In FIG. **5**, hatched parts represent channel stops and dotted parts electrodes. The horizontal shift registers **31**–**33** are respectively provided with transfer electrodes **31E**–**33E**; the separating input part **34** with the transfer electrode **34E**; and the memory part **4B** with a transfer electrode **4BE**. In this specific embodiment, the transfer operation is carried out by one phase driving. However, it may be carried out by multi-phase driving in two or more phases.

In the drawing, each set of parts A, B, C and D, which is arranged upward from part A, forms a unit cell. Assuming that the potentials in terms of electrons of the parts A–D of the unit cell are expressed as P(A-)–P(D), a virtual phase is formed by ion injection or the like having a relation of $P(A)<P(B)$. The potential levels are fixed. The parts C and D below each of the

transfer electrodes always have their potentials in a relation of P(C)<P(D). There is obtained the relation of P(A)<P(B)<P(C)<P(D) when a low level potential is impressed on each electrode and another relation P(C)<P(D)<P(A)<P(D) when a high level potential is impressed. Clock pulses impressed on the electrodes are indicated by symbols beginning with ϕ. Pulses ϕ1–ϕ3 are impressed on the electrodes 31E–33E; pulses ϕT to be impressed on the electrode 34E; pulses ϕS to be impressed on the electrode 4BE; and pulses ϕCL to be impressed on the clearing gate CL. FIGS. 6(*a*) and 6(*b*) respectively show clock timing to be used for vertical and horizontal transfers. These clock pulses are used in the recording mode, the external recording or the external monitor mode. In FIGS. 6(*a*) and 6(*b*), clock pulses ϕI are applied to the image sensing part 4A.

The image sensor 4, which has the electrodes arranged as shown in FIG. 5, operates as follows: Referring to FIG. 6(*a*), in the vertical transfer of the electric charge from the image sensing part 4A to the memory part 4B, the clock pulses ϕ1, ϕS, ϕT, ϕ3, ϕ2, ϕ1 and ϕCL are supplied in synchronization with a vertical synchronizing signal V.SYNC, with these pulses being in synchronization with each other during a period between points of time t1 and t2. These clock pulses are approximately in phase and are, in number, at least equal to the number of the vertical picture elements of the image sensing part 4A. By this, the electric charge remaining in the memory part 4B is discarded to the drain CD and, at the same time, the electric charge of the image sensing part 4A is transferred to and stored at the memory part 4B. After a point of time t3, accumulated electrical charges of the last column of the memory part 4B are shifted by clock pulses ϕS, one line after another. Then, with clock pulses ϕT, ϕ3, ϕ2 and ϕ1 supplied as shown in the drawing, the information in the horizontal direction is divided for every three picture elements and supplied to the three horizontal shift registers 31–33 as applicable. Following this, the information in each of the registers 31–33 are read out, one after another, after a point of time t4. Details of operation to be performed during the period between the points of time t3 and t4, that is, the operation to divide and selectively supply the information of the last line of the memory part 4B to the three horizontal shift registers 31–33, as applicable, via the separating input part 34 as described below with reference to FIGS. 5 and 6(*a*) and 6(*b*). For the sake of simplifying the illustration, the following description is limited to the shift of electric charges taking place in three columns I, II, and III, which are arranged as one set in the memory part 4B shown in FIG. 5. Other sets, each consisting of three columns, are, of course, concurrently operating in the same manner.

At the point of time t3, when the level of the clock pulse ϕT becomes a high level, the electric charges accumulated at parts 116, 117 and 118 in the last line of the memory part 4B respectively shift to parts 111, 114 and 115 within the separating input part 34. After that, when the level of the clock pulse ϕT becomes low, the electric charges which have moved to these parts 111, 114 and 115 further move to other parts 110, 113 and 106. A little later than the clock pulse ϕT, the clock pulses ϕ3, ϕ2 and ϕ1 are applied one after another. Then, the electric charge, which is at first accumulated at the part 118 of the column I of the memory part 4B and is later transferred to the part 106 of the separating input part 34, moves via the parts 105 and 104 of the horizontal register 33, the parts 103 and 102 of the horizontal register 32 and the part 101 of the horizontal register 31 to the part 100 of the horizontal register 31 to be accumulated there.

Then, when the clock pulse ϕT is again applied, the electric charges, which are at the parts 111 and 114 of the separating input part 34, come via the parts 109 and 112 to the parts 108 and 106. When the clock pulses ϕ3 and ϕ2 are applied one by one a little later than the clock pulse ϕT, the electric charge, which is transferred to the part 106 of the separating input part 34 from the part 117 of the column II of the memory part 4B, moves via the parts 105, 104 and 103 to the part 102 of the horizontal register 32 to be accumulated there.

When the clock pulse ϕT is applied once more, or for the third time, the electric charge, which is at the part 108 of the separating input part 34, moves to another part 106 via the part 107 of the separating input part 34. Then, when the clock pulse ϕ3 is applied a little later than the clock pulse ϕT, the electric charge, which is at first accumulated in the part 116 of the column III of the memory part 4B and is transferred to the part 106 of the separate input part 34, moves via the part 105 to the part 104 of the horizontal register 33 to be accumulated there.

The electric charges which have been accumulated in the last line of the memory part 4B are thus distributed in groups from the columns I, II and III via the separating input part 34 to the applicable horizontal shift register 31–33. In other words, stripe filters of the colors R, G and B are applied having the group of the column I covered by B, that of the column II by G and that of the column III by R. For example, an electric charge corresponding to B is accumulated in the horizontal register 31; an electric charge corresponding to G in the horizontal register 32; and an electric charge corresponding to R in the horizontal register 33, respectively.

At the point of time T4 and thereafter, the electric charges thus supplied to these horizontal registers 31, 32 and 33 are read out as shown at OUT1, OUT2 and OUT3 in FIG. 6(*b*). Upon completion of reading out of one horizontal line portion of an electric charge of the memory part 4B through the horizontal shift registers 31, 32 and 33, the clock pulse ϕS is applied to the memory part 4B as shown in FIG. 6(*b*). This causes the accumulated electric charge of each horizontal line to be vertically shifted to an extent corresponding to one horizontal line. As a result, a new electric charge is taken into the last line. After that, the above-stated operation between the points of time t3 and t4 is performed distributing this new one line portion of accumulated electric charge to the horizontal registers 31, 32 and 33.

The electric charges accumulated in all the lines of the memory part 4B are thus divided and separated for the different colors R, G and B and are read out with the above-stated operation repeatedly performed.

The operation described above is performed in the image sensing mode (or the recording mode, for example). In the monitor mode, this embodiment has signal electric charges added up and consolidated in one horizontal shift register 33 for the purpose of increasing the sensitivity of the image sensor 4. In the monitor mode, the clock pulses ϕ3 are alone used while the other clock pulses ϕ2 and ϕ1 shown in FIGS. 6(*a*) and 6(*b*) are not used. The electric charges accumulated at the parts 118, 117 and 116 of the last line of the memory part 4B are moved to the parts 105 and 104 of the horizontal regis-

ter 33 in the same manner as in the image sensing mode described in the foregoing. However, since the other horizontal registers 32 and 31 never become high level in this case, no electric charge moves to these registers 32 and 31. Therefore, all the electric charges are added up and consolidated at the horizontal shift register 33. In this instnace, no chrominance signal is, of course, produced. However, since the monitor 24 is arranged for a black-and-white signal (monitor 24 of FIG. 1), the above-stated arrangement does not affect the operation of the monitor 24.

Furthermore, in the image sensing mode, or the recording mode, for example, the electric charges of the registers 31, 32, 33 must be prevented from mixing with each other during the horizontal transfer of the electric charges supplied to the horizontal shift registers 31–33. For this purpose, there may be provided control gate means which separates each of these registers 31–33 from other registers. In another feasible method for preventing such mixing, the shift of the electric charge from the part A of each register 31–33 shown in FIG. 5 to another part C is made in a time sequence of register 33→register 32→register 31 and the shift of the electric charge from the part C to the part A in a time sequence reverse to that above.

An experiment was conducted with the above-stated signal adding up arrangement applied to an image sensing system in which a frame transfer CCD having the three horizontal registers 31, 32, 33 of 780×490 cells was employed as the image sensor 4 with a stripe color filter. Signals from the image sensing system were supplied to a black-and-white liquid crystal display device of 260×245 cells. In this experiment, the sensitivity was increased about 6 times as much as the sensitivity obtained in the image sensing mode. Since only one horizontal register 31, 32, or 33 was driven, the power consumption of the whole apparatus was reduced to ½ or thereabouts.

In this embodiment, the control constant of the shutter/stop driving control device (6 of FIG. 1) for automatic exposure control is switched over from one value to another as the mode of the apparatus is shifted between the monitor mode and the image sensing mode by the mode setting circuit. The control constant thus varies according to the increase in the sensitivity of the sensor 4. Therefore, when the sensitivity changes with the mode switched over during the process of sensing an object image, the driving control on the shutter/stop device varies accordingly, so that the level of the output signal of the image sensor 4 remains stable.

In the electronic camera arranged as shown in FIG. 1, power to unnecessary parts of the camera is either cut off or cut down based on the selected mode for the purpose of reduction in power consumption, which is an important matter for an electronic camera. In the following list, parts to which power is to be supplied in each of the different modes are indicated with the symbols of connection lines L1–L14, while power to all other parts is either cut off or cut down as mentioned above:

(1) Monitor mode: L1–L4, L7 and L14
(2) Recording mode: L1–L3, L5, L6, L8–L10
(3) Monitor reproduction mode: L10, L11, L13 and L14
(4) External monitor mode and external recording mode: L1–L3, L5 and L6
(5) External reproduction mode: L10–L12

In the recording mode, the power may be supplied via the lines L13 and L14 in addition to the abovestated lines to also operate thereby the monitor 24. In order to cut off or cut down power to unnecessary parts for each of the different modes as mentioned above, a rated voltage or current is supplied only to the connection lines indicated at items ('1)–(5) of the above list in response to the selecting operation of the selectors S1–S4, while power to other connection lines is either cut off or cut down. The selectors S1–S4 operate according to the output of the mode setting circuit MS, so that power can be automatically controlled by the output of the mode setting circuit MS. In a modification of this power supply arrangement, the power supply source 27 of FIG. 1 is replaced with a microprocessor; the connection lines L1–L14 are used as signal lines between the microprocessor and each of the applicable parts while these parts have power supplied via the connection lines L1–L14 which are separately provided; and thus the power to the above-stated unnecessary parts is either cut off or cut down by the microprocessor.

FIGS. 7(*a*)–7(*f*) are flowcharts showing the above-stated control operation on the power supply. FIG. 7(*a*) shows a main routine, wherein the operating mode is read out. Then, the power supply is controlled in accordance with an applicable subroutine, shown in FIGS. 7(*b*)–7(*f*), based on the mode selected from the modes including the monitor mode, recording mode, external reproduction mode, monitor reproduction mode and external monitor mode (or external recording mode).

Futhermore, in FIG. 1, the circuit arrangement or circuit constants of the driving control circuit 7A, 7B, the image sensing signal processing circuit 9A, 9B or the reproduction signal processing circuit 21A, 21B, etc. variable with the selected mode for reduction in power consumption and improvement in picture quality. For example, in the monitor mode, the driving control circuit 7A, which supplies driving pulses suited for the mode, and the image sensing signal processing circuit 9A, which processes the output of the image sensor 4 produced in that mode, are selected. Or, if these circuits 7A, 9A, 21A are arranged in common with other circuits, the circuit constant is changed to a value suited for the selected mode. In the image sensing mode, such as the recording mode, the driving control circuit 7B and the image sensing signal processing circuit 9B are selected or, if these circuits are arranged in common with other circuits, the circuit constant is changed to a value suited for the image sensing mode. In the monitor reproduction mode, the reproduction signal processing circuit 21A is selected or, if the reproduction signal processing circuit 21A is arranged in common with the other circuit, the circuit constant thereof is changed to a value suited for the monitor reproduction mode. The circuit constant changing operation in each of the modes mentioned above may be automatically accomplished in response to mode selection by some mechanical or electrical means. If a part of the driving control circuit 7A, the image sensing signal processing circuit 9A or the reproduction signal processing circuit 21A is arranged in common with the other circuit while the remaining part is provided for one of the selectable modes, the remaining part of the circuit may be selectable in the same manner as mentioned above.

A method for switching the image sensing signal processing circuit 9A and the reproduction signal processing circuit 21A according to the above-stated mode selection will be described by way of example below with reference to FIG. 8:

In the case of FIG. 8, a frame transfer type solid-state image sensor which is shown in FIG. 4 is employed as an example of the image sensor 4 of FIG. 1. The illustration includes AGC circuits 9GR, 9GG and 9GB which are respectively provided for signals R, G and B; signal processing circuits 9PR, 9PG and 9PB; and a matrix circuit 9M. In the image sensing mode, such as the recording mode, a selector S5 is shifted to a position "b" to allow a luminance signal Y and color difference signals R-Y and B-Y to be produced from the matrix circuit 9M to the recording signal processing circuit 10 of FIG. 1. A known circuit can be employed as each of the above-stated AGC circuits 9GR, 9GG, 9GB. Therefore, details of these circuits 9GR, 9GG, 9GB are omitted here. Meanwhile, in the monitor mode, the selector S5 is shifted to the other position "a" thereof in response to the output of the mode setting circuit MS. Then, for example, the signal G is produced as a black-and-white signal from the channel of this signal to the monitor 24 via a low-pass filter (LPF) 9F and an NTSC encoder 9E. Although this signal is not a chrominance signal, the NTSC encoder 9E is used for the purpose of permitting insertion of a synchronizing signal. With the mode setting circuit MS operated to effect switch-over between the monitor mode and the image sensing mode, an image sensing signal processing method, suited for the selected mode, is selected in this manner. In this embodiment, a black-and-white signal is formed by using a G channel. This arrangement applies to a case where the register 32 is used for reading out a black-and-white video signal. However, where the picture element signals are to be added up by using the register 33, a luminance signal for the monitor mode is formed by using the output of the processing circuit 9PR. Such being the arrangement of this embodiment, a correct video signal is always obtainable even where picture element signals are added up by means of one horizontal shift register 31, 32, 33 within the image sensor 4 which is arranged as shown in FIG. 8.

FIG. 9 shows, by way of example, switching means for switching between the reproduction signal processing circuits 21A and 21B according to the mode selection mentioned in the foregoing. From the output of the reproduction amplifier 15 of FIG. 1, a luminance signal is separated by means of a band-pass filter 21F1 and a chrominance signal by a low-pass filter 21F2. These signals are then respectively processed by a luminance signal processing circuit 21PB and a chrominance signal processing circuit 21PC. In the reproduction mode using an external monitor, a selector S4', which corresponds to the selector S4 in terms of function, is shifted to a position "b" thereof. The outputs of the processing circuits 21PB and 21PC are then supplied via an NTSC decoder 21D1 from an external video output terminal (26 of FIG. 1) to an external device. Whereas, in the reproduction mode using the built-in monitor (24 of FIG. 1), the above-stated selector S4' is shifted to a position "a" thereof. As a result, the output of the luminance signal processing circuit 21PB alone is supplied via a low-pass filter 21F3 and a decoder 21D2 to the monitor 24. A reproduction signal processing method is thus selected to suit for the reproduction mode selected between the mode using the built-in monitor 24 and another mode using the external monitor.

Therefore, in case of observing an image obtained by means of a black-and-white monitor of low resolution, the above-stated arrangement eliminates occurrence of a false signal.

What is claimed is:

1. An image sensing apparatus, comprising:
(a) an image sensor, for generating an image signal, having a plurality of picture elements;
(b) monitor means, for monitoring said image signal, having a fewer number of picture elements than said image sensor;
(c) utilizing means, other than said monitor means, for utilizing said image signal; and
(d) information amount reducing means for reducing the amount of information in said image signal to an amount that can be displayed by said monitor means, said information amount reducing means including driving means for driving said image sensor in at least a first mode and a second mode, the image signal generated by said image sensor when driven in said first mode being supplied to said utilizing means and the image signal generated by said image sensor when driven in said second mode being supplied to said monitor means, said driving means driving said image sensor so as to read out the image signal generated by said image sensor to have a first resolution in said first mode, and driving said image sensor so as to read out the image signal generated by said image sensor to have a second resolution lower than said first resolution in said second mode by adding together signals generated by a predetermined number of said picture elements of said image sensor.

2. An image sensing apparatus according to claim 1, wherein said driving means includes means for driving said image sensor such that signals generated by a predetermined number of said picture elements arranged in a vertical direction are added together.

3. An image sensing apparatus according to claim 1, wherein said driving means includes means for driving said image sensor such that signals generated by a predetermined number of said picture elements arranged in a horizontal direction are added together.

4. An image sensing apparatus according to claim 1 or 2, wherein said driving means includes means for driving said image sensor such that signals generated by predetermined pairs of said picture elements are added together.

5. An image sensing apparatus according to claim 4, wherein said driving means includes means for driving said image sensor such that signals generated by the same predetermined pairs of said picture elements are always added together.

6. An image sensing apparatus according to claim 3, wherein said driving means includes means for driving said image sensor such that signals generated by predetermined triplets of said picture elements are added together.

7. An image sensing apparatus according to claim 1, wherein said utilizing means includes recording means for recording said image signal.

8. An image sensing apparatus according to claim 1, wherein said driving means lowers the resolution of said image signal when driving said image sensor in said second mode by driving said image sensor to operate in a non-interlaced manner.

9. An image sensing apparatus, comprising:
(a) an image sensor, for generating image information, having a plurality of picture elements;
(b) monitor means having a fewer number of picture elements than said image sensor; and

(c) information amount reducing means for receiving the information generated by said image sensor and for reducing the amount of the received image information to an amount that can be displayed by said monitor means, said information amount reducing means including frequency cut-off means for cutting off a predetermined frequency component of the received image information.

10. An appartus according to claim **9**, wherein said information amount reducing means further includes means for cutting off a predetermined chrominance information component of the received image information.

11. An apparatus according to claim **9**, further comprising means for cutting off power supply to predetermined circuits within said image sensing apparatus in association with the operation of said information amount reducing means.

12. An image sensing apparatus according to claim **21**, wherein said information amount reducing means further includes change-over means for changing the cut-off frequency of said frequency cut-off means.

13. An image sensing apparatus according to claim **12**, wherein each of said picture elements of said image sensor is provided with a color filter having one of a plurality of different colors, wherein said image sensor has a plurality of reading means for reading the image signal generated by said picture elements, and wherein said information amount reducing means further includes control means for operating said image sensor in a first mode and a second mode, said control means operating said image sensor in said firt mode such that each of said plurality of reading means only reads signals generated by ones of said plurality of picture elements corresponding to color filters having the same color and operating said image sensor in said second mode such that a predetermined one of said plurality of reading means reads signals generated by all of said plurality of picture elements.

14. An image sensing apparatus according to claim **13**, further comprising utilizing means, other than said monitor means, for utilizing said image information generated by said image sensor, wherein said change-over means changes the cut-off frequency of said frequency cut-off means according to whether said image information generated by said image sensor is supplied to said monitor means or to be said utilizing means.

15. An image sensing apparatus, comprising:

(a) a solid-state image sensor having a plurality of picture elements for generating an image signal and a plurality of reading means for reading the image signal generated by said picture elements, each of said picture elements being provided with a color filter having one of a plurality of different colors;

(b) monitor means, for monitoring said image signal, having a fewer number of picture elements than said image sensor; and

(c) information amount reducing means for reducing the amount of information in said image signal to an amount that can be displayed by said monitor means, said information amount reducing means including control means for operating said image sensor in a first mode and a second mode, said control means operating said image sensor in said first mode such that each of said plurality of reading means only reads signals generated by ones of said plurality of picture elements corresponding to color filters having the same color, and operating said image sensor in said second mode such that a predetermined one of said plurality of reading means reads signals generated by all of said plurality of picture elements, and wherein a video signal is generated from outputs of all of said plurality of reading means when said image sensor is operated in said first mode and a video signal is generated from an output of said predetermined one of said plurality of reading means when said image sensor is operated in said second mode.

16. An image sensing apparatus according to claim **15**, wherein said control means operates said image sensor in said second mode such that said predetermined one of said plurality of reading means reads out signals generated by picture elements corresponding to color filters having a plurality of different colors.

17. An image sensing apparatus according to claim **16**, wherein said control means operates said monitor means as a black-and-white monitor in said second mode.

* * * * *

EXHIBIT 1022

US006512541B2

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Dunton et al.

(10) **Patent No.: US 6,512,541 B2**
(45) **Date of Patent: *Jan. 28, 2003**

(54) **INCREASING IMAGE FIELD OF VIEW AND FRAME RATE IN AN IMAGING APPARATUS**

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(73) Assignee: **Intel Corporation**, Santa Clara, CA (US)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Dec. 8, 1997**

(65) **Prior Publication Data**

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(52) **U.S. Cl.** **348/230**; 348/240; 348/239
(58) **Field of Search** 348/222, 224, 348/229, 230, 240, 239, 14, 15, 18, 19, 340, 135, 169, 172; 250/203.1, 203.6

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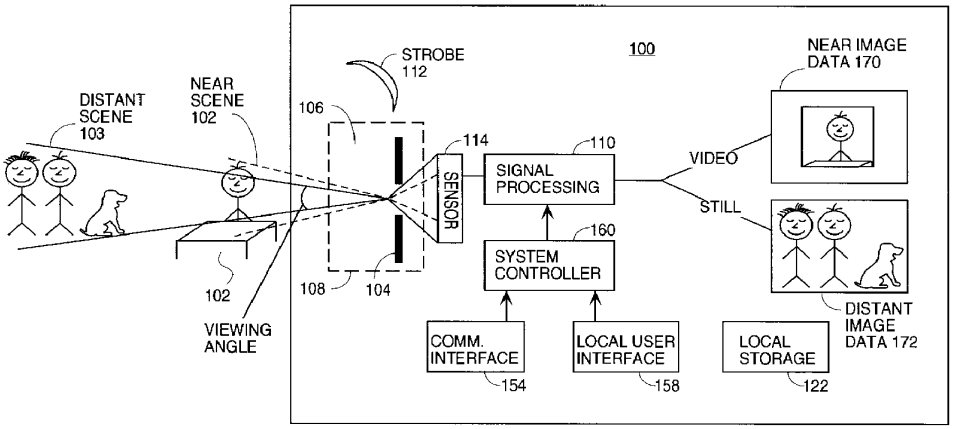
* cited by examiner

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Assistant Examiner—Mitchell White
(74) *Attorney, Agent, or Firm*—Blakely, Sokoloff, Taylor & Zafman LLP

(57) **ABSTRACT**

An imaging apparatus that is configurable to operate in at least two modes. One mode is particularly suitable for still image capture, whereas the second mode is suitable for video image capture and other rapid frame rate applications. The image data in the second mode is smaller (lower resolution) than the image data obtained in the first mode. The reduction is accomplished by either digital scaling, cropping, or by a combination of optical scaling and selective readout of sensor signals. The simple digital scaling provides a fixed angular field of view for both modes of operation, while cropping alone gives a smaller field of view. Using the combination of optical scaling and selective sensor signal readout, however, provides a wider field of view for the second mode of operation while at the same time providing lower resolution images, thus improving frame rate in the second mode of operation. The embodiments can be used in a wide range of imaging applications, including digital cameras used for both still image capture and video.

17 Claims, 6 Drawing Sheets



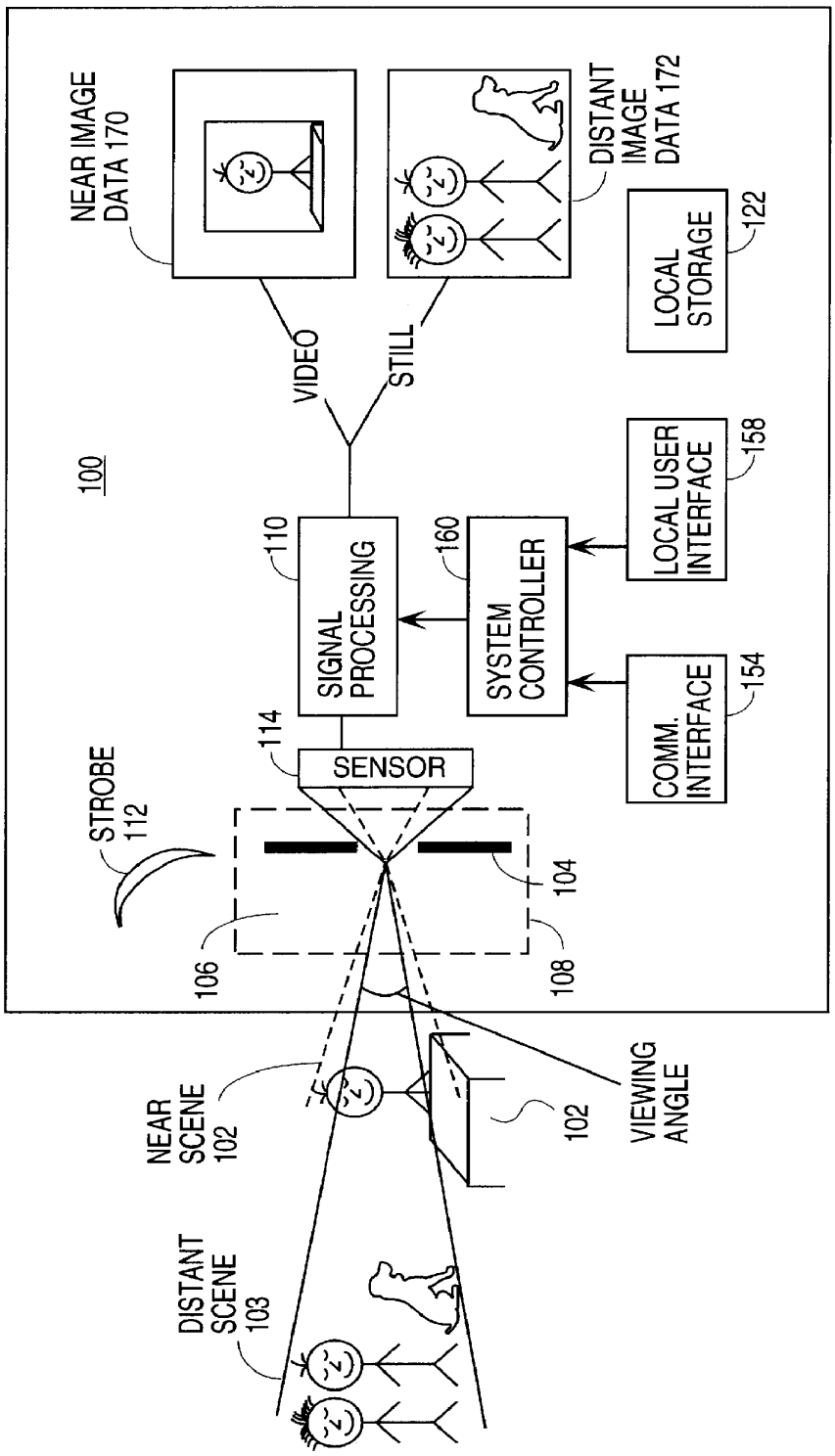

NEAR IMAGE DATA 170
DISTANT IMAGE DATA 172
VIDEO
STILL
LOCAL STORAGE
122
100
110
SIGNAL PROCESSING
160
SYSTEM CONTROLLER
LOCAL USER INTERFACE
158
COMM. INTERFACE
154
114
SENSOR
STROBE 112
104
106
108
NEAR SCENE 102
102
VIEWING ANGLE
DISTANT SCENE 103

FIG. 1

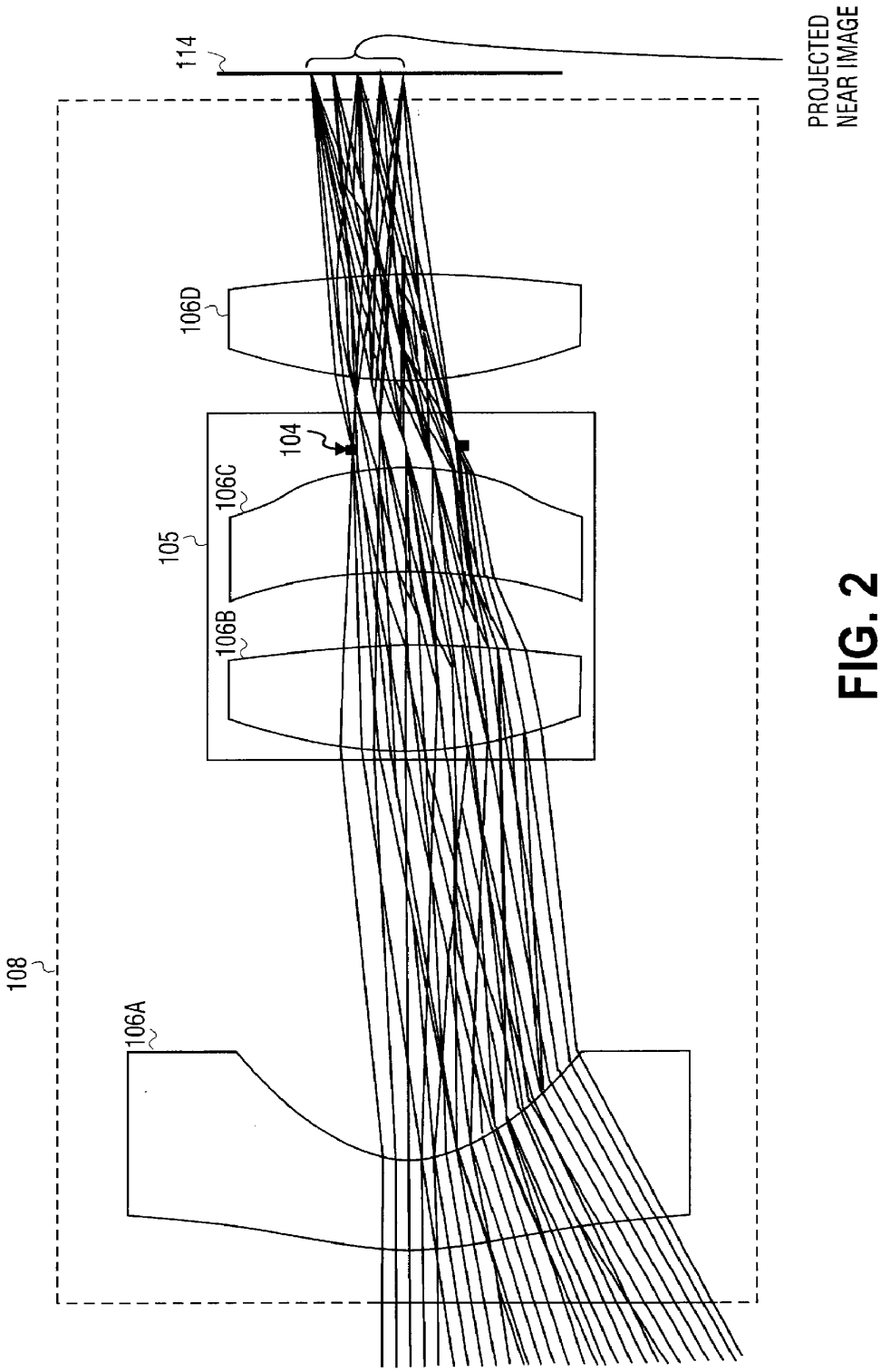


FIG. 2

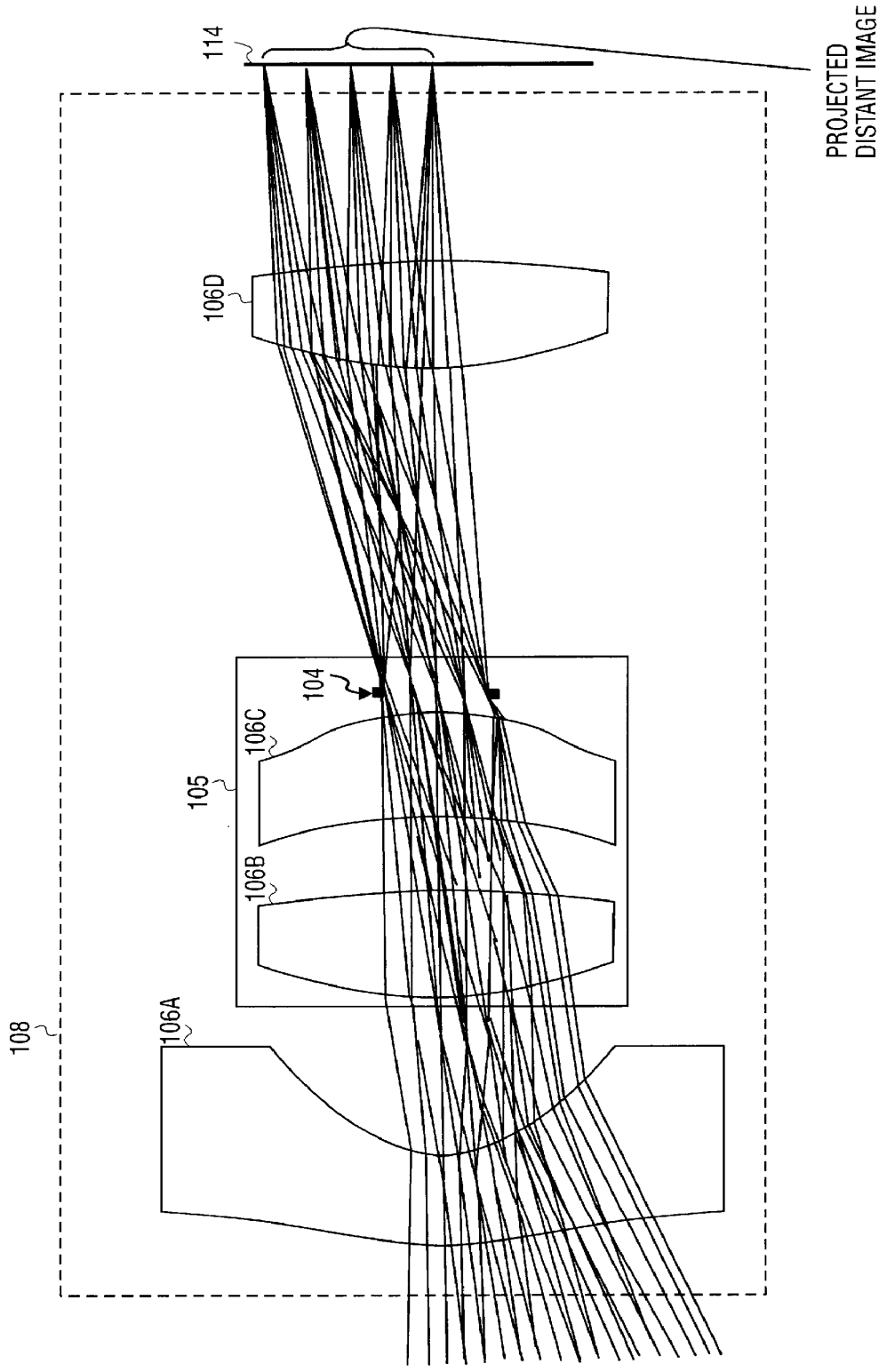


FIG. 3

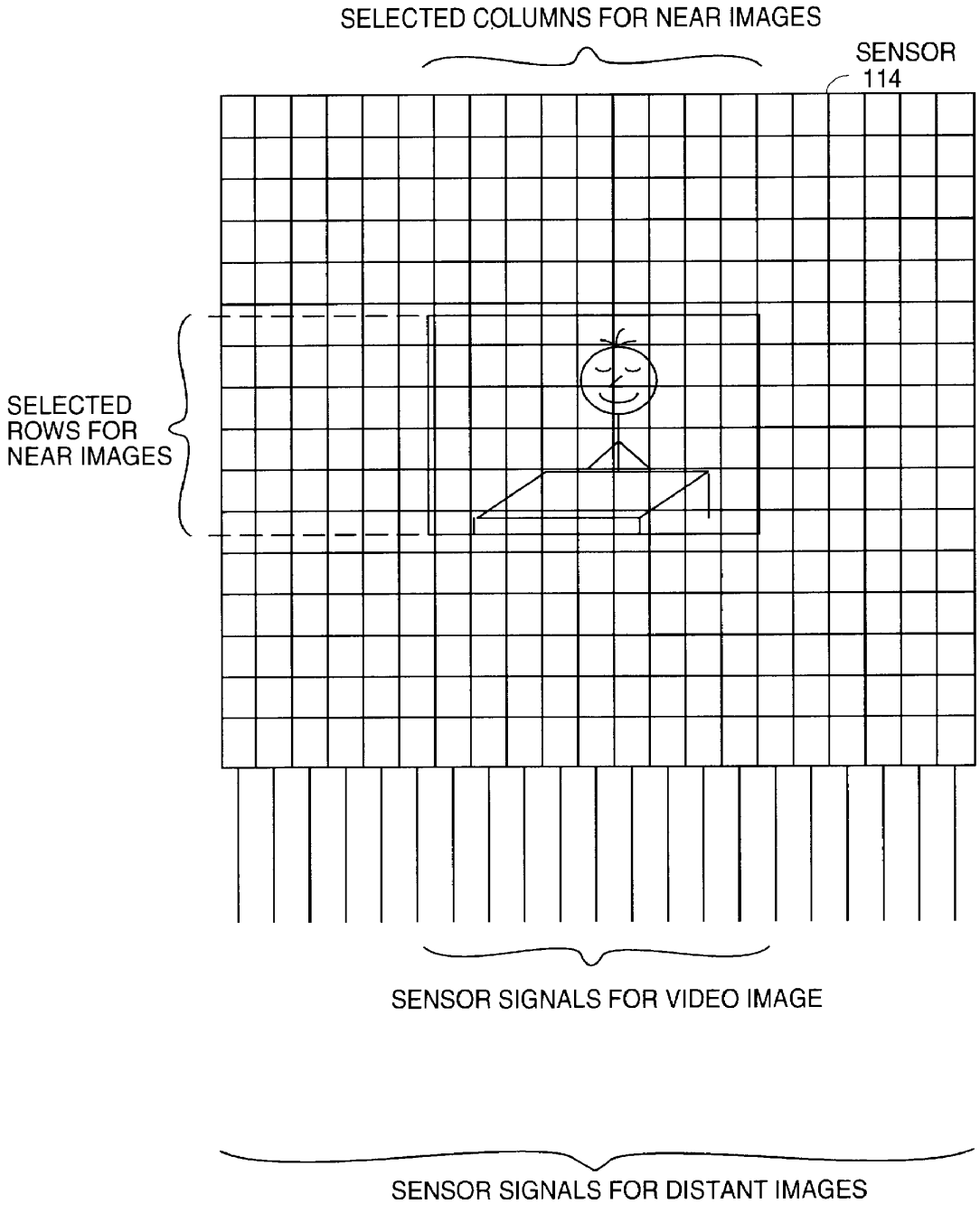

SELECTED COLUMNS FOR NEAR IMAGES
SENSOR
114
SELECTED
ROWS FOR
NEAR IMAGES
SENSOR SIGNALS FOR VIDEO IMAGE
SENSOR SIGNALS FOR DISTANT IMAGES

FIG. 4

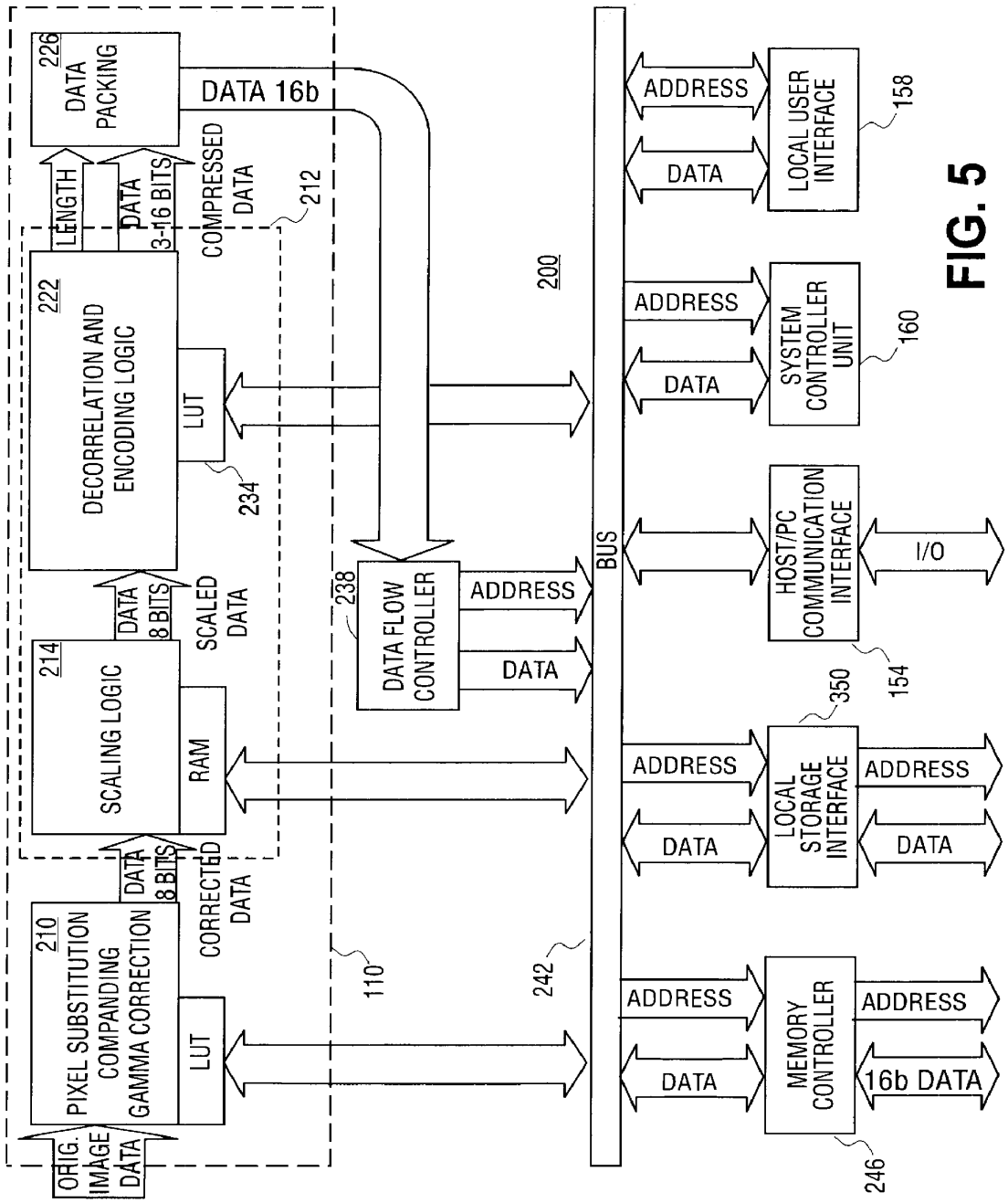

226
DATA PACKING
DATA 16b
LENGTH
DATA 3-16 BITS
COMPRESSED DATA
212
222
DECORRELATION AND ENCODING LOGIC
LUT
234
DATA 8 BITS
SCALED DATA
214
SCALING LOGIC
RAM
DATA 8 BITS
CORRECTED DATA
210
PIXEL SUBSTITUTION COMPANDING GAMMA CORRECTION
LUT
ORIG. IMAGE DATA
110
238
DATA FLOW CONTROLLER
ADDRESS
DATA
200
BUS
242
ADDRESS
DATA
LOCAL USER INTERFACE
158
ADDRESS
DATA
SYSTEM CONTROLLER UNIT
160
ADDRESS
DATA
HOST/PC COMMUNICATION INTERFACE
I/O
154
350
ADDRESS
DATA
LOCAL STORAGE INTERFACE
ADDRESS
DATA
ADDRESS
DATA
MEMORY CONTROLLER
ADDRESS
16b DATA
246

FIG. 5

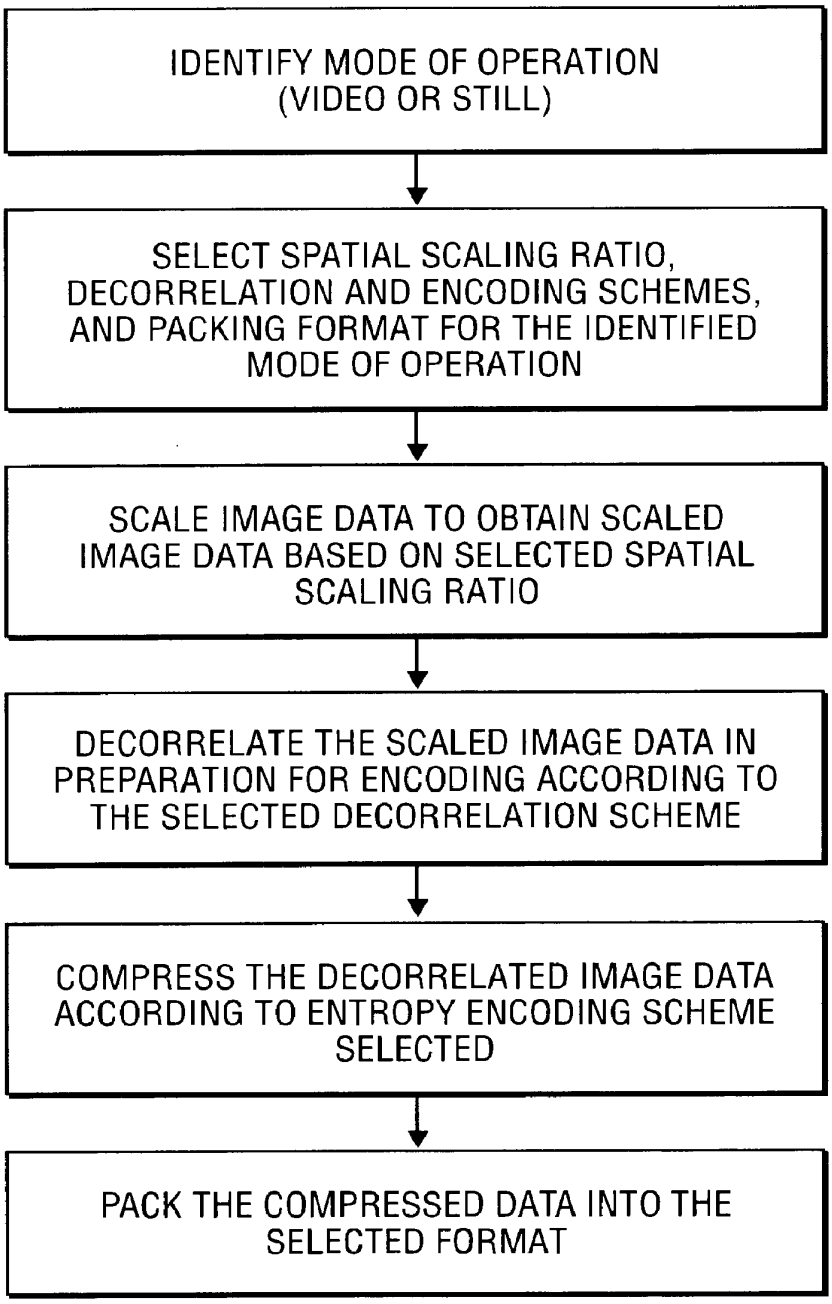

IDENTIFY MODE OF OPERATION (VIDEO OR STILL)
SELECT SPATIAL SCALING RATIO, DECORRELATION AND ENCODING SCHEMES, AND PACKING FORMAT FOR THE IDENTIFIED MODE OF OPERATION
SCALE IMAGE DATA TO OBTAIN SCALED IMAGE DATA BASED ON SELECTED SPATIAL SCALING RATIO
DECORRELATE THE SCALED IMAGE DATA IN PREPARATION FOR ENCODING ACCORDING TO THE SELECTED DECORRELATION SCHEME
COMPRESS THE DECORRELATED IMAGE DATA ACCORDING TO ENTROPY ENCODING SCHEME SELECTED
PACK THE COMPRESSED DATA INTO THE SELECTED FORMAT

FIG. 6

INCREASING IMAGE FIELD OF VIEW AND FRAME RATE IN AN IMAGING APPARATUS

BACKGROUND

This invention is generally related to electronic imaging, and more particularly to changing an image field of view and image frame rate in an imaging apparatus.

Modern electronic imaging systems have become an important part of every household and business, from traditional applications such as video cameras and copiers to more modern ones such as the facsimile machine, scanner, medical imaging devices, and more recently, the digital camera. The digital camera has been developed as a portable system that acquires and stores detailed still images in electronic form. The images may be used in a number of different ways such as being displayed in an electronic photo-album or used to embellish graphical computer applications such as letters and greeting cards. The still images may also be shared with friends via modem anywhere in the world within minutes of being taken.

Most purchasers of digital cameras have access to a desktop computer for viewing the still images. Therefore, such purchasers might also enjoy using the digital camera to communicate with another person via videoconferencing or to view images of motion in a scene. Using a digital camera as a video camera or videoconferencing tool, however, presents requirements that may conflict with those for capturing still images. For instance, due to the limited transmission bandwidth between the camera and a host computer used for viewing video images, the transmitted frames of video images must be of a typically lower resolution than still images.

To meet a given image frame rate over a limited transmission bandwidth, one solution is to simply electronically scale the detailed still image frames into lower resolution image frames prior to transmitting them. Alternatively, the detailed image can be "cropped" to a smaller size, and therefore lower resolution image. In this way, the amount of spatial data per image frame is reduced, so that a greater frame rate can be achieved between the digital camera and the host computer.

Electronic scaling and/or cropping of the detailed image, however, does not address another problem posed by videoconferencing, namely that due to close proximity of the object (a person's face or body) to the digital camera during the video phone or videoconferencing session, a wider field of view is required of the images. The field of view can loosely be thought of as relating to the fraction of the scene included in the transmitted image frame.

Digital cameras typically use an optical system with a fixed effective focal length. Although a detailed still image using such a camera could have an acceptable field of view for distant scenes, electronically scaling the image for video operation does not increase the field of view, while cropping actually decreases the field of view. Therefore, what is needed is a mechanism that allows a digital camera to capture images of close-up scenes having a wider field of view but with lower resolution, in order to increase frame rate for rapid frame rate applications such as video phones and videoconferencing.

SUMMARY

The invention in one embodiment is directed at a circuit for processing first sensor signals to yield first digital image data, where the first signals are generated by an image sensor in response to a first image of a scene projected on the sensor. The circuit is further configured to process second sensor signals to yield second digital image data having a lower resolution than the first data. The second signals are also generated by the image sensor but this time in response to a second image projected on the sensor, where the second image has a greater angular field of view but is smaller than the first image.

The circuit may be incorporated into an imaging apparatus such as a digital camera as a different embodiment of the invention. The imaging apparatus includes the image sensor coupled to an optical system, where the optical system has an adjustable effective focal length, such as in a zoom lens, in order to focus light from a scene onto the sensor to create the first and second images. The second image data is obtained through a combination of (1) the optical system being adjusted to project the second image having a wider field of view than the first image on the image sensor, and (2) the circuit processing the second sensor signals which are generated in response to the second image. The first image data is generated while the camera operates in "still" mode to capture detailed images of distant scenes, whereas the second image data results while operating in "video" mode to capture less detailed but wider angle images of near scenes typically encountered during, for example, videoconferencing.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features as well as advantages of the different embodiments of the invention will be apparent by referring to the drawings, detailed description, and claims below, where:

FIG. **1** illustrates a digital image capture apparatus providing images in dual mode according to a first embodiment of the invention.

FIG. **2** illustrates the detail in an embodiment of the optical system used in the imaging apparatus to generate a near image.

FIG. **3** illustrates detail in the optical system that generates a smaller field of view but larger image, according to another embodiment of the invention.

FIG. **4** is a diagram of an image sensor with a projected near image and the associated sensor signals to be processed by a circuit embodiment of the invention.

FIG. **5** shows a data flow diagram of the path taken by image data for video and still modes of operation.

FIG. **6** illustrates a flow diagram of imaging operations that can be performed by the embodiment of FIG. **5**.

DETAILED DESCRIPTION

As briefly summarized above, the embodiments of the invention are directed at an apparatus and associated method for capturing images having increased angular field of view and at the same allowing an increased frame rate due to their lower resolution. The techniques are particularly suitable for an imaging system such as a digital camera that operates in at least two modes to provide still and video images. The video images have lower resolution but a greater angular field of view than the still images. The greater angular field allows the video images to capture close-up scenes that are typically found in videoconferencing sessions, while their lower resolution permits the transmission of images at a higher frame rate to a host processor over a limited transmission bandwidth. The method and apparatus embodiments

of the invention achieve such a result by a combination of optical scaling to obtain a smaller image size for video mode, and selectively reading only those sensor signals which are generated in response to the smaller image.

For purposes of explanation, specific embodiments are set forth below to provide a thorough understanding of the invention. However, as understood by one skilled in the art, from reading this disclosure, the invention may be practiced without such details. Furthermore, well-known elements, devices, process steps, and the like, are not set forth in detail in order to avoid obscuring the invention.

FIG. **1** shows a digital image capture apparatus **100** according to a first embodiment of the invention. The apparatus **100** has an optical system **108**, including a lens system **106** and aperture **104**, for being exposed to incident light reflected from a scene whose image is to be captured. For this embodiment, two scenes in particular are identified, a near scene **102** and a distant scene **103**. The near scene may be, for instance, a videoconferencing session where a user is sitting at a desk with the apparatus **100** positioned approximately 2 feet in front of the user. The distant scene **103** includes the presence of objects that are located farther away from the apparatus **100**, e.g., 8–10 feet, such as when taking still images.

The apparatus **100** may also include a strobe **112** or electronic flash for generating supplemental light to further illuminate the scenes when the apparatus **100** is operating under low light conditions.

The optical system **108** channels the incident light rays onto an electronic image sensor **114**. The image sensor **114** has a number of pixels or photocells (not shown) which are electrically responsive to incident light intensity, and, optionally, to color. Each of the pixels in the sensor **114** generates a sensor signal that together represent a captured image with sufficient resolution to be acceptable as a still image. Contemplated resolutions include 640×480 and higher for acceptable quality still images.

The sensor **114** generates sensor signals in response to an image of a scene formed on the sensor. The signal processing block **110** then processes the sensor signals into captured digital image data representing the image projected on the sensor **114**. An analog-to-digital (A/D) converter (not shown) may be included in the sensor **114**, as part of the same single integrated circuit die, to generate digital sensor signals (one per pixel) that define a digital image of the exposed scene.

The captured image data include near image data **170** and distant image data **172**. These are obtained in part by adjusting the optical system **108** to change its focal length and, more generally, its modulation transfer function (MTF), to focus images of either the near scene **102** or distant scene **103** onto the sensor **114** at the focal plane of the optical system. The signal processing unit **110** processes the sensor signals according to image processing methodologies to yield the near image data **170** or the distant image data **172**. The near image data may be provided as video images which are streamed to an image processing system such as a host computer (not shown) via the communication interface **154**. The larger and greater resolution distant image data may also be transferred to the host via the interface **154**, but at a lower frame rate. The image data is then decompressed (if necessary), rendered, and/or displayed in the host computer.

The image data, particularly the distant (or still mode) image data, may optionally be stored in a local storage **122** aboard the apparatus **100**. The local storage **122** may include a FLASH semiconductor memory and/or a rotating media device such as a hard disk. The FLASH memory may be removable, such as the Intel® Miniature Card. The rotating media may also be removable or fixed, and may be of the magnetic disk or other type suitable for storing image data files.

The apparatus **100** can be configured to operate in at least two modes. A first mode generates near image data **170**, suitable for video operation. A second mode generates distant image data **172**, suitable for still image capture. Mode selection can be made by the user via mechanical control (not shown) on the apparatus **100**. Mechanical knob settings can be received and translated by a local user interface **158** into control signals and control data that is processed by a system controller **160**. Alternatively, the apparatus **100** can be tethered to the host computer (not shown) such as a personal computer (PC) via the communication interface **154**. The user can then make the mode selection through software running on the host which in turn communicates the proper control signals and data to the system controller **160**.

The system controller **160** orchestrates the capture of images in both modes of operation in response to the mode selection made by the user. In particular, the system controller configures the signal processing block **110** to provide the near or distant image data as described in greater detail below.

In the first embodiment of the invention, the effective focal length of the optical system **108** must be altered between the different modes. FIGS. **2** and **3** illustrate two different settings of the optical system **108** corresponding to the two different modes of operation for the apparatus **100**. The optical system **108** as shown includes a lens system **106** consisting of four lens elements **106***a–d* that are positioned in front of the sensor **114**. An adjustable or movable lens and aperture combination **105**, such as a zoom lens, is also included. The zoom lens or combination **105** can be moved by the user actuating a lever, ring, or by an electromechanical mechanism such as a solenoid or motor. The lens combination **105** includes lens elements **106***b*, **106***c* as well as the aperture **104**. For clarity, only the light rays from the lower half of the scenes are shown in the figures. Although optical system **108** is shown as a lens system having four separate lenses and a fixed aperture **104**, one skilled in the art will recognize that other variations are possible which yield a smaller near image with greater angular field of view.

By simply adjusting the position of combination **105** from a near position in FIG. **2** to a distant position in FIG. **3**, the size of the image projected onto sensor **114** can be increased. This optical scaling feature results in a larger image size for the still image (distant image data) mode of operation.

The other significant characteristic of the optical scaling is the change in angular field of view. The angular field of view can loosely be thought of as relating to the fraction of the scene included in the image projected onto the sensor **114**. Thus, although the projected image in FIG. **2** is smaller than that of FIG. **3**, a greater fraction of the scene is included in the near image of FIG. **2** as shown by the additional light rays that enter the optical system **108** through the first lens **106***a*.

In order to obtain the smaller near image data **170** and greater frame rate when the apparatus **100** is configured with the optical system **108** in the near position, the signal processing block **110** and the sensor **114** are configured (by control signals and data received from the system controller **160**, see FIG. **1**) to process only the pixel signals originating from those rows and columns of the sensor **114** that define

the region on which the smaller image is formed. This can be seen in FIG. **4** which shows a near image being formed on an array of pixels in the sensor **114** and using fewer bitlines than the maximum resolution of the array. Instead of reading all of the sensor signals (which can be read for obtaining the maximum resolution of the image sensor array) shown in FIG. **4**, only those sensor signals coming from the pixels in those rows and columns which define the region of the near image are read. The fewer sensor signals result in both lower processing times in the signal processing block **110**, and greater image frame rate through a limited bandwidth interface between the sensor **114** and signal processing block **110**. This in turn results in greater image frame rate through the host communication interface **154** (see FIG. **1**).

The image data can be further compressed and/or scaled by the signal processing unit **110** as discussed below in connection with FIGS. **5** and **6** in order to increase the frame rate while transmitting the images through a bandwidth-limited communication interface **154**.

To further reduce the cost of manufacturing an apparatus **100** that operates in both still capture and video modes, optical system **108** can be fixed to project images on the sensor **114** having approximately 55° of angular field of view. Such a field of view may be an acceptable compromise for both the near and distant scenes. The distant scene would be captured as a detailed still image, while the near scene (e.g., videoconferencing session) would be handled by digitally scaling (using the signal processing unit **110**) the detailed still image to reduce its resolution. This gives greater frame rate for the video images, but no increase in the field of view as compared to still images. Embodiments of the signal processing unit **110** are shown in FIGS. **5** and **6** and described below.

To summarize, the above-described embodiments of the invention are an imaging apparatus (such as a digital camera), a method performed using the imaging apparatus, and a circuit that provides analog and digital processing, for increasing image field of view while at the same time increasing the image frame rate. The embodiments of the invention are, of course, subject to some variations in structure and implementation. For instance, the embodiment of the invention as signal processing block **110** can be implemented entirely in analog and hardwired logic circuitry. Alternatively, the digital scaling and compression functions of the signal processing block **110** can be performed by a programmed processor. Therefore, the scope of the invention should be determined not by the embodiments illustrated but by the appended claims and their legal equivalents.

Signal Processing Architecture

The image capture apparatus **100** can be electronically configured for dual mode operation by configuring the signal processing block **110** to provide either still image data or a sequence of video images using the logical block diagram and architecture of FIG. **5**. In one embodiment, the block **110** implements digital signal and image processing functions as logic circuitry and/or a programmed data processor to generate compressed image data having a predefined resolution and compression ratio from detailed, original image data received from the sensor **114**.

FIG. **5** shows a data flow diagram for an embodiment of the invention of the path taken by image data for both video and still modes of operation. The processing block **110** includes a chain of imaging functions which may begin with a correction block **210**. The correction block **210** is used whenever the quality of the original image data received from the sensor **114** warrants some sort of pre-processing before the image is scaled and compressed. In certain cases, the correction block **210** performs pixel substitution, companding, and gamma correction on the original image data received from the image sensor. The original image data should be of sufficient detail (e.g., 768×576 spatial resolution or higher is preferred) to yield still images of acceptable quality.

Pixel substitution may be performed in block **210** to replace invalid pixel data with valid data to provide a more deterministic input to subsequent imaging functions. Companding may be performed to lower the resolution of each pixel (the number of bits per pixel). For example, the original image data can arrive as 10 bits per pixel, whereas a preferred pixel resolution for the logic circuitry may be 8 bits (1 byte). Conventional gamma correction may also be performed to conform the information content of the image to that expected by the host computer where the image will be ultimately displayed.

Other functions that may be performed in block **210** on each received original image frame include fixed pattern noise reduction which is often needed before compressing an image. Once again, whether or not any correction functions are performed by block **210** in general depends on the quality of the original image data received from the sensor **114** and any subsequent image processing such as scaling or compression to be performed before the image data is ready for storage or transmission to the host computer.

Once the original image data has been corrected or otherwise processed into the desired size or format by correction block **510**, the corrected data may be scaled and compressed if needed to meet the transmission and storage requirements of the communication interface **154** and the optional local storage **122** (see FIG. **1**). To meet such requirements, the processing block **110** can include scaling and compression logic **514** to perform any necessary image scaling and compression prior to transmission and storage.

For instance, the scaling and compression logic **214** may be configured to reduce image size and resolution to yield smaller, less detailed video images, as compared to larger and more detailed still images. Smaller and less detailed image data may be required in order to transmit a rapid sequence of video images that are to be decompressed and viewed in a host/PC. However, if the transmission link between the apparatus **100** and the host/PC has sufficient bandwidth to transmit a sequence of detailed original image data at the needed rate to the host/PC, then the scaling and compression logic **514** can be simplified or even eliminated for both still or video operation.

A number of digital image processing functions are contemplated for the logic **514**. These or others similar in function may be configured as described below by one skilled in the art depending on the performance (speed of rendering the compressed image data) and image quality desired. The imaging functions have been implemented in one embodiment as separate units of logic circuitry as seen in FIG. **5**. The functions are described as follows in conjunction with the flow diagram of FIG. **6**.

The logic **514** can perform a 2-D spatial scaling of the corrected image data in order to yield smaller images that may be easier to store or transmit. The scaling is done according to a selected scaling ratio using conventional known techniques. The scaling ratio may be integer or fractional. The scaling can be performed in a 2-dimensional fashion by, for instance, utilizing two separate 1-dimensional scaling processes.

The logic **514** can be used for both video and still image capture simply by selecting the appropriate scaling ratio, as

indicated in step **614**. For instance, a 4:1 sub-sampling of the corrected image may be performed in video mode so that 16 pixels from the corrected image data are averaged together to produce 1 pixel in the scaled image data. Based on standard sampling theory, and assuming uncorrelated noise sources, the sub-sampling may also improve the signal to noise ratio by $\sqrt{16}$, or a factor of 4. Lower scaling ratios such as 2:1 may also be used, where 4 pixels are averaged to generate a single pixel in the scaled image data, resulting in a signal to noise ratio (SNR) improvement of 2. By scaling the more detailed corrected image data in this way during operation in video mode, the imaging system compensates for the increased noise due to lower light levels that are typically encountered with video operation, such as during videoconferencing. The scaling step, if needed, appears as step **618** in FIG. **6**.

Next in the chain of imaging function blocks in FIG. **5** is the decorrelation and encoding logic **522**. The scaled image data received from the logic **514** is decorrelated by logic **522** in preparation for entropy encoding as indicated in step **622**, according to a selected one of a number of decorrelation methodologies. Once again, the user may select a particular decorrelation methodology that is suitable for obtaining the normally smaller size video images, as indicated in step **614**.

The decorrelation function can generate error image data as differences between neighboring pixels. One particular method that can be used for image decorrelation is digital pulse code modulation (DPCM). To obtain more compression of the image data, if needed, for example, in transmitting a large number of video image frames, "loss" may be introduced in the form of "quantization" (mapping a first set of data to a smaller set of values) errors using DPCM.

The next stage in the chain of imaging function blocks is entropy encoding, also performed by logic **522**. The technique uses a variable length encoding technique to compress the decorrelated image data, if needed, in step **626**. For instance, a commonly known entropy encoding methodology that may be used is Huffman encoding. Entropy encoding involves replacing symbols in the decorrelated image data by bit strings in such a way that different symbols are represented by binary strings of different variable lengths, with the most commonly occurring symbols being represented by the shortest binary strings. The logic **522** thus provides compressed image data having variable size, for instance as seen in FIG. **5** where the scaled 8-bit data is encoded into compressed data having variable size of 3–16 bits.

Once again, the encoding methodologies for obtaining video and still images can be different and may be selected, as indicated in step **614**, depending on the mode of operation identified earlier in step **610**. For instance, a larger set of symbols (having variable binary string lengths) may be used for encoding still image data as compared to video image data. This is because there may be more time allocated in the host/PC to decompress still images than to decompress video images. In contrast, for encoding video images, a more limited set of symbols having uniform binary string lengths should be employed to obtain faster decompression of a series of video image frames. In addition, having a uniform binary string length allows usage of a fixed amount of bandwidth to transmit the image data that is specifically suitable for a host/PC interface such as the Universal Serial Bus (USB).

The image processing system shown in FIG. **5** includes additional logic that facilitates the dual mode operation described above. In particular, the logic circuitry in blocks **510**, **514**, and **522** use programmable look-up tables (LUTs) **533**, **534**, and **535** and random access memories (RAMs) **535** for flexibility in performing their respective imaging functions. Each LUT or RAM provides information to its respective imaging function logic as specified by the selected methodology for the particular mode of operation. For instance, the scaling logic **514** uses a RAM **235** as a storage area to store intermediate scaling computations. Also, the LUT **534** for the decorrelation and encoding logic **522** can be loaded with different rules and data required for performing decorrelation and encoding as known in the art, depending on whether a still or a video image is desired. In a particular embodiment, two look-up tables (LUTs) are used for LUT **534**, one for listing the characters (a so-called "code book") and one for listing the string lengths.

Different techniques may be used to determine the proper values to be loaded into the RAM and LUTs. For instance, image metering may be performed by the controller **160** to determine lighting and other factors which impact decorrelation and entropy encoding. Also, as mentioned earlier, transmission and storage constraints may dictate greater compression, especially during video operation where a large number of image frames are generated, so that the LUTs for decorrelation and entropy encoding will include a smaller code book for compression of the image data.

Although the different LUTs and RAM described above may be implemented as part of a single, physical RAM unit or alternatively may be combined in different combinations as one or more RAM units, each LUT and RAM is preferably implemented in a physically separate unit to obtain faster performance of the imaging functions.

After the image data has been compressed according to the desired mode by the compression logic **512**, the now variable size data is then passed to the data packing unit **526** where the data is packed into constant size, and therefore more manageable, data segments for more efficient storage and transmission over a computer bus. Once again, if the image data from the sensor **114** is sufficiently acceptable as is, and there are no further transmission or storage constraints on such data, then the data packing unit becomes superfluous, since the sensor image data has a constant size and can be easily stored or transferred outside the imaging apparatus with minimal processing.

In the data packing unit **526**, received data blocks of different size are packed into blocks having a predefined, constant size, as indicated in step **630**. For example, in FIG. **5**, the data packing unit packs the variable size compressed image data into 16-bit blocks. The 16-bit blocks are then forwarded to a data flow controller **538** such as a Direct Memory Access (DMA) controller, which then adds address information to each data block before accessing a bus **542** in order to forward the 16-bit blocks onto the bus. The memory controller **546** accepts the 16-bit blocks over the bus **542** and stores them temporarily in memory such as dynamic RAM (DRAM) (not shown) aboard the apparatus **100**.

After being packed, the still image data may then be transferred over the bus **542** to the optional local storage **122** (see FIG. **1**) via a local storage interface **550** coupled to the bus. For instance, the local storage device **122** may be a removable FLASH memory card which receives the image data prepared as a "file", including compression tables, file headers, time and date stamps, and metering information attached to the image data. The card may then be removed from the apparatus **100** and inserted into a PC to transfer the still image data for decompression, viewing and/or further processing in the PC.

As an alternative to using a removable storage device, the communication interface **154** may be used to transfer both

the still and video images outside the apparatus **100**. This may be accomplished by preparing the still image data as a disk file appropriate for transmission using the particular bus standard used in the communication interface **154**, to be transferred to a host computer for storage and access by a host processor (not shown). The video image data can be streamed according to known techniques to the host computer via the controller interface according to a peripheral bus standard such as USB or IEEE 1394-1995.

The dual mode operation of the image capture apparatus **100** has been described in the context of a bus-based image processing architecture shown in FIG. **5**. To further facilitate software control of the different modes of operation in this architecture, a number of memory-mapped control registers (not shown) may be coupled to the bus **542** to allow the controller **160** to configure the apparatus **100** with the desired mode of operation. Instructions can be provided for execution by the system controller **160** to access the LUTs, RAM, and control registers via the bus **542** in order to program the parameters needed for the proper image processing methodologies of the selected mode of operation. For instance, the different rules and parameters for scaling, decorrelation, and entropy encoding methodologies for all modes of operation may be stored as controller instructions aboard the apparatus **100** during manufacture, where each mode of operation is assigned a different set of methodologies. The appropriate set can be loaded into the processing block **110** in response to a mode selection by the user, made through either the local user interface **158** or the host/PC communication interface **154**.

Although the embodiment of the processing block **110** described above in connection with FIG. **5** is implemented as logic circuitry, the image processing system of FIG. **5** may alternatively be equipped with a programmed high performance processor executing instructions to perform the digital imaging functions of the block **110**. Exemplary steps that may be performed by such a processor are illustrated in FIG. **6**, and were described above simultaneously with the logic circuitry embodiment in FIG. **5**. The sequence of steps in FIG. **6** may be performed by the system controller **160**, or by a separate, dedicated processor (not shown) that is also coupled to the bus **542**.

To summarize, the above described embodiments of the invention in FIGS. **5** and **6** may be used in an apparatus such as a digital camera that operates in both still mode (for capturing still images as a portable camera) and in video mode (where the digital camera is tethered via a computer peripheral bus interface to a host computer or other image viewing system). The camera has an image sensor and a video and still processing block **110** that is configured to capture detailed images in still mode, in both outdoor and indoor scenes. In video mode, the camera may be configured to compress a sequence of the detailed images (if needed for transmission and storage) using the same processing block **110** in order to capture a video sequence that can be transmitted to the host computer for viewing via a computer peripheral bus interface.

The embodiments of the invention described above in FIGS. **5** and **6** are, of course, also subject to some variations in structure and implementation. For instance, although the image data path in the processing block **110** is shown as being 8 bits wide initially and up to 16 bits when compressed, one skilled in the art will recognize that the invention can be implemented using other data path widths. Also, the system controller **160** may be combined with the data flow controller **538** into one physical, integrated circuit unit such as a microcontroller.

Therefore, the scope of the invention should be determined not by the embodiments illustrated but by the appended claims and their legal equivalents.

What is claimed is:

1. A circuit for use in a digital camera to capture digital images of near and far scenes, comprising:

a signal processing circuit that can be configured to operate in a still capture mode and a video capture node, in the still capture mode the circuit is to process first pixel signals that define an electronic still image of a far scene, the first pixel signals to be generated by a first pixel area of a sensor area of a sensor array in response to the pixel area being illuminated by an optical image of the far scene, and

in the video capture mode, the signal processing circuit is to process second pixel signals that define each of a plurality of electronic images of a near scene, the plurality of electronic images of the near scene to be prepared for transmission to a display device via a computer peripheral bus, the second pixel signals to be generated by a second pixel area of the sensor array in response to the second area being illuminated by a plurality of optical images of the near scene, the optical images of the near scene being smaller than the optical image of the far scene so that the second area is smaller than the first area and the second signals are a subset of the first signals, the circuit is to process the second signals and not others of the first signals in the video capture mode.

2. The circuit of claim **1** wherein

the first signals are digital signals, and

the signal processing circuit includes digital signal and image processing circuitry to form the digital images.

3. The circuit of claim **1** wherein the first signals are analog signals, and the signal processing circuit includes an analog to digital converter to convert the analog signals into digital signals, and the processing of the first and second signals includes converting them from analog into digital form.

4. The circuit of claim **3**, wherein the signal processing circuit is to read the second pixel signals but not others of the first pixel signals and then digitally process the second pixel signals but not others of the first pixel signals.

5. The circuit of claim **1** wherein the first signals represent the maximum resolution of the sensor array.

6. A method comprising:

selecting a still capture mode of operation in a digital camera; and then

processing first pixel signals that define an electronic still image of a far scene, the first pixel signals being generated by a first pixel area of an image sensor array in response to the pixel area being illuminated by an optical image of the far scene; and then

selecting a video capture mode of operation in the digital camera;

adjusting an optical system coupled to the image sensor array, to form an optical image of a near scene on a second pixel area of the image sensor array that is smaller than the first area, the optical near image being smaller than and having a greater angular field of view than the optical far image; and then

processing second pixel signals that define each of a plurality of electronic images of the near scene, the second signals being a subset of the first signals and being generated by the second pixel area in response to that pixel area being illuminated by the optical near image; and

further transmitting the plurality of images of the near scene to a display device via a computer peripheral bus, to display motion in the near scene.

7. The method of claim **6** wherein the first signals are digital signals.

8. The method of claim **6** wherein the first signals are analog signals.

9. The method of claim **8**, wherein processing second pixel signals comprises:

reading the second pixel signals but not others of the first pixel signals; and then

digitally processing the second pixel signals but not others of the first pixel signals.

10. The method of claim **6** wherein the first signals represent the maximum resolution of the sensor array.

11. The method of claim **6** wherein the adjusting of the optical system includes moving a lens of the system to change the effective focal length of the optical system.

12. An imaging system comprising:

an image sensor array having a first pixel area and a smaller second pixel area;

an optical system to focus light from a scene onto a focal plane at which the sensor array is disposed, the optical system being adjustable to change its effective field of view of a near scene and a far scene;

means for processing first pixel signals that define an electronic still image of the far scene, the first pixel signals to be generated by the first pixel area in response to the area illuminated by an optical image of a far scene when the system is configured in a still capture mode of operation;

means for processing second pixel signals that define a plurality of images of the near scene, the second signals to be generated by the second pixel area in response to the second area being illuminated by a plurality of optical images of the near scene when the system is configured in a video capture mode of operation, the optical images of the near scene being smaller than the optical image of the far scene, the second signals being a subset of the first signals and said second pixel processing means to process the second signals and not others of the first signals video) capture mode; and

a computer peripheral bus interface to transmit the plurality of electronic images of the near scene to a video display.

13. The system of claim **12** wherein the first signals are digital signals.

14. The system of claim **12** wherein the first signals are analog signals.

15. The system of claim **14**, wherein the means for processing second signals is to read the second pixel signals but not others of the first pixel signals and then digitally process the second pixel signals, but not others of the first pixel signals.

16. The system of claim **12** wherein the processing means includes a processor.

17. The system of claim **12** further comprising:

a system controller coupled to configure the processing means to capture near and far images.

* * * * *

EXHIBIT 1023

US006563535B1

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(54) **IMAGE PROCESSING SYSTEM FOR HIGH PERFORMANCE DIGITAL IMAGING DEVICES**

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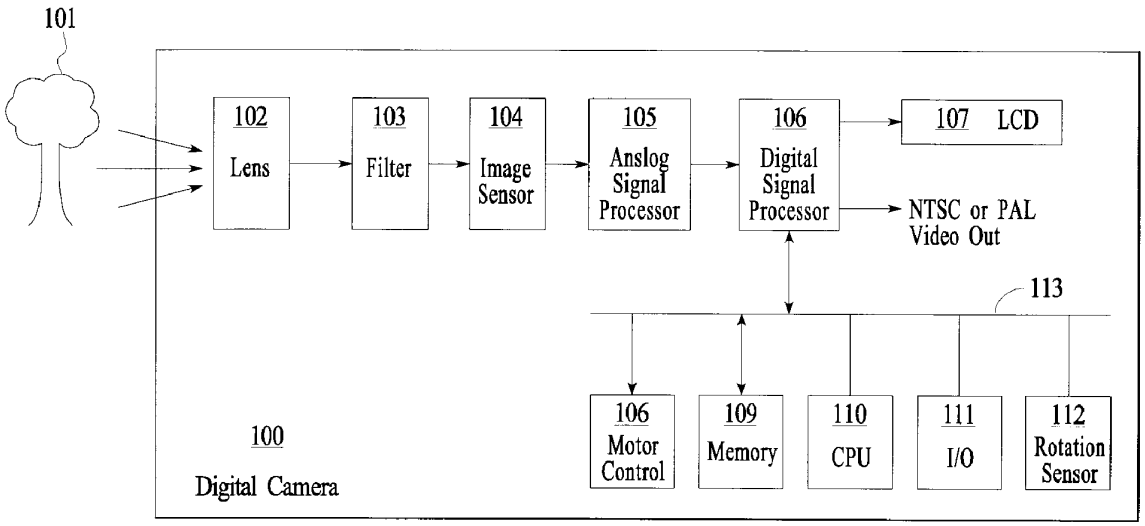
* cited by examiner

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Assistant Examiner—Rashawn N Tillery
(74) *Attorney, Agent, or Firm*—Sawyer Law Group LLP

(57) **ABSTRACT**

An image processing system for high performance digital imaging in a digital camera. The reflected light from an image is focused through a lens and optically filtered. A CCD array converts this image into an electrical signal. This electrical signal is processed and then converted into an equivalent digital signal. A digital signal processor is then used to process the raw digital signal. The DSP includes a capture data path, a data flow control, an image processing data path, a compression/decompression engine, a resize circuit, a display processing circuit, and a rotation circuit. Data is routed between the DSP and memory via a bus. By selectively activating and reusing certain parts of the hardware architecture and various data paths, at least four modes of operation can be supported: live view, instant review, and play mode. Furthermore, the correct image is automatically displayed in all four modes, regardless of the orientation of the image or the physical orientation of the camera (both at the time the picture was taken and at the time the picture is being rendered for display).

18 Claims, 13 Drawing Sheets



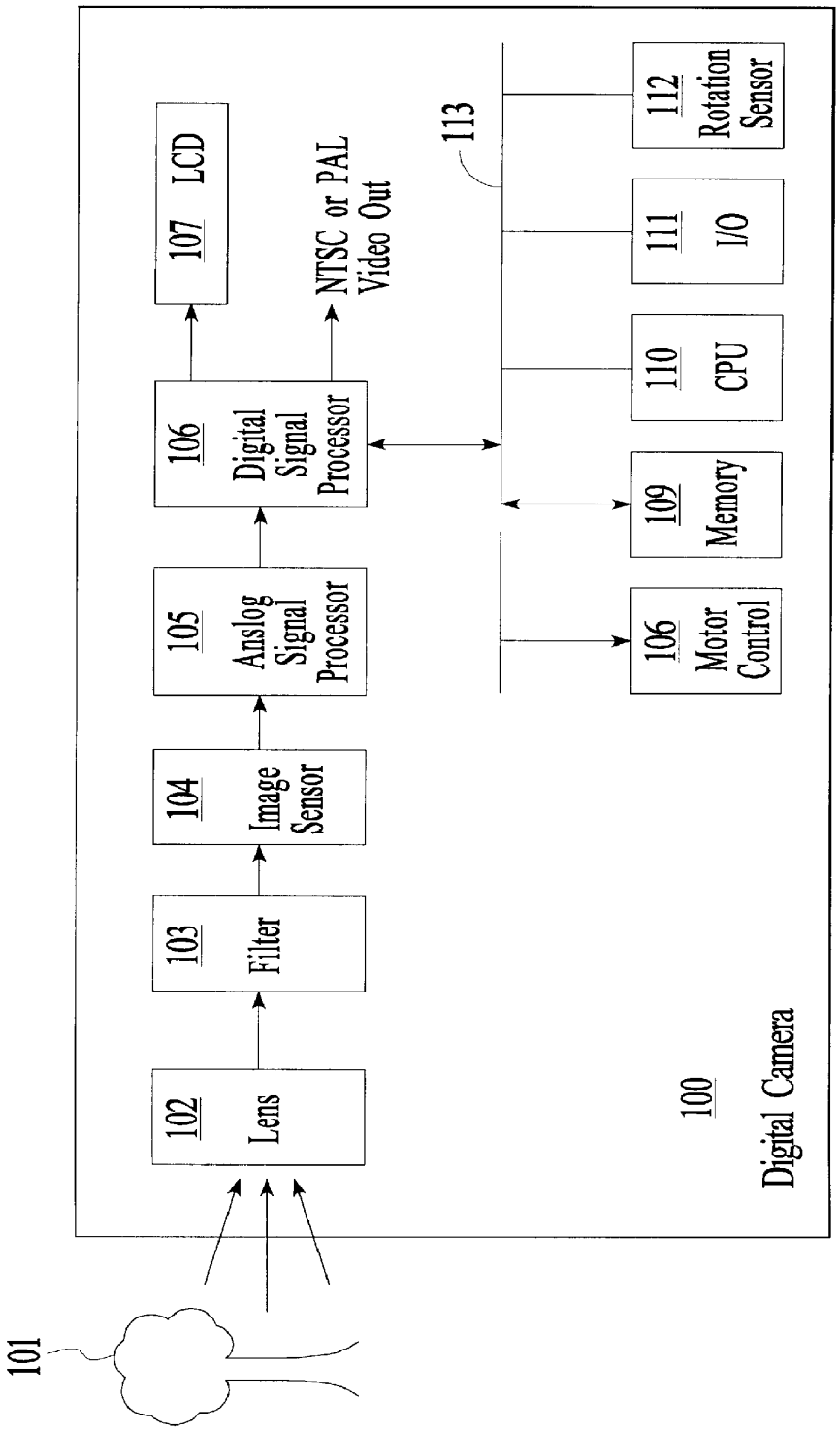

101
100
Digital Camera
102
Lens
103
Filter
104
Image Sensor
105
Anslog Signal Processor
106
Digital Signal Processor
107
LCD
NTSC or PAL Video Out
113
106
Motor Control
109
Memory
110
CPU
111
I/O
112
Rotation Sensor

FIG. 1

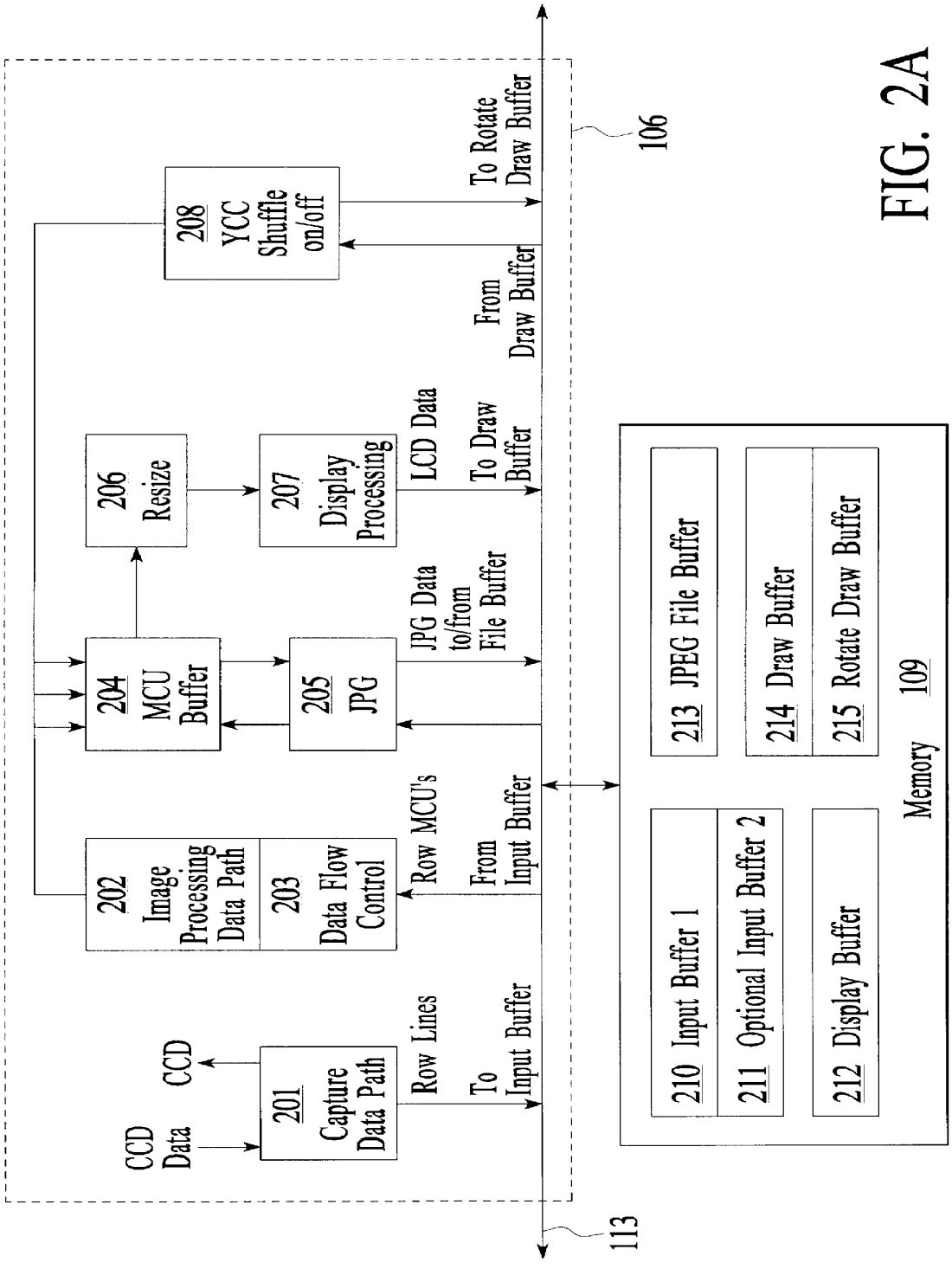

CCD Data
CCD
201 Capture Data Path
Row Lines
To Input Buffer
202 Image Processing Data Path
203 Data Flow Control
Row MCU's
From Input Buffer
204 MCU Buffer
205 JPG
JPG Data to/from File Buffer
206 Resize
207 Display Processing
LCD Data
To Draw Buffer
208 YCC Shuffle on/off
From Draw Buffer
To Rotate Draw Buffer
106
113
210 Input Buffer 1
211 Optional Input Buffer 2
212 Display Buffer
213 JPEG File Buffer
214 Draw Buffer
215 Rotate Draw Buffer
Memory 109

FIG. 2A

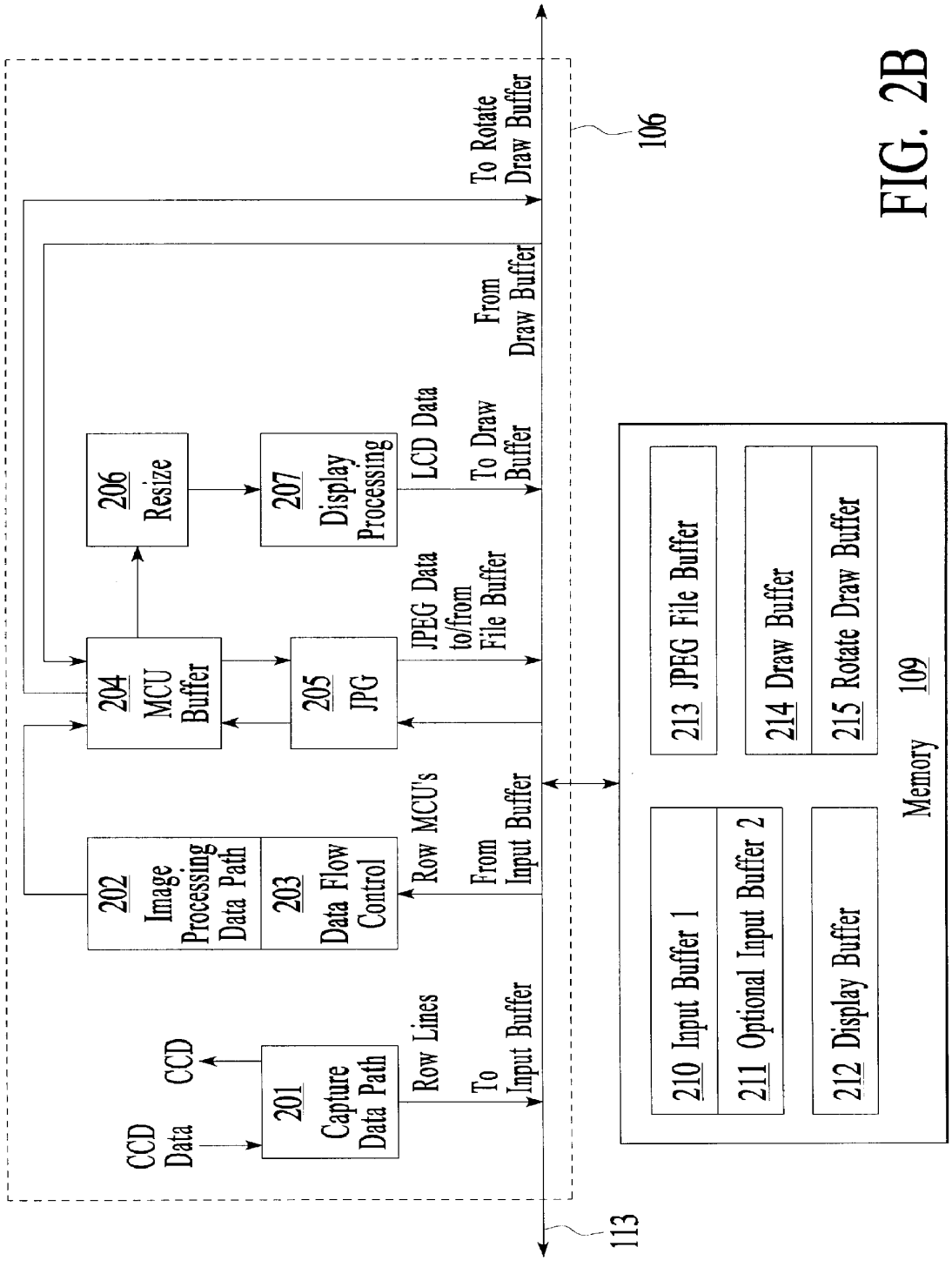

CCD Data
CCD
201 Capture Data Path
Row Lines
To Input Buffer
202 Image Processing Data Path
203 Data Flow Control
Row MCU's
From Input Buffer
204 MCU Buffer
205 JPG
206 Resize
207 Display Processing
JPEG Data to/from File Buffer
LCD Data
To Draw Buffer
From Draw Buffer
To Rotate Draw Buffer
106
113
210 Input Buffer 1
211 Optional Input Buffer 2
212 Display Buffer
213 JPEG File Buffer
214 Draw Buffer
215 Rotate Draw Buffer
Memory 109

FIG. 2B

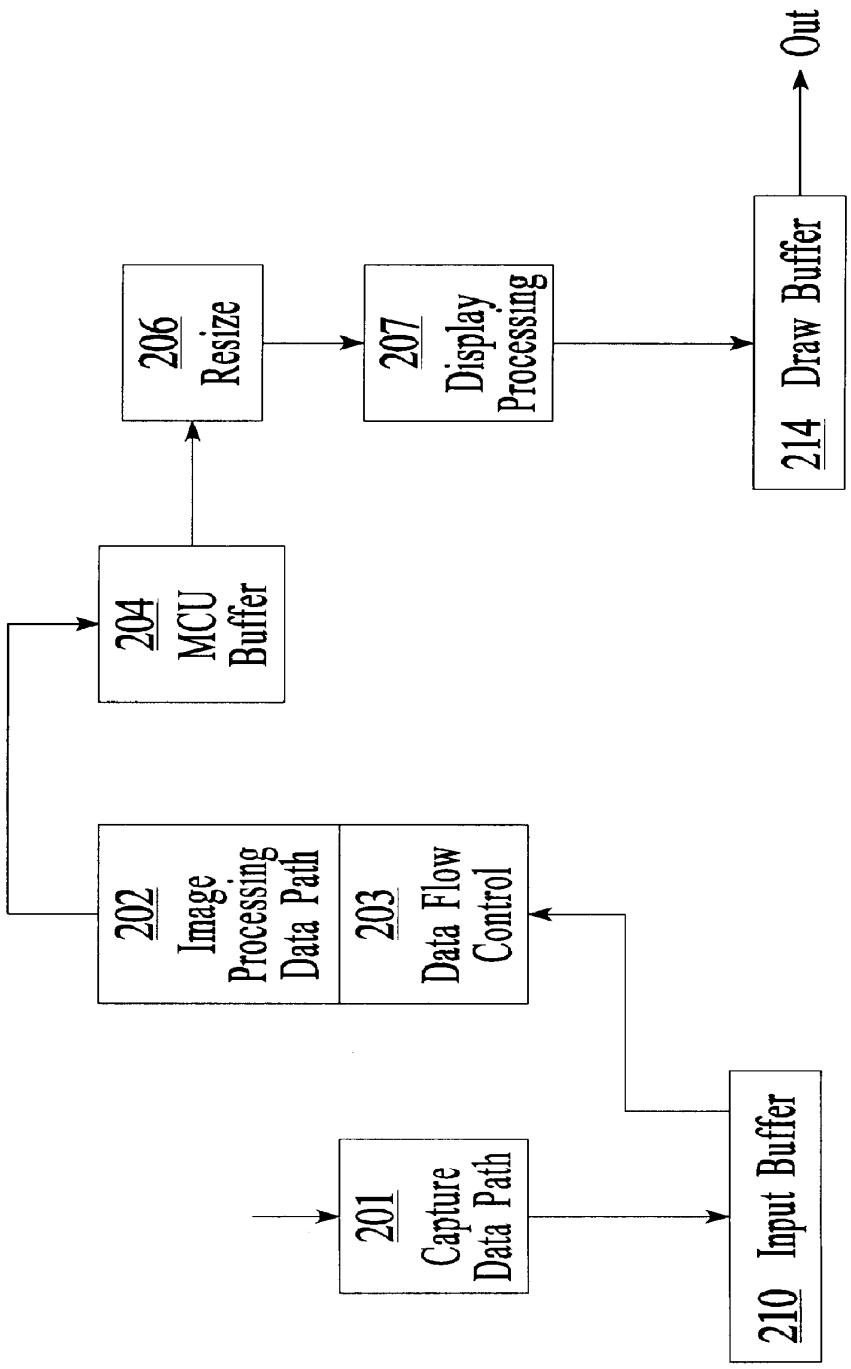

Out
214 Draw Buffer
207 Display Processing
206 Resize
204 MCU Buffer
202 Image Processing Data Path
203 Data Flow Control
201 Capture Data Path
210 Input Buffer

FIG. 3A

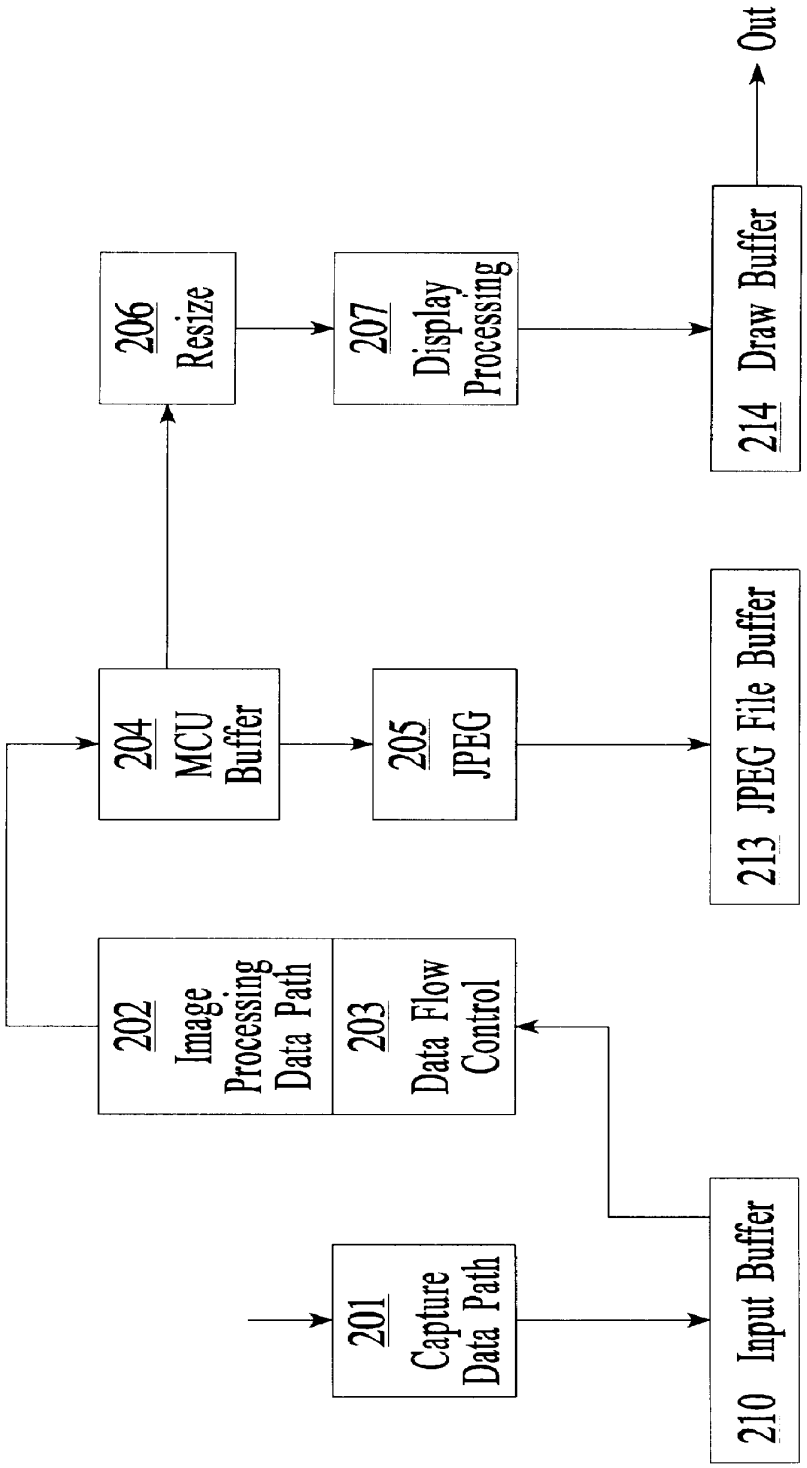

Out
206 Resize
207 Display Processing
214 Draw Buffer
204 MCU Buffer
205 JPEG
213 JPEG File Buffer
202 Image Processing Data Path
203 Data Flow Control
201 Capture Data Path
210 Input Buffer

FIG. 3B

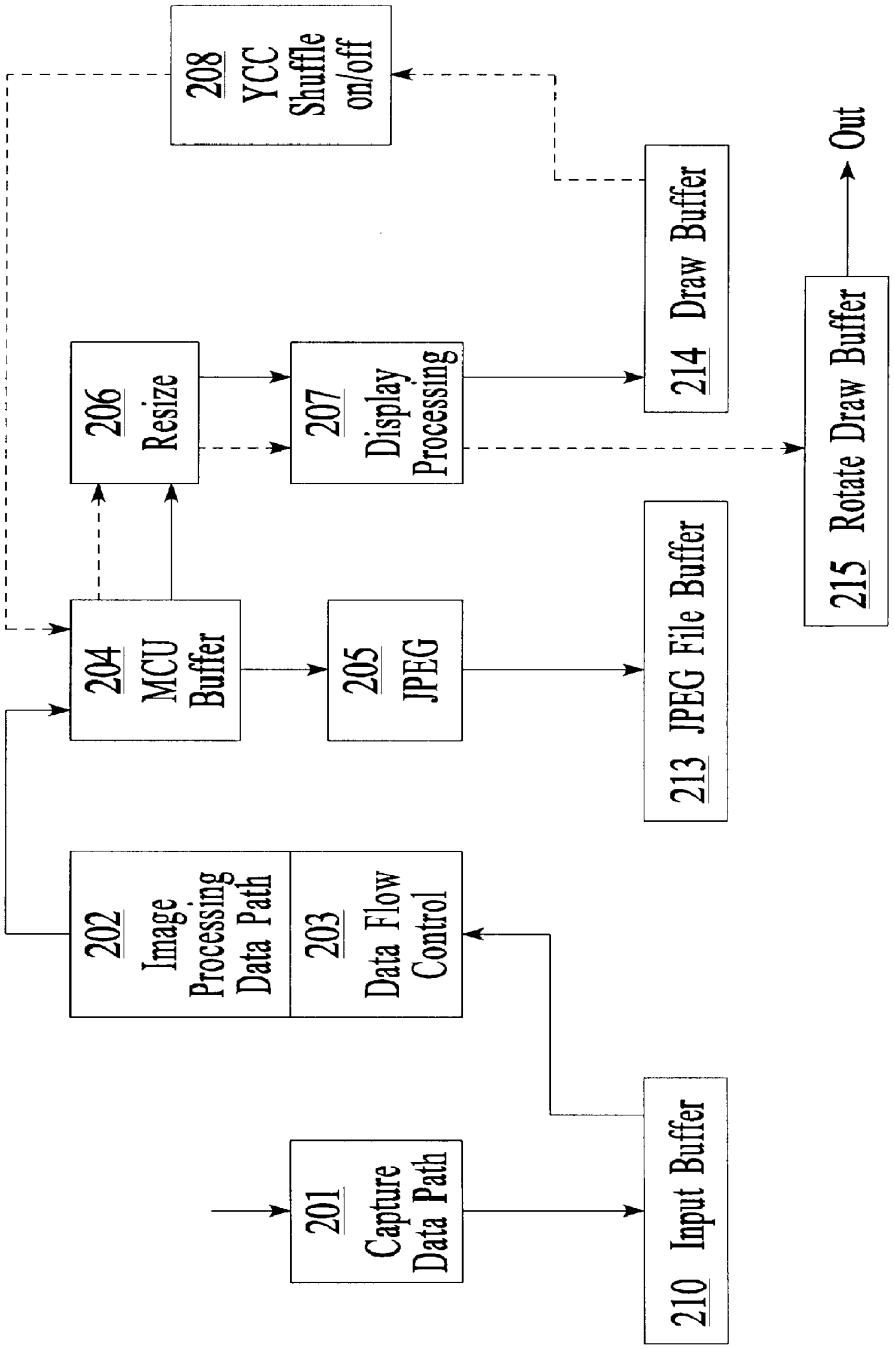

208 YCC Shuffle on/off
206 Resize
207 Display Processing
214 Draw Buffer
Out
215 Rotate Draw Buffer
204 MCU Buffer
205 JPEG
213 JPEG File Buffer
202 Image Processing Data Path
203 Data Flow Control
201 Capture Data Path
210 Input Buffer

FIG. 3C

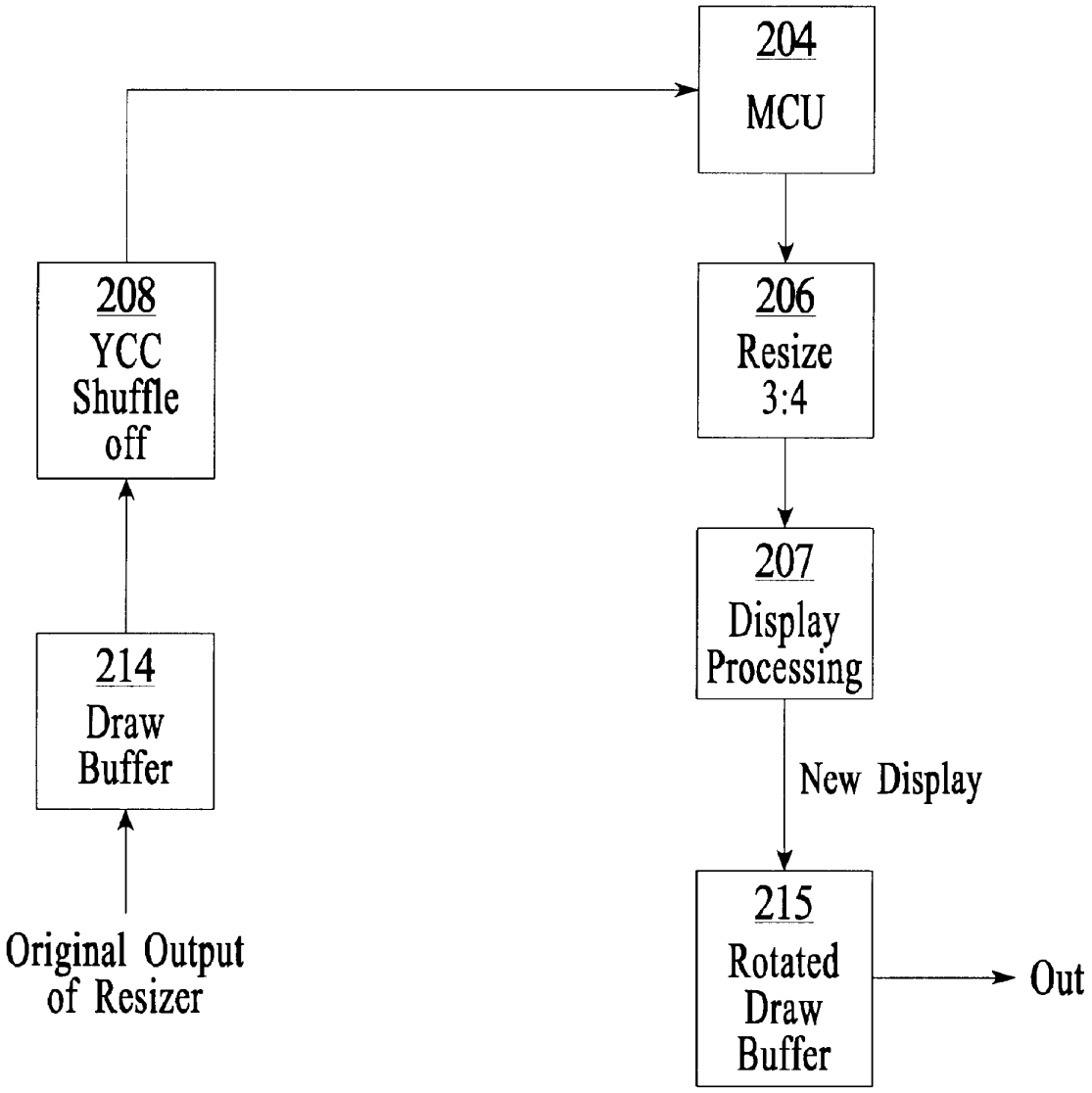

204
MCU
208
YCC
Shuffle
off
206
Resize
3:4
207
Display
Processing
214
Draw
Buffer
New Display
215
Rotated
Draw
Buffer
Out
Original Output
of Resizer

FIG. 3D

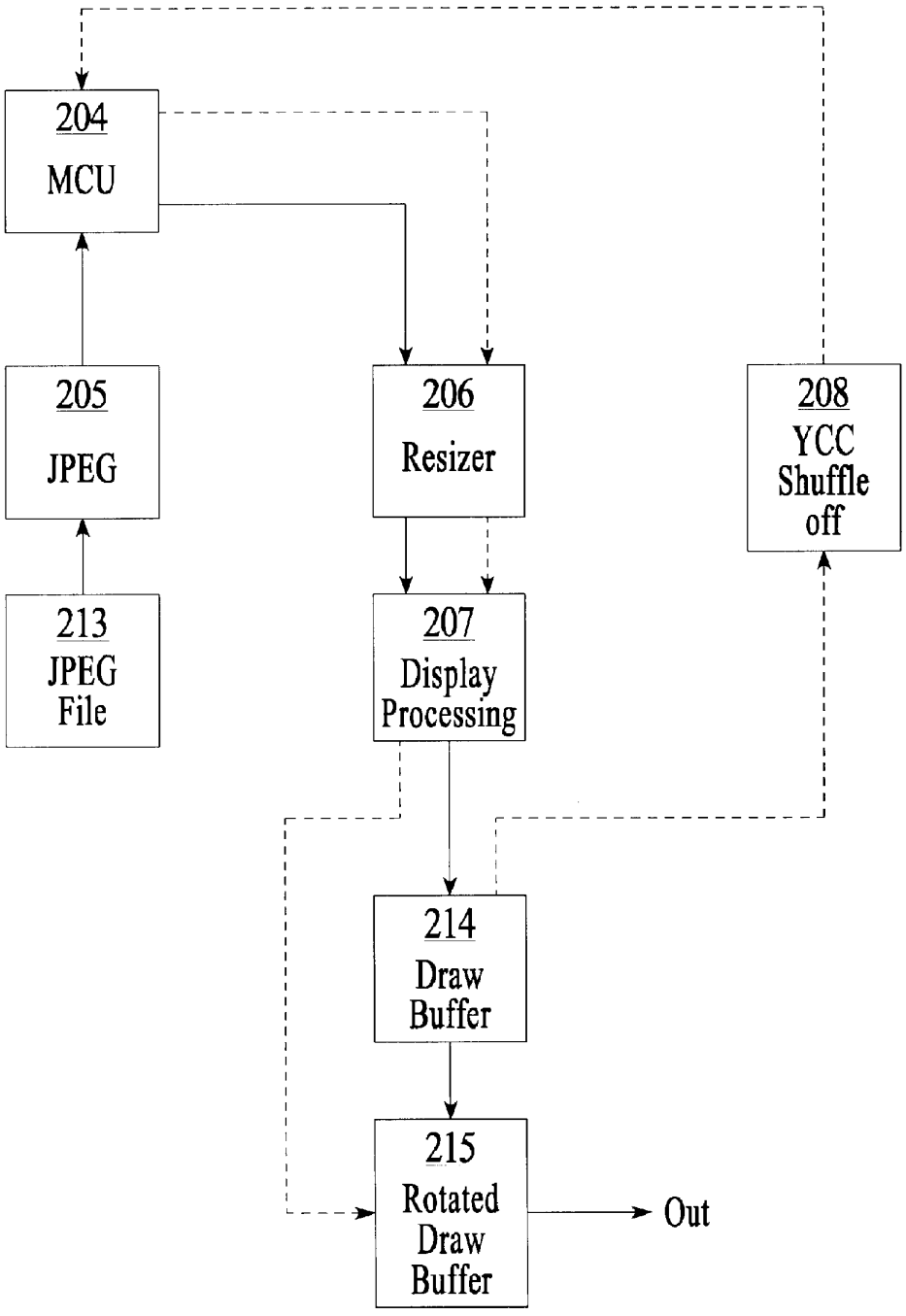

204
MCU
205
JPEG
213
JPEG
File
206
Resizer
207
Display
Processing
208
YCC
Shuffle
off
214
Draw
Buffer
215
Rotated
Draw
Buffer
Out

FIG. 3E

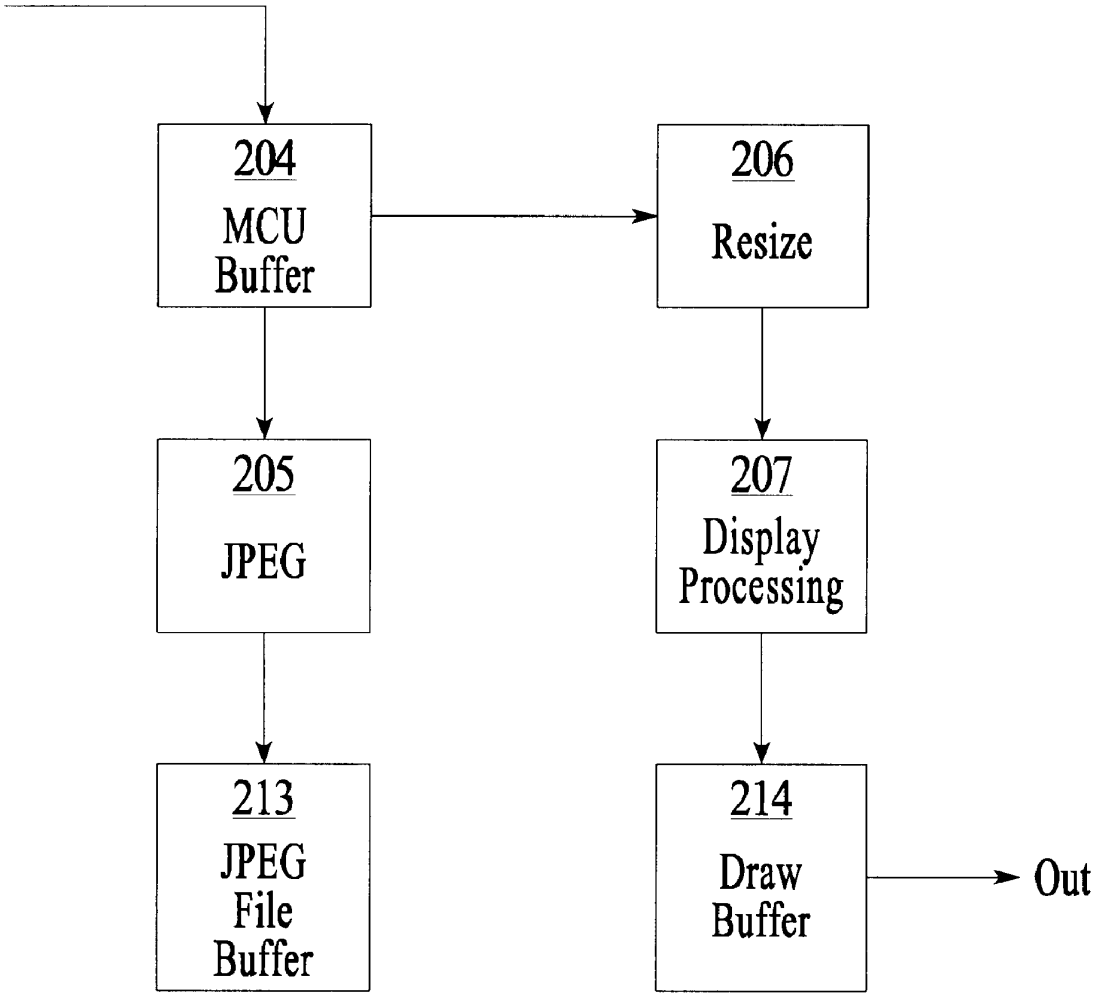

204
MCU
Buffer
206
Resize
205
JPEG
207
Display
Processing
213
JPEG
File
Buffer
214
Draw
Buffer
Out

FIG. 3F

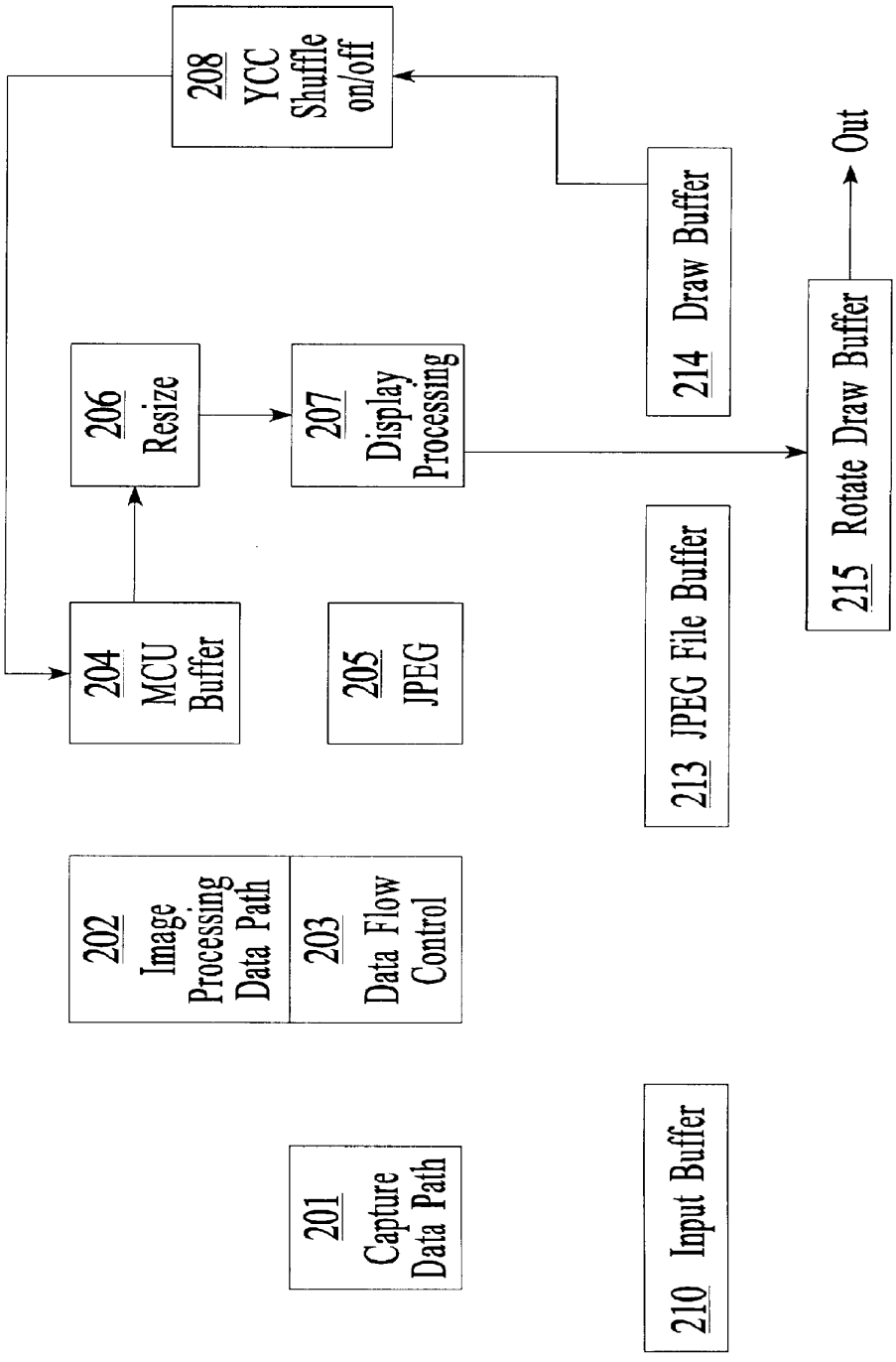

208 YCC Shuffle on/off
206 Resize
207 Display Processing
214 Draw Buffer
Out
204 MCU Buffer
205 JPEG
213 JPEG File Buffer
215 Rotate Draw Buffer
202 Image Processing Data Path
203 Data Flow Control
201 Capture Data Path
210 Input Buffer

FIG. 3G

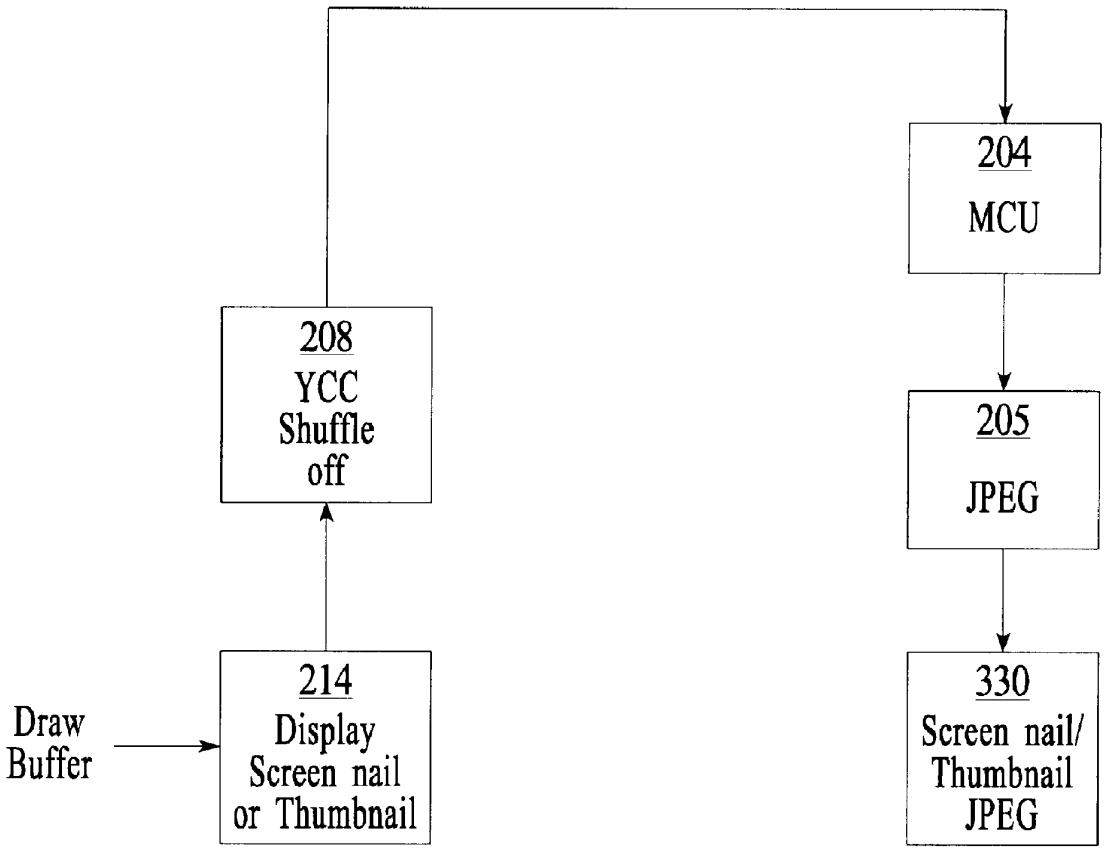

204
MCU
208
YCC
Shuffle
off
205
JPEG
214
Display
Screen nail
or Thumbnail
Draw
Buffer
330
Screen nail/
Thumbnail
JPEG

FIG. 3H

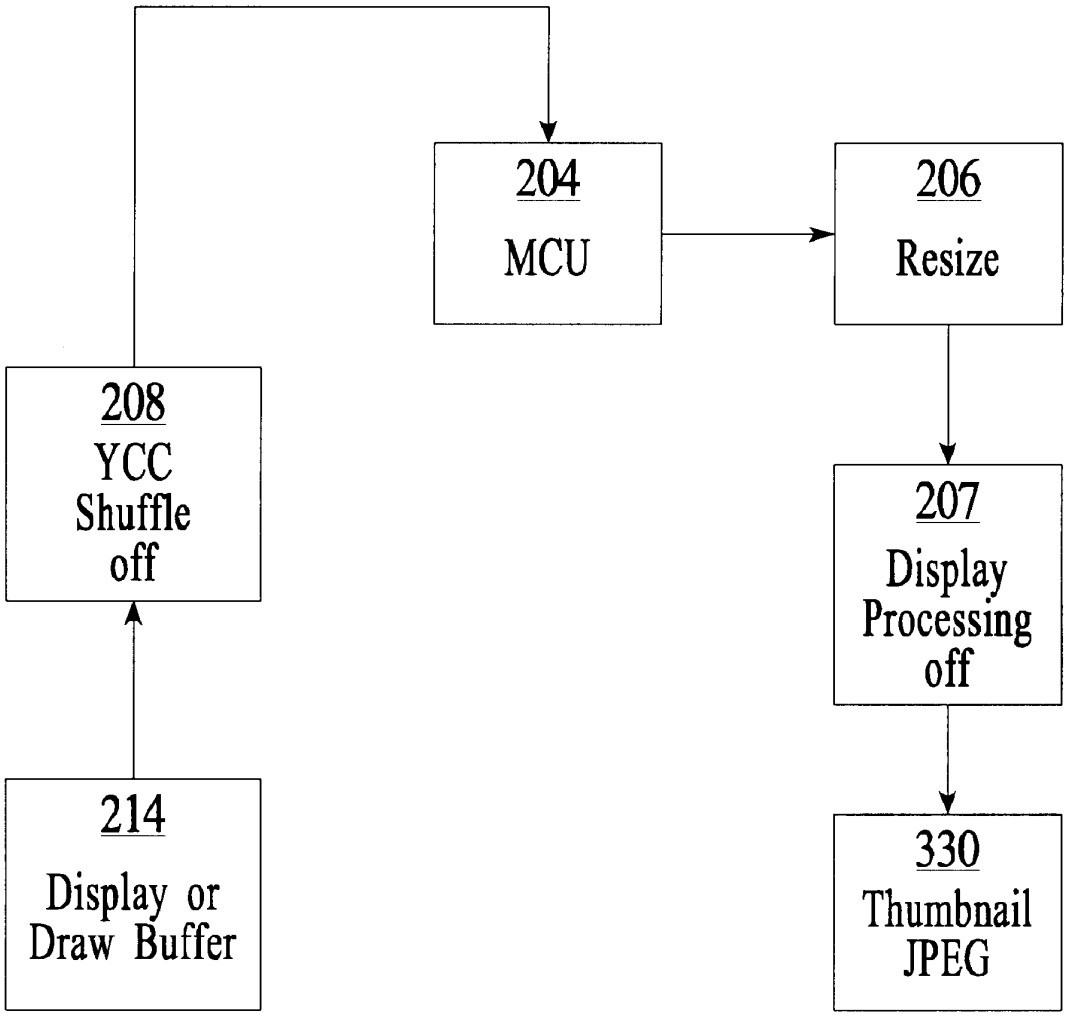

204
MCU
206
Resize
208
YCC
Shuffle
off
207
Display
Processing
off
214
Display or
Draw Buffer
330
Thumbnail
JPEG

FIG. 3I

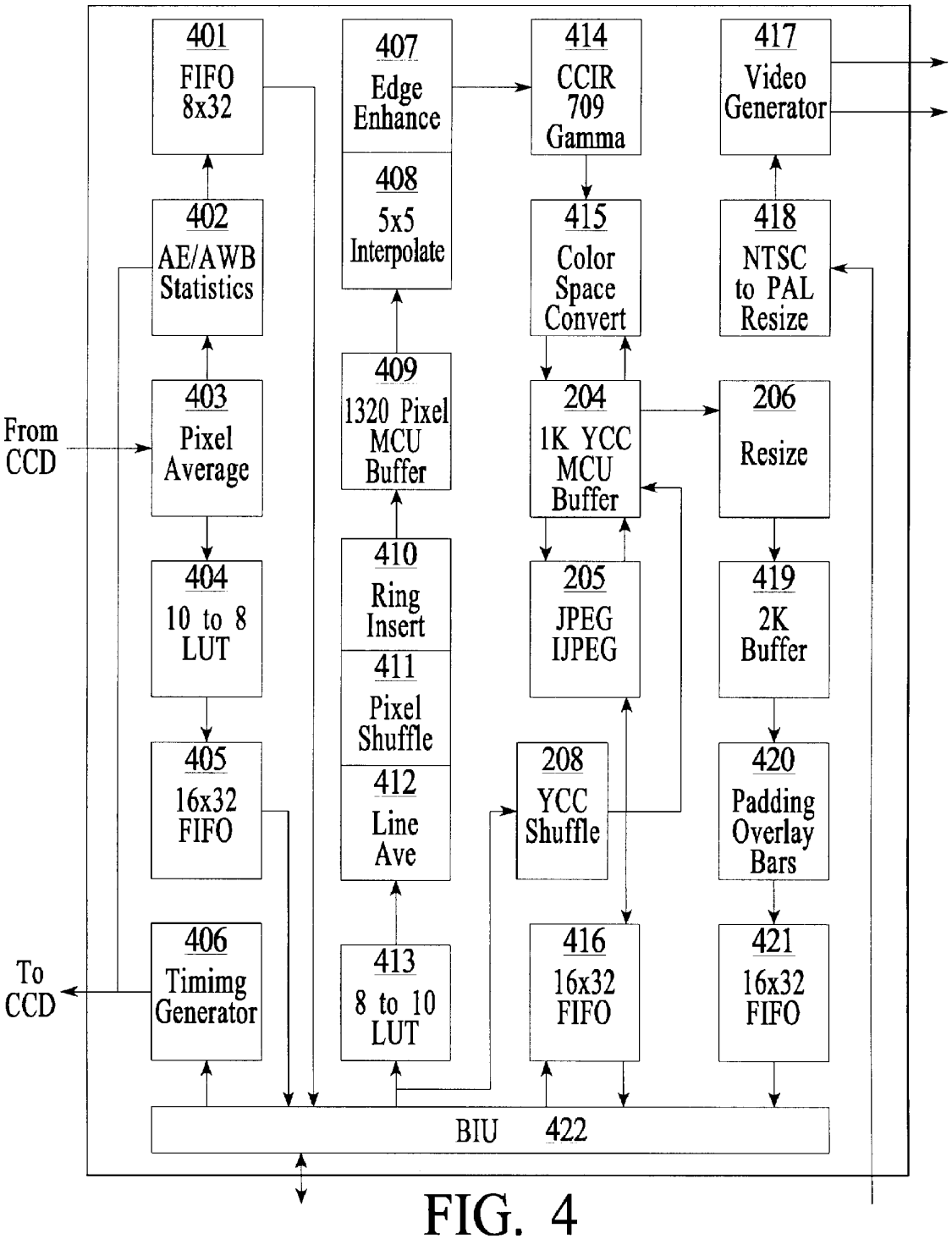

401
FIFO
8x32
402
AE/AWB
Statistics
403
Pixel
Average
404
10 to 8
LUT
405
16x32
FIFO
406
Timimg
Generator
From
CCD
To
CCD
407
Edge
Enhance
408
5x5
Interpolate
409
1320 Pixel
MCU
Buffer
410
Ring
Insert
411
Pixel
Shuffle
412
Line
Ave
413
8 to 10
LUT
414
CCIR
709
Gamma
415
Color
Space
Convert
204
1K YCC
MCU
Buffer
205
JPEG
IJPEG
208
YCC
Shuffle
416
16x32
FIFO
417
Video
Generator
418
NTSC
to PAL
Resize
206
Resize
419
2K
Buffer
420
Padding
Overlay
Bars
421
16x32
FIFO
BIU
422

FIG. 4

IMAGE PROCESSING SYSTEM FOR HIGH PERFORMANCE DIGITAL IMAGING DEVICES

FIELD OF THE INVENTION

The present invention relates generally to digital cameras, and more particularly to an image processing system for high performance digital imaging.

BACKGROUND OF THE INVENTION

Given the rapid advances made in semiconductor technology and digital imaging, it was just a matter of time before digital cameras were developed and introduced. Most digital cameras today are similar in size with and behave similar to conventional photographic cameras. But instead of capturing an image through a lens and recorded onto a photosensitive material as with traditional cameras, digital cameras capture an image using a charge-coupled device (CCD). The composite image is represented by thousands of discrete picture elements, known as pixels. The color of each pixel is given in the form of digital data consisting of binary encoded 1's and 0's. This digital data is then processed and stored into memory (e.g., internal flash memory, external memory cards, buffers, etc.) for subsequent use.

By adopting a digital imaging approach, digital cameras offer several advantages over more traditional cameras because the bits of data can now be more readily manipulated using digital signal processing techniques. For instance, the backside of a digital cameras can be equipped with a liquid crystal display (LCD) screen. In a record mode of operation, the LCD acts as a viewfinder in which the LCD displays objects and scenes in real-time. At any time, the user can click to capture the "picture" displayed on the LCD. In a playback mode of operation, pictures can be displayed on the LCD either individually or in groups of four, nine, or sixteen pictures. Users can manually page through the current archive of stored pictures by pressing the appropriate buttons. Furthermore, a user can instantly delete certain pictures. In addition, pictures can be viewed in full size, scaled down in size, or zoomed to larger sizes. Another benefit is that digital cameras can rotate the orientation of the pictures so as to automatically switch between landscape versus portrait formats. A common feature found in many digital cameras is a burst mode of operation, whereby a single click of a button can cause the camera to take several pictures in rapid succession, thereby creating a film-like sequence of images.

Due to their digital nature and in order to offer these advanced features, modern digital cameras were typically designed using specialized circuitry to handle each of the advanced features. Although this approach makes digital cameras relatively fast, it dramatically increases the overall cost, size, battery consumption, and weight of the digital cameras. In addition, the captured image display might appear to be slightly different than a live-view display if one were to use different circuits and data paths.

One solution to these drawbacks is to couple a generic processor to memory via a bus, where the processor is programmed to perform all of the enhanced functionality's, and digital data is shuttled between the memory and processor via the bus. However, this approach suffers from one major drawback; it is relatively slow. When a user presses a button, he or she expects instant feedback and response. The user does not want to wait the number of seconds it takes to process an image. It has been discovered that the software

approach is slow because it primarily suffers from two disadvantages. First, because the advanced features are typically performed by software, it can take a long time to configure and execute the requisite programming steps. Second, the bus speed becomes a limiting factor as large amounts of data need to be transferred between the processor and memory. Essentially, the bus becomes overloaded. The end result is that software-based digital cameras may be too slow to suit the tastes of consumers, depending on the processor/bus combination.

Thus, there is a need for an advanced architecture which facilitates high-speed image processing, offers advanced features, and yet is cost-effective. The present invention provides a novel solution by implementing a special hardware configuration which has been optimized for increased speed. Certain parts and paths of the circuit are reused and shared so as to leverage existing resources with minimal impact on its speed and functionality. By sharing certain resources, duplication is reduced, thereby decreasing costs. Furthermore, the present invention is adaptable to be used in virtually any type of digital camera and CCD array.

SUMMARY OF THE INVENTION

The present invention pertains to an image processing system for high performance digital imaging in digital cameras and the like. The reflected light from an image is focused through a lens and optically filtered. A CCD array converts this image into an electrical signal. This electrical signal is processed and then converted into an equivalent digital signal. A digital signal processor (DSP) is then used to process the raw digital signal. The DSP includes a capture data path, a data flow control, an image processing data path, a compression/decompression engine, a resize circuit, a display processing circuit, and a rotation circuit. Data from the CCD is routed to the capture data path for processing. The processed data is then sent over a main bus to be stored in an input buffer. The data flow control finds the appropriate image data for retrieval. Further processing is performed (e.g., decompressing, line averaging, pixel shuffling, ring insertion, interpolation, edge enhancement, gamma correction, and color space conversion). A JPEG compression/decompression engine compresses the resulting image before it is stored as a file. The JPEG engine can subsequently decompress a file for display. The uncompressed file can first be resized to suit the desire of the user and/or rotated, depending on the current physical orientation of the digital camera and that of the image.

By selectively activating and reusing certain parts of the hardware architecture and various data paths, at least four modes of operation can be supported: live view, capture, instant review, and play mode. In a live view mode of operation, the image from the capture data path is stored in the input buffer of the memory, retrieved and processed by the image processing path, buffered, resized if necessary, and displayed along with any appropriate graphics. In a capture mode of operation, the image from the capture data path is stored in the input buffer of the memory, retrieved and processed by the image processing path, buffered, compressed by the JPEG engine, and stored in a file format. And in an instant review mode of operation, the image from the capture data path is simultaneously resized, if necessary, stored in a display buffer, and displayed along with any appropriate graphics. Lastly, in a playback mode of operation, one or more requested image files are read, decompressed, resized if necessary, and displayed along with any appropriate graphics (e.g., padding or overlay bars).

An orientation detector is used to detect the current physical orientation of the display device so that the image from a first draw buffer can be rotated by the rotation circuit, in accordance with the current orientation, and stored in a second draw buffer. The correct image is automatically displayed in all modes, regardless of the orientation of the image or the physical orientation of the camera (both at the time the picture was taken and at the time the picture is being rendered for display).

By utilizing the optimized hardware design and data paths of the present invention, faster image processing can be achieved with a wide range of features, modes of operation, and enhancements. Furthermore, with the novel layout of the hardware design and data paths of the present invention, certain parts and paths can be used in different capacities and in different modes of operation. This reduces the total amount of hardware which is needed, which minimizes the overall cost with minimal or no impact on speed and functionality.

BRIEF DESCRIPTION OF THE DRAWINGS

The operation of this invention can be best visualized by reference to the drawings.

FIG. **1** shows the block diagram of a digital camera upon which the present invention may be practiced.

FIG. **2A** shows a more detailed block diagram of the DSP and memory.

FIG. **2B** shows an alternative embodiment of the detailed block diagram of the DSP and memory.

FIG. **3A** shows the data processing flow diagram for a live view mode of operation.

FIG. **3B** shows the data processing flow diagram for a capture and instant review mode of operation when the camera is in a horizontal, unrotated position.

FIG. **3C** shows the data processing flow diagram for a capture and instant review mode of operation, whereby the camera is in a rotated position (e.g., portrait state).

FIG. **3D** shows the data processing flow diagram for the post unrotation of an image for instant review.

FIG. **3E** shows the data processing flow diagram for the post rotation of an image for instant review given that the image is not found in the draw buffer.

FIG. **3F** shows the data processing flow diagram for a normal, unrotated play mode of operation.

FIG. **3G** shows the data processing flow diagram for a rotated play mode of operation.

FIG. **3H** shows data path flow diagram for generating compressed screen nail or thumb-nail images.

FIG. **3I** shows data path flow diagram for generating thumb-nail from screen-nail.

FIG. **4** is a detailed block diagram of the currently preferred embodiment of the digital signal processor.

DETAILED DESCRIPTION

An imaging system for high performance digital imaging devices is described. The following description is presented to enable one of ordinary skill in the art to make and use the invention and is provided in the context of a patent application and its requirements. Although the present invention is described in the context of a digital camera, various modifications to the preferred embodiment will be readily apparent to those skilled in the art, and the generic principles herein may be applied to other embodiments (e.g., digital scanners, video teleconferencing circuitry, multimedia apparatus, digital VCRs, digital camcorders and recorders, etc.). That is, any image capture device which displays images, icons and/or other items, could incorporate the features described herein below and that device would be within the spirit and scope of the present invention. Thus, the present invention is not intended to be limited to the embodiment shown but is to be accorded the widest scope consistent with the principles and features described herein.

FIG. **1** shows the block diagram of a digital camera upon which the present invention may be practiced. Digital camera **100** is comprised of a lens assembly **102**, filter **103**, image sensor **104**, analog processor **105**, and digital signal processor (DSP) **106**. The image of an object or scene **101** is captured by reflected light passing through lens assembly **102**. The light is then filtered by a color filter array **103** (e.g., a Bayer array) which provides both luminance and color information pertaining to the image. The image is then converted into an electrical signal by image sensor **104** (e.g., a CCD device). The raw image data (e.g., in CCD format) is then routed through an analog signal processor (ASP) **105**. ASP **105** is an ASIC chip which performs several analog as well as digital functions: analog signal processing, bad pixel replacement, pixel averaging, white balance gain control, and analog-to-digital (A/D) conversion. The raw CCD image data is then passed on to the digital signal processor (DSP) **106**. The DSP ASIC chip **106** combines the following related functions: front-end pixel data path to a frame buffer, statistics generation, image processing, compression/decompression, live view generation, rotation, resize, video generation, and timing generation. The processed image from DSP **106** is displayed onto a built-in LCD **107**. LCD **107** can act as a viewfinder and as a display for captured images. The image signal can also be output from DSP **106** in either an NTSC or PAL format.

A main bus **113** is used to carry data transmissions and/or control signals between the DSP **106** and motor controller **108**, memory **109**, central processing unit (CPU) **110**, input/output (I/O) device **111**, and rotation sensor **112**. The motor controller **108** controls the motor used in digital camera for physically adjusting the lens assembly **102**. Memory **109** is dynamic random-access memory (DRAM) and can include either non-volatile memory (e.g., flash, ROM, PROM, etc.) and/or removable memory (e.g., memory cards, disks, etc.). Memory **109** is used to store raw image digital data as well as processed image digital data. CPU **110** is a processor (e.g., the 823 processor manufactured by Motorola Inc. of Schaumberg, Ill.) which can be programmed to perform various tasks associated with the digital camera **100**. The I/O device **111** serves as an interface, whereby the user, through the use of buttons, menus, arrows, overlays, cursors, prompts, etc., can control various functions of the digital camera **100**. Rotation sensor **112** senses the current orientation of the digital camera **112** so that captured images can be automatically rotated to the desired landscape or portrait format for display. It should be noted that there are many different configurations which can be used to practice the present invention. In one embodiment, the CPU and the DSP **106** reside on a single chip. In other embodiments, the CPU and DSP reside on two or more separate chips. What is of particular importance is the hardware architecture found in the DSP block **106**.

FIG. **2A** shows a detailed block diagram of the preferred embodiment of the DSP **106** and memory **109**. The capture data path block **201** basically interfaces with the image capture head (e.g., the CCD). Some of its functions include controlling the CCD driver, performing slight compression, collecting statistics regarding the raw CCD data, generating

timing references, and loading the input buffer **210** with the slightly compressed raw data. An optional second input buffer **211** is provided to increase performance using standard "Ping-Pong" buffering techniques. When the image is subsequently requested, it is the job of the data flow control block **203** to locate and fetch the appropriate CCD image data from the input buffers **210** or **211** and pass this raw data to the image processing data path **202**. It is the function of the data flow control block **203** to transform raw lines into blocks of pixels called minimum computational units (MCU). The imaging data path block **202** basically takes the raw CCD data and converts it into a real image data capable of being displayed. Some functions involved in this conversion process include edge enhancement, pixel interpolation, ring insert, pixel shuffle, line averaging, gamma correction, and color space conversion. The final output is displayable image data (e.g., in YCC format).

A buffer **204** is used to coordinate the transfer of displayable image data to the JPEG block **205**, which compresses the data. The compressed displayable image data is then stored in file buffer **213**. The displayable image data can subsequently be retrieved from file buffer **213** and decompressed by JPEG block **205**. If necessary, the displayable data can be resized (e.g., enlarged or reduced) by resize block **206**. Display processing **207** then performs the requisite graphic functions on the image data in order to generate the final LCD display (e.g., the preferred embodiment is to prepare image data for graphical overlay and do actual graphics by software during the final rendering step, padding, overlays, menus, prompts, date and time stamp, etc.). Note that the graphics overlay and layouts can also be rotated and resized accordingly to fit onto the screen. The LCD display data is temporarily stored in draw buffer **214** before being rendered for display on the LCD screen. If the image needs to be rotated (to the right or left 90 degrees) to obtain the correct landscape or portrait view, the displayable image data is retrieved from the draw buffer **214**, and its pixels are swapped accordingly by the YCC shuffle block **208**. The rotated image is then temporarily stored in the rotate draw buffer **215**. It should be noted that some of the blocks **201–208** can be implemented in software. For example, a portion of the display processing can be performed in software. Although the goal is to increase the overall speed, a part of this architecture can, nevertheless, be implemented as a software process for simplification, size reduction, logic minimization and flexibility purposes. Generally the most computationally complex blocks which are least likely to be replaced by software include the JPEG **205**, image processing data path **203**, and resizer **206** blocks. Conversely, the entire or parts of the data flow control **203**, display processing **207**, and/or YCC shuffle **208** blocks can be implemented as a software process.

There are several advantages which makes the hardware architecture of the present invention superior to other configurations. Namely, the same path is used to process live view as well as to process subsequent capture, instant review, and playback views. Bus **113** is used to convey incoming real-time data used for a live view display as well as data that had been captured and stored as a file. Thereby, combinations of blocks **202–208** coupled to bus **113** can accept and process both real-time CCD as well as previously captured and stored file data. Because of this lack of differentiation, the display of real-time images is exactly the same as the display of images for instant review, capture, and playback modes. There are no annoying discrepancies between the various displays.

Another primary advantage is the fact this one hardware architecture of the present invention has enough flexibility and versatility such that it can support all four modes of operation: live view, capture, instant review, and playback. The live view mode causes the actual image that is seen by the camera in real time to be displayed on the camera's LCD. The capture mode of operation stores a picture when the user clicks the shutter button. The instant review mode of operation displays an image immediately after the shutter button is clicked by the person taking the picture. The user can immediately review the picture that was just taken. If the user is not satisfied with the picture, he/she may simply discard that picture and shoot again. Also, capture instant review are essentially simultaneous with this architecture, allowing it to be used to "show" a burst real time as it is captured. The play back mode sequentially displays a series of stored pictures on the LCD. For example, a user may take a rapid series of shots of some event (e.g., a golf swing) and later playback those time-lapsed images. The captured images may be captured in full, quarter, or one-sixteenth size.

Another advantage offered by the present invention is that the present invention provides automatic processing and correct display of the image, regardless of the orientation of the camera (e.g., portrait, landscape, or upside-down) at the time an image was taken and also regardless of the orientation of the camera at the time an image is subsequently rendered for display. The present invention handles live view generation with the camera in either portrait (vertical) or landscape (horizontal) orientation; image capture with camera rotation or without camera rotation; instant review with image rotation, without image rotation, with camera rotation, or without camera rotation; and play mode with image rotation, without image rotation, with camera rotation, or without camera rotation. According to the present invention, all of the above modes and orientations can be accomplished through the use of the same hardware architecture. Each of these four modes of operation, their respective data processing flows, and requisite active blocks are discussed in detail below and in reference to FIGS. **3A–3F** and FIG. **4**.

Not only does the present invention provide for all the various modes, orientations, and display sizes, but it also leverages each of the blocks **202–208** such that they can be used interchangeably from one mode/orientation/size to the next. Depending on which particular mode/orientation/size is currently desired, certain ones of these blocks **202–208** are activated to achieve the desired results required for that particular mode/orientation/size. In other words, one can selectively utilize certain combinations and data flows to achieve a wide range of desired effects. Hence, the total amount of hardware that is needed to provide all of the above functionality's can be achieved efficiently and economically with minimal impact to bus bandwidth and the camera's overall processing speed. As an example, the resize block **206** is optimized to perform resizing functions. As such, it is used in live view, instant review (rotated and unrotated), and play (rotated and unrotated) modes. However, it is not used during the capture mode. Likewise, the YCC shuffle block **208** is used during the instant review (rotated) and play (rotated) modes. The JPEG block **205** is used to compress data from the MCU buffer for storage in the file buffer **213** during the capture and instant review (unrotated and rotated) modes. Additionally, JPEG block **205** is used to decompress data retrieved from file buffer **213** during the play (unrotated and rotated) mode. A detailed description describing how, when, and why each of the blocks **202–208** are used follows.

FIG. **2B** shows an alternative embodiment of the DSP and memory, whereby a direct path to the MCU is provided.

Referring now to FIG. 3A, the data processing flow diagram for a live view mode of operation is shown. The live view mode displays on the LCD screen the image that is seen by the camera in real time. As the camera is pointed and moved, the scene on the LCD display changes accordingly. The raw CCD data from the image capture head is input to the capture data path **201**, processed, and stored in the input buffer **210**. The data flow control **203** retrieves this data which is processed by the image processing data path **202** and sent to the MCU buffer **204**. A resize block **206** is used to fit the image captured by the CCD onto the LCD's image size. The requisite display processing is performed in block **207**. In the preferred embodiment, when the camera is held horizontally (i.e., landscape), the image is temporarily stored in the draw buffer and fit immediately rendered out for display on the LCD. In a vertical orientation, the data flow control block **203**, during live review, ignores the state of the orientation sensor. Thus, the image flow is straight forward because the simultaneous rotation of the CCD and LCD display obviates the need to perform image rotation by the hardware. In one embodiment, the data flow control block **203** determines the order by which data is fed into the image processing data path **202**, thereby effecting the rotation of the image.

FIG. 3B shows the data processing flow diagram for a capture mode of operation when the camera is in an unrotated, horizontal orientation. The capture mode of operation stores a picture when the user clicks the shutter button during the live view mode of operation. The block diagram for capture mode is basically the same as for the live view mode described above, except that the image data from MCU buffer **204** is compressed by JPEG block **205** and stored in JPEG file buffer **213**. In addition, the image data from MCU buffer **204** is resized (if necessary) by block **206**; graphical information is added by display processing block **207**; and the final image is stored in draw buffer **214**.

FIG. 3C shows the data processing flow diagram for a capture mode of operation when the rotated camera is in a vertical orientation when the shutter button is pressed. In this case, a second pass is needed. A first pass is performed in the same manner as described above for the unrotated capture mode of operation except that data flow control block **203** rotates the image from the frame buffer (always landscape) to the current rotation of the camera (left or right portrait or upside down). Also, the display processing block **207** postpones generation of it's graphical information. A second pass is then performed after the first pass. The second pass is indicated by the dotted lines. In general, the image data from the draw buffer **214** is unrotated by YCC shuffle block **208**, which is turned on. The resulting image data is stored back to the MCU buffer **204**. From the MCU buffer **204**, the image data is fed into resize block **206**. On the second pass, a 1:1 resize is performed since the resizing was already performed during the first pass. In effect, the rotation for instant review is canceled because the camera is also rotated. During the second pass, the display processing block **207** generates the graphical information. Thereupon, the image and graphical data is stored in the rotate draw buffer **215** and subsequently rendered out for display.

FIG. 3D shows the data processing flow diagram for the post rotation of an image for instant review. If the camera is rotated back to normal (landscape) orientation while the instant review is still active, (i,e., the camera has not returned to live view mode) the CPU can be programmed to detect this by polling the orientation sensor. If this state is detected, a rotated image can be generated, as described below. The software determines whether the image is currently stored in the draw buffer **214**. The image may have been stored in draw buffer **214** as part of the processing flow associated with the capture mode described above and in reference to FIG. 3C. If the correctly rotated image without graphics, is found in draw buffer **214**, it is retrieved and passed through block **208** with YCC shuffle turned off. This image is then fed into MCU buffer **204** and then resized 3:4 by resizer block **206** to fit it onto the screen. Display processing block **207** generates the appropriate graphics overlay which is stored along with the image in rotated draw buffer **215**. Eventually, this data is read out for display.

FIG. 3E shows the data processing flow diagram for the post rotation of an image for instant review given that the image is not found in the draw buffer or it only exists with graphics data. Assume as with the previous case that the camera is in a rotated orientation when the shutter was clicked to capture an image. Now, user rotates the camera back to an unrotated orientation (e.g., landscape) for instant review of the captured image. Assume also that the image is not found in the draw buffer (e.g., the image in the draw buffer was discarded in order to free up additional memory). In this case, the image in the form of a JPEG file **213** is processed by JPEG engine **205** before being fed into the MCU buffer **204**. Resizer **206** is used to fit the image, which is rotated with respect to how it was captured (e.g., portrait), to the correct size of the screen. In this first pass, the display processing **207** is turned off so that graphics is not generated. The image is then temporarily stored in the draw buffer **214**. In a second pass, represented by the dashed lines, the rotated image in the draw buffer **214** is fed through block **208** with YCC shuffle turned off. After passing through MCU buffer **204**, the image is reduced by 35% so that it will fit into the landscape mode screen. Otherwise, it would be too tall to fit. The appropriate display processing **207** is performed to generate the graphics. Thereupon, the graphics and processed image is stored in the rotated draw buffer **215** before being drawn for display. Note that both passes can be accomplished in one step if the needed resize ratio is available.

FIG. 3F shows the data processing flow diagram for a play mode of operation when the image and camera are both in horizontal orientation or both are in vertical orientation. In a play mode, one or more pictures are sequentially rendered for display on the LCD. The requested picture or pictures are retrieved from the JPEG file buffer **213** and decompressed by JPEG block **205**. The decompressed image data is then sent to the MCU buffer **204** which coordinates the data transfer to the resize block **206**. The images can then be scaled down (e.g., to a LCD size) or zoomed (i.e., enlarged) by resize block **206**. The requisite display processing by block **207** is performed, and the image is then sent to the draw buffer **214** to be rendered for display on the LCD screen.

FIG. 3G shows the data processing flow diagram for a play mode of operation when the camera is currently in a vertical orientation and the image is in a horizontal orientation or if the camera is in a horizontal orientation and the image is in a vertical orientation, as determined by the rotation sensor. In either case, the same flow is followed as described above in reference to FIG. 3E, except that a second pass is performed and display processing if turned off on the first pass. For the sake of clarity, only the flow diagram corresponding to the second pass is shown. The image data in draw buffer **214** is fed back to the YCC shuffle block **208**. The YCC shuffle block **208** rotates the image by shuffling the pixels. The rotated image is then resized by resizing block **206** because its dimensions have changed.

After the appropriate display processing by block **207**, the rotated, resized image is then sent to the rotate draw buffer **215** to be rendered for display on the LCD screen.

FIG. **3H** shows a data flow diagram for generating compressed screen-nail or thumb-nail images. There is a direct path from the YCC block **208** to the MCU block **204**. This allows resized images to be compressed (e.g. screen-nails). Note that this only allows compression or resizing of existing image; rotation or unrotation would be performed in software. Alternatively this path may be eliminated by performing the same function in software.

FIG. **3I** shows a data flow diagram for generating a thumb-nail image from a screen-nail image.

It can be seen based on FIGS. **3A–3I** and the descriptions given above that the same set of blocks **201–208** or circuits can be used to achieve virtually any mode, orientation, or display size for a digital camera. The only thing that changes is the selection of the appropriate data path(s) and the activation of selected blocks. Although the final hardware architecture of the present invention appears straightforward in retrospect, it was deceptively difficult to conceive. This is because one has to first decide on which blocks are to be implemented and define each block's respective functions. Duplication must be minimized. Next, the data paths must be laid out so as to interconnect the various blocks in such a manner that certain combinations produce all of the desired results correctly. Flexibility, adaptability, and high functionality are key. Moreover, the data must be routed through the various data paths as fast as possible so that there is no bottleneck in any one path that might reduce the overall bandwidth. Other considerations include which ones of the blocks should be activated and under what circumstances should they be activated. All these factors were taken into account in order to produce the integrated solution of the present invention which effectively and efficiently utilizes the available hardware resources.

The actual circuits that were implemented for each of the blocks are now described with reference to FIG. **4**. It should be noted, however, that there exist many different circuits which can be used to implement the present invention. For example, there are many different ways in which a resize circuit or a rotate circuit can be designed. The following description relates to the currently preferred embodiment of the digital signal processor **106**. In general, the capture data path comprises of the FIFO **401**, AE/AWB statistics **402**, pixel average **403**, 10 to 8 LUT **404**, and 16×32 FIFO **405** blocks. The image processing data path and data flow control consists of the edge enhance **407**, 5×5 interpolate **408**, 1320 pixel MCU buffer **409**, ring insert **410**, pixel shuffle **411**, line average **412**, 8 to 10 look-up-table (LUT) **413**, CCIR 709 gamma, and color space converter **415** blocks.

In the currently preferred embodiment, data is processed in blocks known as MCU's-minimum computation units. An MCU is defined and well known in the art of image processing, especially as they relate to YCC **411**, YCC **422**, and discrete cosine transformations (DCTs). The primary method of achieving processing compatibility between these data paths involves storing raw CCD data from the capture data path into memory in line format to support image rotation while reducing bus bandwidth, and to then transform the raw lines in memory into raw MCU's, which are necessary to support the image processing and compression chain. Each of the specific blocks are described in detail below.

Starting with the raw CCD data generated by the CCD array (or some other equivalent image capture head), this data is input to the pixel average block **403**. The pixel average block **403** performs pixel averaging to reduce lines to half and quarter length. The averaging is performed by adding values and shifting as follows:

Full Output: Ra, Ga, Rb, Gb, Rc, Gc, Rd, Gd

Half Output: (Ra+Rb)/2, (Ga+Gb)/2, (Rc+Rd)/2, (Gc+Gd)/2

Quarter Output: (Ra+Rb+Rc+Rd)/4, (Ga+Gb+Gc+Gd)/4

It should be noted that this block **403** does averaging of pixels on a line. The compliment function, line averaging, is done when the data is returned to the ASIC for image processing. In this case, MCU's are returned, making it easy to do the line averaging. This dual process eliminates aliasing in the image for 1/4 and 1/16 resolution captures. For 1/16 capture, CCD line skipping (e.g., 2 out of 4) may be used without serious image quality effects. However, for 1/4 capture, line skipping should not be used. During live view mode, typically the CCD is being scanned using line skipping, for 50% vertical resolution, reduced bus bandwidth, and faster frame rate. As can be seen from Table 1 below, for CCD's 1152 and larger, 1/16 mode is used for live view. To accomplish this, a combination of 2 out of 8 line skipping and Quarter Output is used. This is necessary to provide sufficient read-out speed for large CCD's, as well as keeping the bus bandwidth low enough during live view. It should be noted that using 1/4 or 1/16 size in live view is optional.

TABLE 1

CCD Size and Live View Size Table

Image Size		1/4 Image Size		1/16 Image Size		M Pixels
640	480	320	240	160	120	0.31
768	576	384	288	192	144	0.45
896	672	448	336	224	168	0.61
1024	768	512	384	256	192	0.79
1152	864	576	432	288	216	1.00
1280	960	640	480	320	240	1.23
1536	1024	768	512	384	256	1.58
1536	1152	768	576	384	288	1.77
1792	1344	896	672	448	336	2.41
2048	1536	1024	768	512	384	3.15

*Live view sizes to resizer are shown underlined

The AE/AWB statistics block **402** receives its data from the Pixel Average block **403** (either the Half Output or Quarter Output, depending on CCD size). This size is used by the statistics circuit. This is done by selecting one of two outputs from the Pixel Average block **403**, and doing either 2/4 or 2/8 line skipping. Since actual line skipping may also be done, this setting must be set taking into account the Timing Generator **406** setting. In any case, the resulting data used by the statistics circuit is between 288 wide and 512 wide, with the corresponding height. The AE/AWB block **402** generates an 8×6 set of averages for normal 4:3 CCD's, and 8×4 set of averages for 3:2 CCD's. This is accomplished by varying the block size depending on the CCD size. Furthermore, the AE/AWB Statistics block **402** needs to be capable of handling the pixel offset during a rotated capture sequence. In addition, it optionally collects "sum of absolute differences" for each of the statistics blocks to assist in providing automatic focus.

The FIFO 8×32 block **401** receives the data from the AE/AWB statistics block **402** and requests a DMA transfer when the buffer has 32 bytes (half full). This FIFO **401** supports quad word transfers. The pixel average block **403** also supplies its 10-bit data to the 10 to 8 LUT block **404**,

which converts it into an 8-bit compressed data. This LUT block **404** reduces the memory footprint for CCD data, but without loss of image quality.

Thereupon, the 16×32 FIFO **405** takes data from the LUT **404** and requests a quad or octal DMA transfer when half full. In addition to the octal transfer, the DMA for this data also supports interlacing. This is required since many large CCD's utilize an interline scan method for full resolution capture, where 25% or 50% of the lines are transferred per scan.

The data from FIFO **405** is then sent to the memory over a 32-bit bus via the bus interface unit (BIU) **422**. Most transfers over this bus between memory and the DSP are in quad, octal, or programmable length bursts to increase bus bandwidth. In addition to the DMA interface, there are a number of registers inside the DSP ASIC which are accessible by software. The BIU **422** gives bus read/write access to these registers. See U.S. application Ser. No. 08/916,186, "Method & System for Organizing DMA Transfers to Support Image Rotation", filed Aug. 21, 1997, assigned to assignee of the present application and incorporated herein by reference. In another embodiment, access can be achieved through a serial port. In this case, double buffering of registers is required, due to slow transfer rates. Transfer between buffers is activated at frame boundaries.

The timing generator **406** supports 2/4 and 2/8 line skipping—either by actual CCD line skipping or by not clocking data from the A/D into the DSP ASIC, depending on CCD capability. In addition, the active pixel election during capture takes into account the required offset for the Bayer pattern for left or right portrait rotation. This requires shifting the active area either one column right or one line down, depending on which rotation is required.

FIG. **5** shows how the active pixels are selected for a 8×6 imager, assuming the landscape orientation. As shown, the pixels used are exactly 8×6. Ring pixel insertion is done at a different stage in the process. The extra "available" pixel and line are unused in this case. A left portrait is when the user rotates the camera clockwise, looking from the rear. This requires the top of the portrait image to be on the left side of the landscape image. The image data shuffle is a right rotate in this case. A right portrait is when the user rotates the camera counter-clockwise, looking from the rear. This requires the top of the portrait image to be on the right side of the landscape image. The image data shuffle is a left rotate.

FIG. **6** shows how the pixel selection is shifted for left and right portrait capture. The capture is shifted right one pixel for left portrait, and is shifted down one pixel for right portrait. This preserves the sequence of GB/RG once the pixels are shuffled into the correct positions. In addition to the above modes, the "upside down" mode may also be supported. This mode is required for cameras where the lens can be rotated 180 degrees for a self-portrait. A sensor determines when the lens has reached 180 degree position, and tells the software to invert the image. Actually, the software "flips" the image both left to right and top to bottom. The pixel offset required for this is shown in FIG. **7**. The data is actually upside down in the frame buffer. This can be corrected by either the DMA on the way into the frame buffer, or the DMA on the way out of the frame buffer.

The Timing Generator **406** must also be able to set the active area independently of the actual CCD imager size. This functionality is required for digital zoom. The present invention allows all of the standard image sizes to be captured from a CCD which are equal or smaller than the CCD size. This enables a 5-step zoom for each 2× of zoom. For example, if the CCD is 1152×864, the steps supported are: 1024, 896, 768, 640, 576 (2×), 512, 448, 384, 320, and 288 (4×). Furthermore, the timing generator **406** has many control registers, which must be accessible via the system bus or a second control bus.

Data from memory is fed via the BIU **422** to the 8 to 10 LUT block **413**, which takes data from the frame buffer and decompresses it back to 10 bit linear data. This may require a RAM table look-up. Alternatively, a specific version can be produced to reduce ASIC size.

From the LUT block **413**, the data is sent to the ring insert **410**, pixel shuffle **411**, and line average **412** blocks. It should be stressed that there are many different ways, besides these three particular blocks, in which to implement these functions. First, the line average block **412** averages 4 lines into 2, or simply passes the data through without change. When this function is turned on, the DMA feeds twice as many lines per block. The number of lines of pixels required is defined in the ring pixel insert block **410**. This block is used in conjunction with timing generator line skip 2/4 or 2/2 and pixel average 2/4 or 2/8 to build high quality 1/4 and 1/16 size images for capture. Normally, for live view, this function is turned on to produce an image size for 288 to 512 horizontally. The mode selected depends on the CCD size. Of course, one can implement a resizer capable of resizing to any given resolution.

When the line average function is turned on, the DMA moves blocks which are twice as high (i.e., contains twice as many lines) as when the line average function is turned off. These lines are averaged down, using a similar process as used for pixel averaging. This is demonstrated for two pixels per line below:

Line 1 input	Ra	Ga
Line 2 input	Gb	Bb
Line 3 input	Rc	Gc
Line 4 input	Gd	Bd
Line 1 output	(Ra + Rc)/2	(Ga + Gc)/2
Line 2 output	(Gb + Gd)/2	(Bb + Bd)/2

The line average block **412** requires a single control bit: 1=line average, 0=off.

Second, the pixel shuffle block **411** rearranges the data for portrait left and right cases and in one embodiment, upside down case as well. This is illustrated for 4×4 blocks, as shown in FIG. **8**. This process can be accomplished by addressing the data correctly as it is moved into the pixel MCU buffer **409**. The pixel shuffle block **411** requires two control bits to indicate rotation: 00=landscape, 10=left rotate, 01=right rotate, and optionally 11=upside-down.

Third, the ring insert block **410** is responsible for insertion of ring pixels at the edges of the image. The proximity to the edge is provided by data in control registers. This information is also required for the DMA function, since a different amount of data must be transferred when at the image edge. FIG. **9** shows how data is transferred by the DMA to support data in Live View and Landscape Capture. Note that the first and last pass across the data is different than all passes away from the top and bottom of the image. This is because there are no ring pixels in the frame buffer. Also note that each successive pass rescans four lines from the previous row. This is necessary to provide the full overlap of data for the interpolator. The DMA must back up four lines at the beginning of each row to accomplish this. However, if the line average function is turned on, the DMA will actually have read 36 or 40 lines of data, rather than 18 or 20.

A portrait DMA scan is similar to landscape, but proceeds in different directions. Since DMA cannot really transfer words on a non-longword boundary, it is assumed that all transfers will actually be 20 bytes (burst length of 5). Alternatively, if two quad transfers are required because of system limitations, all additional data must be discarded. This method increases bus loading significantly and is thus, not the preferred method. For the first and last "row", the extra 2 bytes will be discarded. The blocks are the same size for portrait as landscape once they reach the MCU pixel buffer **409**, and ring pixel insertion is done in the same way. However, the data is read in by columns rather than rows. The data is rearranged in the Pixel Shuffle block **411**. The DMA transfers 32 lines of 20 bytes each for portrait mode. But support for fewer than 32 lines is required for the end of a scan row. In which case, there is available a full set of eighteen pixels at the last "row", since all image widths supported are divisible by sixteen. Pixels outside of the MCU at the right or along the bottom, assuming that the image is not a multiple of 16, are filled with black or are appropriately handled in subsequent blocks.

Next, the pixel MCU buffer **409** holds the data for processing by the interpolate block **408**. The 5×5 interpolate block **408** performs a 5×5 matrix operation from 20×20 inputs to form a 16×16 MCU of RGB data. The exact form of the matrix values must be determined. The number of bits of resolution for the matrix coefficients must also be determined, given a 10 bit input resolution. The preferred embodiment includes having the interpolation block **408** and edge enhancement block **407** be a programmable DSP, thereby allowing various algorithms to be used. During the interpolation process, all results must be clipped to the maximum and minimum values.

Block **407** performs edge enhancement. This effectively detects edges in different directions when computing averages for missing color restoration during the interpolation process. This process is best integrated into the Interpolation process of block **408**. The output from these blocks **407**–**408** is preferably CCIR 709 RGB data, having been reconstructed from the Bayer pattern, color corrected, feature enhanced, and gamma corrected. Fine AWB can also be performed in this stage, if required, by adjusting the matrix values appropriately. There is one R, G, and B output value for each of 16×16 pixels. This data is transferred directly to the gamma correction block **414** as it is computed, pixel by pixel.

It is the function of the color space convert block **415** to convert the 8-bit gamma corrected data from RGB space to YCC **422** space (subsampling to **411**, when selected, is done as part of the JPEG block **205**). The output from this stage is a 16×16 array of Y values, and two 16×8 arrays of Cr and Cb values. This gamma correction block **414**, in its simplest embodiment, is essentially a 3×3 matrix with programmable matrix values. Assuming that the JPEG compression engine **205** processes one block while the other block is being loaded, double buffering is performed. Thus, two 512 byte buffers are used. The registers for this block **414** are nine coefficient registers. Assuming 10 bit values, these can be arranged as three 30-bit registers. Note that different color space conversions can be supported: Photo YCC for FlashPix, and CCIR 709 for JPEG. Both of these transformations are required at the same time when Photo YCC is used, since the data going to the resizer for Live View or Instant Review must always be CCIR 709. In addition, during decompression (playback support), Photo YCC must be converted to CCIR 709, since data space used in the frame buffer is only CCIR 709. A determination must be made if the same block with programmable coefficients can do both conversions. It may be necessary to have three blocks: RGB to Photo YCC, RGB to CCIR YCC, and Photo YCC to CCIR YCC. Alternative embodiments of the image processing stages from the MCU input buffers to the YCC buffers are contemplated to be within the scope of the present invention. Furthermore, different solutions are possible, depending on the required quality of the conversion.

The YCC MCU buffer **204** holds one or two MCU's in YCC **422** format. In order to support custom processing of images as they pass from conversion to YCC on to compression, direct access to this memory is preferred from the CPU. In this case, the CPU must be able to tell the JPEG **205** and resizer **206** blocks when the custom modifications are completed on a block. Also, an interrupt must be used to tell the CPU when a block is available for processing. It may be preferable to require custom processing on uncompressed data in memory. This requires a buffer twice the size of the capture buffer, however, but allows full image access for simplified image processing rather than MCU access.

The JPEG/IJPEG block **205** performs either a JPEG compression of an MCU, or a JPEG decompression of an MCU. In the first case, data is retrieved from the MCU buffer **204**, and the results are output to the FIFO. In the IJPEG case, the data is taken from FIFO **416**, and output to the MCU **204**. The JPEG/IJPEG function can operate in **422** and **411**/**420** modes via a programmable register. When operating in **411**/**420**, the JPEG block **205** must do the averaging from **422** to **411**, or IJPEG up sample from **411** to **422** in the preferred embodiment. The MCU block **204** is only a **422** format block. A control register must be included to set for **411** compression vs. **422**. Additionally, two control bits must be included to set the data flow direction (i.e., compress, decompress, or off).

The resize block **206** takes as input the MCU data from either the color space convert **415**, IJPEG, or YCC shuffle **208** blocks, and resizes and repackages it for use in the LCD frame buffer. The LCD buffer may be operating in **216** line 1/2 vertical resolution mode (single repeated field) or in **432** line full interlace mode. Both modes may be supported by this block. In either case, the horizontal resolution is 576 (YCC **422**). The buffer is thus 1152 bytes by 216 lines or 1152 by 432 lines. This covers the "safe area" of NTSC video. Note that this data must always be CCIR YCC. Thus, for playback mode, where Photo YCC is being generated by IJPEG, conversion back to CCIR YCC must occur before the data goes to the Resizer **206**.

There are four resize cases to consider:

1) Live View mode: data is always in landscape mode, the input data is always from 288 to 512 pixels wide, and the LCD buffer is always in 1/2 vertical resolution mode (216 lines).
2) Capture mode and Instant Review: data can be in any of the three orientations, but must still be viewed in landscape mode, since this is still Live View of the data as it is being captured. Therefore, this is also always in 1/2 vertical resolution mode (216 lines). Since the image processing section of the ASIC may have rotated the image for processing, the data must be "unrotated" for display on the LCD. This is done as a second step, using the memory to memory rotation path to be described below.
3) Playback mode: data can be in any of the three orientations, and must be resized depending on orientation. For Landscape, the image should be 1152 bytes or 576 pixels wide (YCC **422**) by 432 lines high. For

Portraits, the image should be 648 bytes or 324 pixels wide by 432 lines high. Note that half of the lines are tossed (not output to memory) if 1/2 vertical resolution mode is being used.

4) Playback zoom mode: this is the same as Playback mode, except the image displayed is a movable window on an image. This is either the "1 to 1" mode, where 1 LCD pixel equals 1 image pixel, or the "1 to 2" mode, where 4 LCD pixels equals 1 image pixel. If half vertical resolution (216 line) is used, half of the lines will be thrown away.

A 2K buffer **419** is interposed between the resize block **206** and padding overlay bars block **420** to temporarily store data. Since less than 1152 bytes per line may be generated by the resizer **206** in some cases, this block must pad the left and right side of the data to fill the LCD. The assumption is that any padding on the top and bottom will be handled by software by setting the appropriate starting address. Further, it is assumed that hardware padding will only be required when the starting address cannot be used to center the image. This is only true for 16 byte padding. This is the case for **320**, **448**, **640**, **896**, **1280**, and **1792**. This also assumes that octal DMA is used and must be on 32 byte boundaries. If quad DMA is used with 16 byte boundaries, hardware padding will not be required.

Overlay bar generation is another function of block **420**. This should only be active when an entire LCD buffer is being generated. Thus, this function should be turned off when images smaller than 288×216 are being resized. The overlay function is capable of producing two "bars" of image data at 50% luminance (Y value divided by 2). This is defined by two "start line" and "end line" values.

A data path is shown in the block diagram for data to DMA directly into the YCC Shuffle block **208**, and then into the MCU buffer **204**. This path allows in-memory image data to be rotated and resized, or compressed. The primary purpose for this path is to rotate the LCD buffer image generated during portrait capture. This case is the "instant review" while the camera is still being held in the portrait position. If the camera is then turned into the landscape position, the image must be resized and rotated. The resize factor is 12/16 (3/4 ratio). It can also be used to generate compressed screen-nail, if desired.

The pixel shuffle block **208** performs a different kind of shuffle here than for the Bayer pattern normally transformed. Basically, the YCC **422** data are broken up into a 16×16 block of Y's, and two 8×16 blocks of Cr and Cb. These are shuffled. The Cr/Cb blocks are transformed after shuffle from 16×8 to 8×16. An averaging or linear interpolating filter may be used for this transformation. Finally, the YCC Shuffle block **208** should have a bypass mode, allowing the data path to be used for resizing or compression only. This would be used to do second-pass resize for already-rotated JPEG images. Since the initial resize will always be to the LCD buffer size assuming landscape, a second pass through the resizer is required to reduce to 75% for portrait. This second pass is required assuming integer resize only in Resize block (N out of 16). There are cases where thumbnail generation would be desirable. One way to accomplish this is to run an image through the resizer **206** a second time. For example, to generate a 3×3 thumbnail display of a "event bracket" capture, resizing 16:5 would give a good result. An alternative embodiment is to have a direct path only, or YCC shuffle (rotate) is done in software. This is a good trade-off since the image is fairly small and can be processed in software quickly.

The NTSC to PAL Resize block **418** generates **720** (CCIR) or **768** (Square Pixel) horizontal pixels from the incoming **640** NTSC pixels when PAL mode is selected. Also, six lines are generated for every five incoming lines for PAL mode. This is accomplished using a line buffer (1280 or 1152 bytes) and stopping the 8xx video controller during the sixth line. The currently preferred method is bilinear interpolation.

The LCD/Video generator block **417** generates composite video, component video, and RGB data for direct drive LCD's. Both analog and digital forms are available. In an alternative embodiment, an "anti-flicker" block can be added to this function. Another alternative feature for the LCD/Video generator is fade capability. This can be a multiplier on the Y channel. The Y value would be multiplied by a value from 0 to 64 for a 64 step fade. A 256-step multiplier value could be supported, so the fader software could use the proper "curve" to effect a linear visual effect. This function could be used for fade-in and fade-out capability during playback. In another embodiment, a separate data path be added to process graphic overlay buffers and 1152×216 image buffers into a single 576×216 data format. This would reduce the bus bandwidth by 10% during LCD refresh.

Hence, an image processing system for high performance digital imaging has been described. The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the Claims appended hereto and their equivalents.

What is claimed is:

1. A method for processing an image in an image capture unit including a display, the method comprising the steps of:

capturing raw image data;

processing the raw image data through a capture data path, wherein the capture data path comprises statistic generation, pixel averaging, and compression;

storing the raw image data in a first memory, wherein the first memory contains raw image data for one or more images;

accessing a particular raw image data from the first memory and performing image processing on the particular raw image data to produce a rotated processed image;

loading the processed image in a second buffer;

compressing the processed image to generate a compressed image;

unrotating the image;

performing display processing to produce graphics for display;

storing the graphics and image in a fourth buffer; and

rendering the graphics and image from the fourth buffer for display on the image capture unit.

2. A method for processing an image in an image capture unit including a display, the method comprising the steps of:

capturing raw image data;

processing the raw image data through a capture data path;

storing the raw image data in a first memory, wherein the first memory contains raw image data for one or more images;

accessing a particular raw image data from the first memory and performing image processing on the par-

ticular raw image data through an image processing data path to produce a rotated processed image, wherein the image processing data path comprises edge enhancement, interpolation, ring insertion, pixel shuffle, line averaging, and decompression;

loading the processed image in a second buffer;

compressing the processed image to generate a compressed image;

unrotating the image;

performing display processing to produce graphics for display;

storing the graphics and image in a fourth buffer; and

rendering the graphics and image from the fourth buffer for display on the image capture unit.

3. In a digital camera, a method for digital image processing, comprising the steps of:

generating a live view image for display with the digital camera in a horizontal, vertical, or upside-down orientation;

capturing an image for subsequent display, wherein the image is captured with the digital camera in either a horizontal or vertical orientation;

rendering a captured image for instant review with the digital camera in either the horizontal or vertical orientation and with the captured image rotated or not rotated;

rendering the captured image for a play mode of operation with the digital camera in either the horizontal or vertical orientation and with the captured image rotated or not rotated;

rotating the image when the digital camera is in the vertical orientation to produce a horizontal image;

storing the horizontal image in memory;

rotating the horizontal image from memory for displaying the live view;

resizing the horizontal image for instant review or play mode if the digital camera is in a horizontal orientation;

displaying a resized horizontal image with a predetermined background on either side of the resized horizontal image;

displaying an indication that the horizontal image was taken when the digital camera was in the vertical orientation;

rotating the horizontal image in a second pass if the digital camera is physically rotated to the vertical orientation.

4. A digital signal processor for use in an image capture apparatus, comprising:

a bus

a capture data path coupled to the bus for accepting CCD data and outputting raw lines to the bus, wherein the capture data path includes a statistics circuit, a pixel average circuit, and a compression circuit;

a memory coupled to the bus for storing the raw lines;

a data flow controller coupled to the bus for generating raw minimum computational units (MCUs) based on the raw lines stored in the memory;

an image processing data path for processing the raw MCUs from the data flow controller;

a buffer for storing the MCU's from the image processing data path;

a JPEG engine for compressing the MCU's before storage in the memory and for decompressing MCU's read from the memory;

a resize circuit coupled to the buffer for resizing image data;

a display processor coupled to the resize circuit for generating graphical information for display with the image data;

a rotation circuit coupled to the bus for rotating the image data and storing a rotated image data in the buffer.

5. A digital signal processor for use in an image capture apparatus, comprising:

a bus

a capture data path coupled to the bus for accepting CCD data and outputting raw lines to the bus;

a memory coupled to the bus for storing the raw lines;

a data flow controller coupled to the bus for generating raw minimum computational units (MCUs) based on the raw lines stored in the memory;

an image processing data path for processing the raw MCUs from the data flow controller;

a buffer for storing the MCU's from the image processing data path;

a JPEG engine for compressing the MCU's before storage in the memory and for decompressing MCU's read from the memory;

a resize circuit coupled to the buffer for resizing image data;

a display processor coupled to the resize circuit for generating graphical information for display with the image data;

a rotation circuit coupled to the bus for rotating the image data and storing a rotated image data in the buffer,

wherein at least four modes of operation are supported: live view, image capture, instant review, and play mode, and wherein the image is automatically rotated in a second pass in accordance with a current physical orientation of the image capture apparatus and with the physical orientation of the image capture apparatus when the image was captured.

6. The digital signal processor of claim **5**, wherein in the live view mode of operation, the image from the capture data path is stored in an input buffer of the memory, retrieved and processed by the image processing path, buffered, resized if necessary, and displayed along with any appropriate graphics.

7. The digital signal processor of claim **6**, wherein if the image capture apparatus is in a vertical orientation, the image is rotated by the rotation circuit before being stored in the memory and the image is rotated again before being rendered for display.

8. The digital signal processor of claim **5**, wherein in a capture mode of operation, the image from the capture data path is stored in an input buffer of the memory, retrieved and processed by the image processing path, buffered, compressed by the compression/decompression engine, and stored in a file of the memory.

9. The digital signal processor of claim **8**, wherein if the image capture apparatus is currently in a horizontal orientation and the image was taken while the image capture apparatus was in a vertical orientation, the image is reduced in size before being rendered for display.

10. The digital signal processor of claim **9**, wherein the display processor generates an indication to the user to change the orientation of the image capture apparatus and when the image capture apparatus is rotated to be in the vertical orientation, the image is rendered for display without resizing.

11. The image capture apparatus of claim **5**, wherein in an instant playback mode of operation, the image from the

capture data path is stored in an input buffer of the memory, retrieved and processed by the image processing path, buffered, compressed by the compression/decompression engine, stored in a file of the memory, read back from the file, decompressed, resized if necessary, and displayed along with any appropriate graphics.

12. The image capture apparatus of claim **5** further comprising an orientation detector for detecting a current physical orientation of the image capture apparatus, wherein the image from a first draw buffer is rotated by the rotation circuit, depending on the current orientation, and stored in a second draw buffer.

13. The image capture apparatus of claim **5**, wherein in a playback mode of operation, one or more requested files are read, decompressed, resized if necessary, and displayed along with any appropriate graphics.

14. The image capture apparatus of claim **5** further comprising an orientation detector for detecting a current physical orientation of the image capture apparatus, wherein the image from a first draw buffer is rotated by the rotation circuit, depending on the current orientation, stored in a second draw buffer, and displayed in a correct orientation.

15. A digital signal processor for use in an image capture apparatus, comprising:

a bus

a capture data path coupled to the bus for accepting CCD data and outputting raw lines to the bus;

a memory coupled to the bus for storing the raw lines;

a data flow controller coupled to the bus for generating raw minimum computational units (MCUs) based on the raw lines stored in the memory;

an image processing data path for processing the raw MCUs from the data flow controller;

a buffer for storing the MCU's from the image processing data path;

a JPEG engine for compressing the MCU's before storage in the memory and for decompressing MCU's read from the memory;

a resize circuit coupled to the buffer for resizing image data;

a display processor coupled to the resize circuit for generating graphical information for display with the image data;

a rotation circuit coupled to the bus for rotating the image data and storing a rotated image data in the buffer;

a double buffered register, wherein transfers of data between buffers is activated at frame boundaries;

wherein at least four modes of operation are supported: live view, image capture, instant review, and play mode.

16. The image capture apparatus of claim **5** further comprises a YCC shuffle block having a data path coupled directly to the buffer.

17. A method for processing an image in an image capture unit including a display, the method comprising the steps of:

capturing raw image data with an image sensor;

processing the raw image data through a capture data path;

transferring the raw image data from the image sensor to a first memory via a bus for storage, wherein the first memory contains raw image data for one or more images;

transferring a particular raw image data from the first memory to a data flow control via the bus;

passing the raw image data from the data flow control to an image processing data path, the image processing data path for performing image processing on the particular raw image data to produce a rotated processed image;

transferring the processed image from the image processing data path to a second buffer through a first dedicated path;

establishing a data path between the second buffer an a compression/decompression engine;

compressing the processed image to generate a compressed image;

transferring the compressed image from the compression/decompression engine to a third buffer via the bus to store a compressed displayable image;

retrieving the compressed displayable image from the third buffer for decompression by the compression/decompression engine to produce displayable image data;

transferring the displayable image data to the second buffer;

transferring the displayable image data from the second buffer to a resize circuit through a second dedicated path;

performing display processing to produce graphics for display;

transferring the graphics and displayable image to a fourth buffer via the bus;

loading the graphics and displayable image from the fourth buffer to a rotate circuit through the bus;

unrotating the displayable image;

rendering the graphics and displayable image from the fourth buffer for display on the image capture unit; and

establishing a third dedicated path from the rotate circuit to the second buffer.

18. A method for processing an image in an image capture unit including a display, the method comprising the steps of:

capturing raw image data;

processing the raw image data through a capture data path;

storing the raw image data in a first memory, wherein the first memory contains raw image data for one or more images;

accessing a particular raw image data from the first memory and performing image processing on the particular raw image data to produce a rotated processed image;

loading the processed image in a second buffer;

compressing the processed image to generate a compressed image;

unrotating the image;

performing display processing to produce graphics for display;

storing the graphics and image in a fourth buffer;

rendering the graphics and image from the fourth buffer for display on the image capture unit; and

performing a second pass when the image capture unit is rotated, the second pass comprising the steps of:

accessing the image from the fourth buffer;

rotating the image;

storing the image in the second buffer;

passing the image through a resize circuit;

adding the graphics during the second pass; and

storing the image in a fifth buffer.

* * * * *

EXHIBIT 1024

United States Patent [19]

Ishman et al.

[11] **Patent Number: 4,612,575**

[45] **Date of Patent: Sep. 16, 1986**

[54] **T.V. VIDEO IMAGE CORRECTION**

[75] Inventors: **Neal H. Ishman**, Springfield; **William S. Alderson**, Manassas, both of Va.

[73] Assignee: **E-Systems, Inc.**, Dallas, Tex.

[21] Appl. No.: **633,923**

[22] Filed: **Jul. 24, 1984**

[51] **Int. Cl.**[4] **H04N 5/14**; H04N 5/21

[52] **U.S. Cl.** **358/160**; 358/105; 358/166; 358/167

[58] **Field of Search** 358/105, 160, 166, 167

[56] **References Cited**

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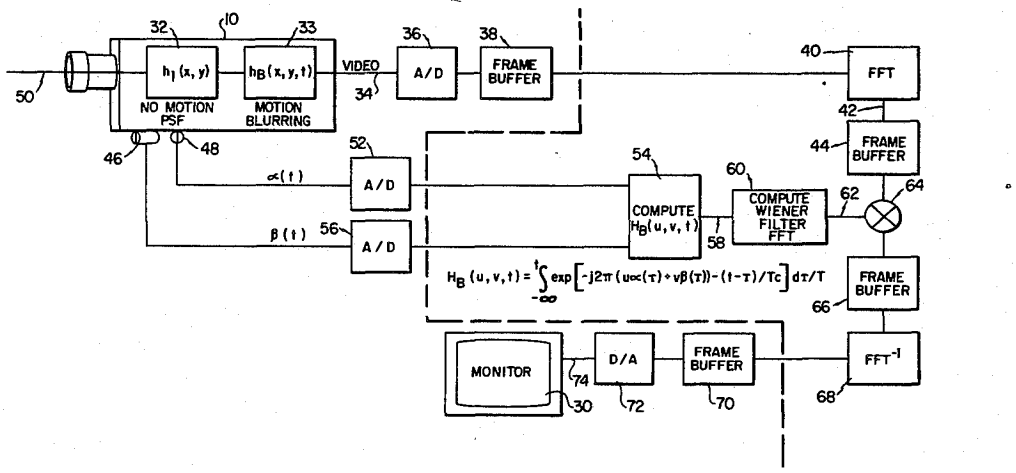
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Primary Examiner—James J. Groody
Assistant Examiner—Michael D. Parker
Attorney, Agent, or Firm—Albert M. Crowder, Jr.

[57] **ABSTRACT**

A video camera image with a motion induced blurring component is corrected by measuring the motion of the video camera by orthogonally mounted rate gyros each producing a signal that varies with camera motion along a defined axis relative to the bore sight of the camera. The video camera signal with the motion induced blurring component is processed into a Fourier transform which is combined with a video deblurring signal. Motion output signals of the rate gyros are processed in a Fourier transform computed Wiener filter to produce the video deblurring signal which is combined with the Fourier transform of the video camera signal. This combination signal is then processed in an inverse Fourier transform and converted into an analog signal for input to a video display monitor. This input signal to the video display monitor is motion corrected and produces a video display corrected for motion of the video camera.

28 Claims, 4 Drawing Figures



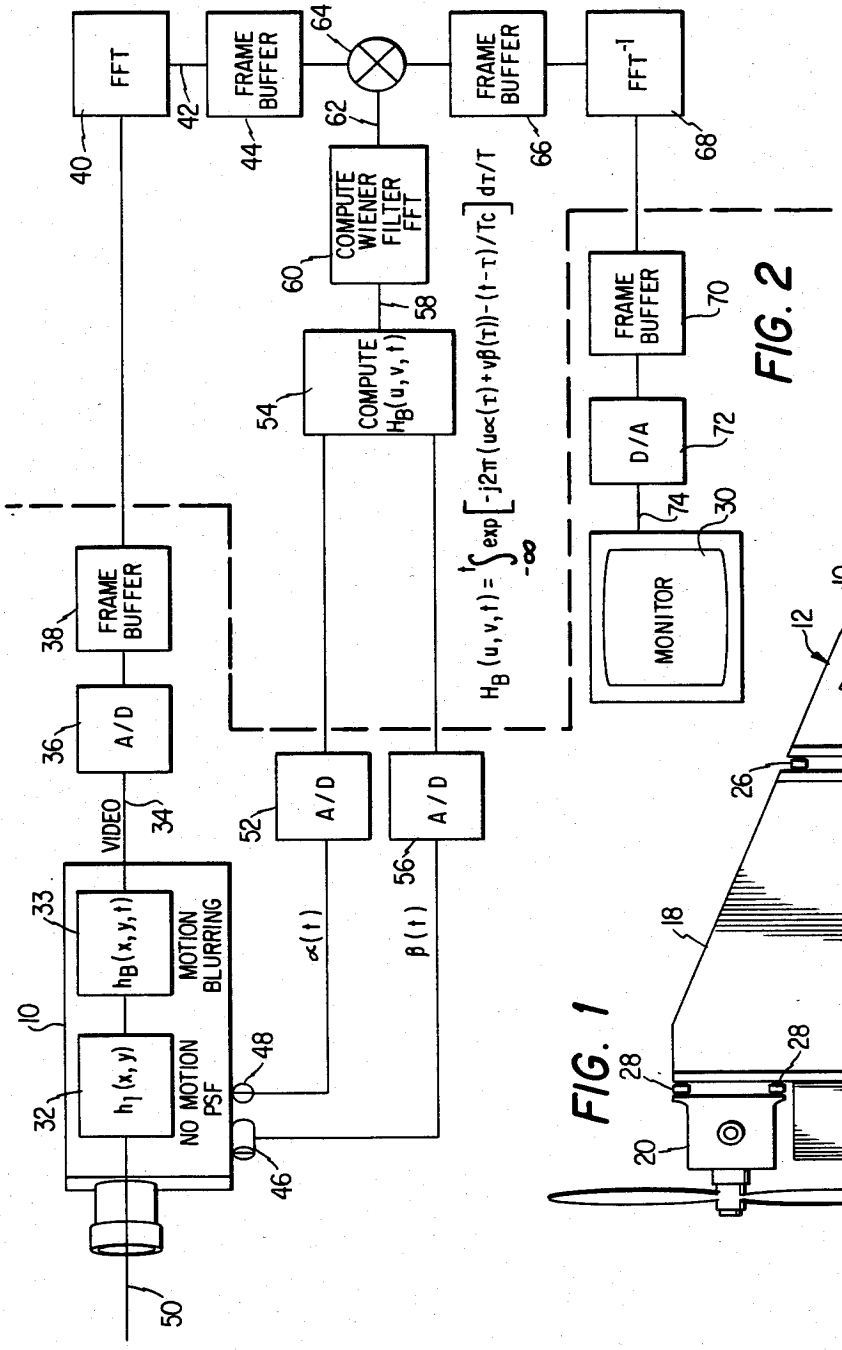

FFT
FRAME BUFFER
FRAME BUFFER
FFT⁻¹
COMPUTE WIENER FILTER FFT
COMPUTE $H_B(u,v,t)$
FRAME BUFFER
D/A
MONITOR
FRAME BUFFER
A/D
VIDEO
A/D
A/D
$h_B(x,y,t)$
MOTION BLURRING
$h_1(x,y)$
NO MOTION PSF
$\alpha(t)$
$\beta(t)$
$H_B(u,v,t) = \int_{-\infty}^{t} \exp\left[-j2\pi(u\alpha(\tau)+v\beta(\tau))-(t-\tau)/Tc\right] d\tau/T$
40
42
44
62
64
66
68
60
58
54
70
72
74
30
38
36
34
52
56
33
10
32
48
46
50

FIG. 2

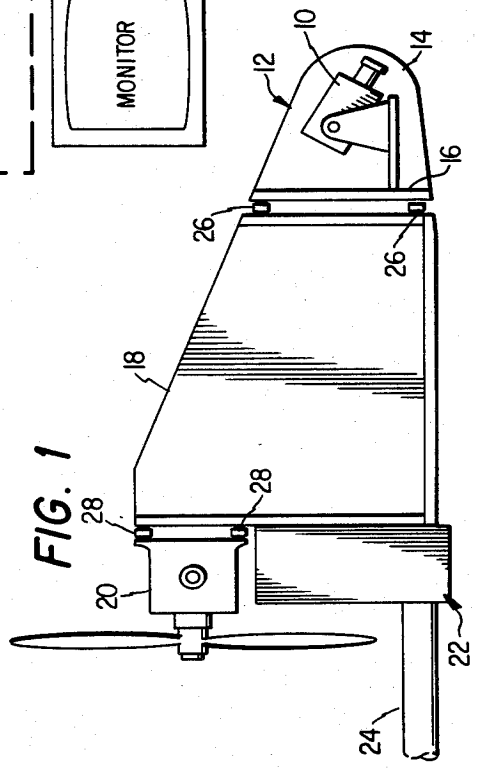

10
12
14
16
26
26
18
28
28
20
22
24

FIG. 1

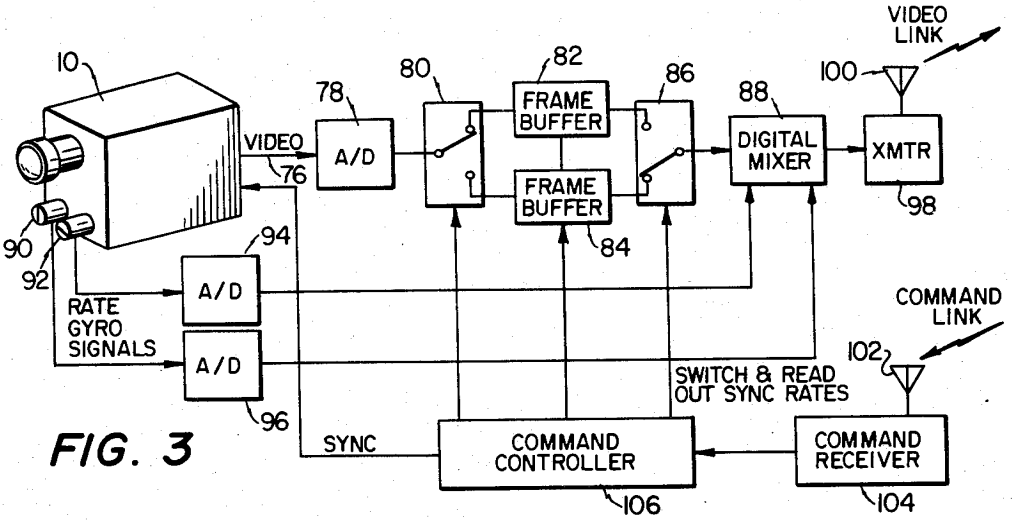

10
VIDEO
76
78
A/D
80
82
FRAME BUFFER
FRAME BUFFER
84
86
88
DIGITAL MIXER
100
VIDEO LINK
XMTR
98
90
92
94
A/D
RATE GYRO SIGNALS
A/D
96
COMMAND LINK
102
SWITCH & READ OUT SYNC RATES
SYNC
COMMAND CONTROLLER
106
COMMAND RECEIVER
104

FIG. 3

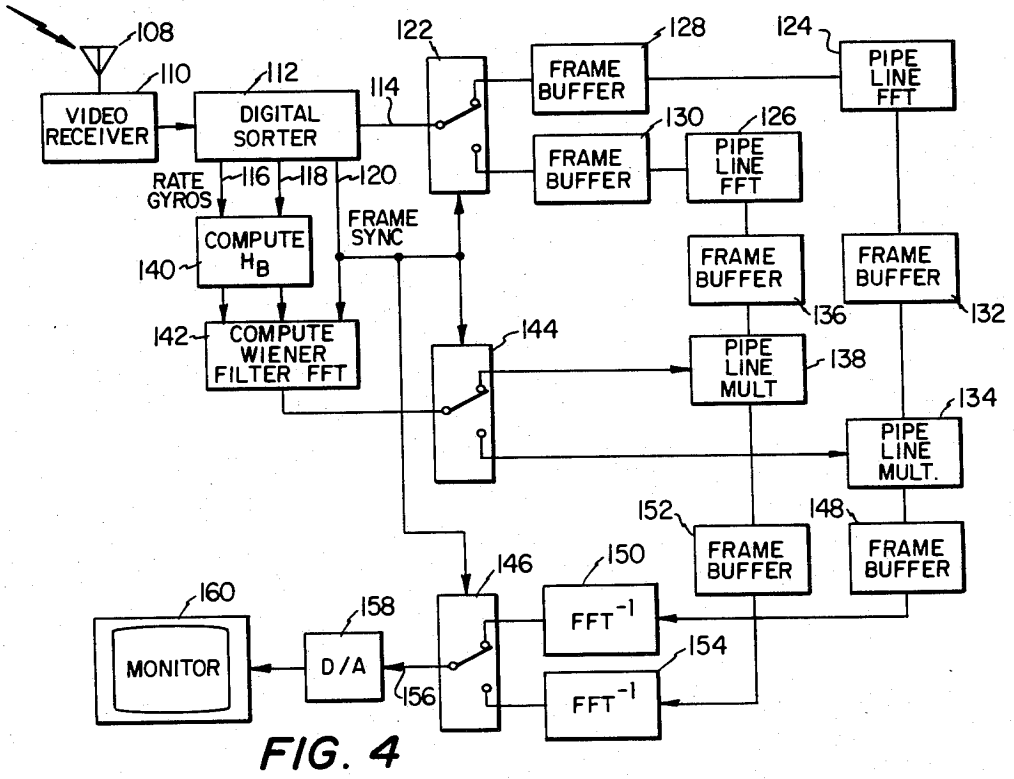

108
110
VIDEO RECEIVER
112
DIGITAL SORTER
114
122
FRAME BUFFER
128
124
PIPE LINE FFT
130
126
FRAME BUFFER
PIPE LINE FFT
RATE GYROS
116
118
120
FRAME SYNC
COMPUTE H_B
140
FRAME BUFFER
136
FRAME BUFFER
132
142
COMPUTE WIENER FILTER FFT
144
PIPE LINE MULT
138
134
PIPE LINE MULT.
152
148
FRAME BUFFER
FRAME BUFFER
146
150
160
158
MONITOR
D/A
156
FFT^{-1}
154
FFT^{-1}

FIG. 4

T.V. VIDEO IMAGE CORRECTION

This invention relates to apparatus and a process for correcting a T.V. video image for motion induced blurring, and more particularly to a method and apparatus for combining the signal of a blurred video image with a measure of the camera bore-sight angular motion to generate a motion corrected video image.

BACKGROUND OF THE INVENTION

Motion induced blurring of a video image has been recognized as a problem particularly with video images attained from small cameras such as carried by many observation vehicles. The problem is apparently more acute in special purpose video observation than in commercial television which can tolerate some blurring. Specifically in the area of military reconnaissance the blurring of a video image is extremely detrimental for target identification. Several techniques have been developed to minimize the blurring of the images resulting from camera angular motion.

One technique for reducing the blurring of video images is to shock mount the video camera to minimize high frequency vibrations which have been identified as a major source of motion induced blurring. Also in an effort to produce motion free video images the bore sight of the camera is gyro stabilized by a servo control having motors for controlling the angular position of two mirrors each mounted on an axis perpendicular to the camera bore sight. It will be readily recognized that the use of servo control techniques for stabilization is costly and results in a rather heavy system. While weight may not be an important factor when a camera is mounted on a pylon, for portable and vehicle mounted video cameras, weight is a factor that must be considered.

While the present invention is not limited to a specific application, in the field of remote pilotless vehicles the added weight and cost caused by inertially controlling the bore sight of the video camera by gyro stabilization of mirrors imposes severe difficulties in field launching and logistics. Also, a remote pilotless vehicle (RPV) is considered an expendable vehicle and the cost of such gyro stabilization of mirrors on orthogonal axis restricts the use of this form of reconnaissance.

SUMMARY OF THE INVENTION

Deblurring of a video image in accordance with the present invention is achieved by shock mounting the camera to minimize high frequency vibration effects and to mount rate gyros on orthogonal axis on the camera to produce measures of camera motion which are processed to remove a motion induced blurring component from the camera video image. Both the video camera signal with the motion blurring component and the rate gyro signals are input to a processing system that combines the video camera signal with the blurring component and the rate gyro signals to produce a motion corrected video image. The technical advantage resulting from the present invention is an inexpensive and lightweight camera system capable of producing a motion corrected video image. The technical improvement is a less complex motion correction system that reliably produces a motion corrected video image.

In accordance with the present invention, there is provided a method for correcting a video image (signal) for motion induced blurring that includes a first step of measuring the motion of a video camera and generating a motion signal related to camera movement. A video camera signal is generated by the video camera with this video signal including a blurring component caused by camera motion. From the motion signal, there is computed a video deblurring signal which is combined with the video camera signal to generate a motion corrected video signal. This motion corrected video signal may then be an input to a display system for producing to an observer a motion corrected video display.

Also in accordance with the present invention there is provided apparatus for correcting a video signal for motion induced blurring. Such apparatus includes a video camera that has means for generating a video camera signal, where the video camera signal has a motion blurring component. Movement of the video camera is measured by means that responds to the motion and generates a motion signal. This motion signal along with the video camera signal are input to a signal correcting processing systems that respond to both inputs which are combined into a motion corrected video signal. Again, the video signal may be input to a display system for producing a motion corrected video display.

In one embodiment of the present invention, both the apparatus and the method utilizes filtering techniques for combining the video deblurring signal with the video camera signal in the generation of the motion corrected video signal. One filtering techniques includes computing a fast Fourier transform of a Wiener filter and combining this output with the Fourier transform of the video camera signal with the motion blurring component. For frame by frame processing of a video signal, a synchronization signal routes the individual frames of data to the centralized processing signal system for generating the video display.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention and its advantages will be apparent from the following detailed description taken in conjunction with the accompanying drawings.

Referring to the drawings:

FIG. 1 is a partial schematic of a remote pilotless vehicle (RPV) with a forward looking shock mounted video camera;

FIG. 2 is a block diagram of a system for deblurring the output of a video camera having a motion induced component;

FIG. 3 is a block diagram of an airborne video signal processing system such as utilized in the remote pilotless vehicle of FIG. 1; and

FIG. 4 is a block diagram of a ground station for receiving signals from the airborne system of FIG. 3 for processing it to a deblurred video display on a monitor.

DETAILED DESCRIPTION

Video cameras are finding extensive use in applications where the camera is subject to vibrations which induce into the output signal of the camera a motion component that causes blurring of the video display. While most commercial television can tolerate this blurring of the video display, it can be extremely detrimental for other applications such as the use of a video camera in reconnaissance aircraft. With reference to FIG. 1, there is shown a partial schematic of a remote pilotless vehicle (RPV) wherein a video camera 10 is mounted in a camera compartment 12 comprising a

transparent cover **14** mounted to a base plate **16**. The base plate **16** is shock mounted to a control compartment **18** that includes various navigation and engine controls along with circuitry of the present invention as will be described. Mounted to the rear of the control compartment **18** is the vehicle engine **20** which is also shock mounted to the control compartment **18**. The elements **22** and **24**, as illustrated in FIG. **1**, refer to various standard components of an RPV which forms no part of the present invention and will not be further described.

To minimize high frequency vibration effects on the camera **10**, such as caused by the engine **20**, the base plate **16** is mounted to the control compartment **18** by means of shock mounts **26**. Such mounts are conventional hardware and have been heretofore used to minimize the high frequency effects on a video camera. Similarly, the shock mounts **28** between the engine **20** and the control compartment **18** are also conventional and designed to minimize the transmission of high frequency vibrations from the engine to the control compartment.

To further minimize the effect of motion of the camera **10** on a display screen, the video signal output from the camera is processed by Fourier transform and Wiener filter techniques.

Referring to FIG. **2**, there is shown a system for deblurring the output of the video camera **10** to produce a motion deblurred signal to a video monitor **30**. As illustrated in the block identified as camera **10**, block **32** comprises a conventional video camera that generates a video signal that is in essence the scene image passed through the system processing function, $h_1(x,y)$, yielding a signal that would offer adequate image fidelity when reconstituted for display. If the camera **10** is subject to motion, there is in essence an additional undesirable processing filter as given by the expression: $h_B(x,y,t)$. Thus the video signal output of the camera **10** as appearing on cable **34** has both the video component as generated by a conventional video camera and a motion induced component, such as given by the expression $h_B(x,y,t)$. This video signal on cable **34** is input to an analog to digital converter **36** that digitizes the analog output of the camera **10** for processing to remove the motion induced component.

Following the converter **36** the video signal with the motion induced component is input to a frame buffer **38** as a memory element to receive data in real time from the converter **36**. This data is stored for processing on a demand basis in a fast Fourier transform network **40**. The fast Fourier network **40** is conventional hardware implemented with "butterfly" elements such as understood by those skilled in the art. An output of the network **40** as appearing on a line **42** is the transform of the output of the video camera **10** on the cable **34** which includes a motion induced component. This transform is put through a frame buffer **44**, again a memory element such as the frame buffer **38**. Frame buffers **38** and **44** and other frame buffers in the circuit of FIG. **2** are utilized because of processing limitations of the various transform and filter networks included within the system.

Mounted to the camera **10** at mutually perpendicular axis are rate gyros **46** and **48**. These gyros are also perpendicular to the line of sight **50** of the camera **10**. Each of these gyros generates a signal varying with the motion of the camera **10** along the respective axis of the gyro. A signal from the gyro **48** is input to an analog to digital converter **52** wherein it is digitized and applied to a computing network **54** that generates a motion signal in the frequency domain as will be explained. The output of gyro **46** is passed through an analog to digital converter **56** and also applied to the computing network **54**.

In the camera **10** there is identified a motion related function within the block **33**. This function identifies the motion component of the video signal on the cable **34** in the spatial domain. To calculate out this motion induced component a similar function is generated from the outputs of the gyros **46** and **48** in the frequency domain. The computing network **54** then generates a motion related signal in the frequency domain which is similar to the motion component of the video signal in the spatial domain on the cable **34**. Thus, the output of the computing network **54** on line **58** is a signal which tracks the motion component of the video signal on the cable **34** as given by the expression in the block **33**.

Typically, the computing network **54** is a programmed computer that generates the function $H_B(u,v,t)$ which varies with the camera charactistics. For example, for one model of video camera the computing network **54** generated the signal H_B in accordance with the following expression:

$$H_B(u,v,t) = \int_{-\infty}^{t} \exp\left[-j2\pi(u\alpha(\tau) + v\beta(\tau)) - (t-\tau)/T_c\right]d\tau/T_c$$

where each of the terms of the expression are given in FIG. **2**.

From the computing network **54** the signal generated on the line **58** is applied to a Wiener filter **60**. Thus, there is input to the Wiener filter **60** a signal which varies with the motion of the camera **10** as detected by the rate gyros **46** and **48**. This signal input to the filter **60** is processed in accordance with the expression:

$$\frac{H_B}{|H_B|^2 + N_n/N_s}$$

Where the term N_n/N_s is a noise-to-signal power ratio.

As such, the output of block **60** is the Fourier transform of the Wiener filter which minimizes the mean square error between an assemble of the blurred image and the desired image. The output of the block **60** on output line **62** is combined by multiplication with the Fourier transform of the blurred image at the output of the frame buffer **44**.

It should be noted that the expression for the Wiener filter as given above is in agreement with a solution commonly found in the literature. At the output of the Wiener filter **60** and the frame buffer **44**, there are now two signals which when combined will produce a video signal with the motion induced component minimized and a deblurred video display will appear on the monitor **30**.

The output of the frame buffer **44** and the Wiener filter **60** are combined in a multiplier **64** on a term by term basis with the result applied to a frame buffer **66**. Again, the frame buffer **66** is a memory element to store the output of the multiplier **64** for further processing. This further processing includes an inverse fast Fourier transform network **68** which generates a video image in the spatial domain with an optimally reduced blurring.

The function of the inverse fast Fourier transform network **68** is conventional and described in literature.

An output of the network **68** is applied to a frame buffer **70** and then to a digital to analog converter **72** having an output signal on a line **74** applied to the monitor **30**. The output signal on the line **74** is the video signal given by the expression of block **32** with the motion induced component of block **33** minimized or removed. Thus, there is produced on the monitor **30** a display of the image received by the camera **10** with the effects of motion greatly reduced.

Referring to FIG. **3**, there is shown an embodiment of the invention for use where the video camera **10** is mounted on a remote vehicle and the video monitor is at a central station spatially removed from the camera **10**. The ground station is shown in block diagram in FIG. **4** and will be described. The system of FIG. **3** may typically be mounted in the RPV of FIG. **1**. A video signal output from the camera **10**, which includes a motion component, is applied by means of a cable **76** to an analog to digital converter **78** and to a two position solid state switch **80**. Connected to one terminal of the switch **80** is a frame buffer **82** and connected to the second terminal is a frame buffer **84**. The frame buffers of FIG. **3** are similar to the frame buffers previously described with reference to FIG. **2**. They perform the same function of storing the digitized video signal having a motion component for further processing. Alternate frames of video date from the camera **10** are stored in alternate frame buffers **82** or **84**. Thus, in the embodiment of FIG. **3**, data from the camera **10** is processed on a frame basis.

Connected to the frame buffers **82** and **84** is a two-position electronic switch **86** that alternately connects the frame buffers to a digital mixer **88**. Thus, one input to the digital mixer **88** is a frame by frame video signal with a motion component from the camera **10**.

Also, input to the digital mixer **88** is the output of rate gyros **90** and **92** mounted to the camera **10** on mutually perpendicular axis and also on an axis perpendicular to the bore sight of the camera. The output of the gyro **92** is digitized in an analog to digital converter **94** and then applied to the digital mixer **88**. Similarly, the output of the gyro **90** is digitized in an analog to digital converter **96** and also applied to the digital mixer **88**. The digital mixer, as the name applied, mixes the video output of the camera **10** with the outputs of the rate gyros **90** and **92** for purposes of transmission to a remote processing station. The mixed signal output of the mixer **88** is applied to a transmitter **98** which generates a signal for transmission by means of an antenna **100** to the processing station.

To initialize the operation of the system of FIG. **3** on a frame by frame basis, a command signal is received at an antenna **102** and input to a command receiver **104** that generates a command signal to a controller **106** to start the operation of the system. In response to the command signal, the controller **106** generates a synchronization signal to the camera **10** and also synchronization signals to the electronic switches **80** and **86**. In addition, the controller **106** generates read-out signals to the frame buffers **82** and **84**. Basically, the command controller **106** is a clock responsive to the command signal that gnerates synchronization and read-out signals for operation of the system of FIG. **3**.

Each time a synchronization signal is generated to the camera **10** to start a new frame of data, the electronic switches **80** and **86** are switched to an alternate position to connect one of the frame buffers to the camera to receive the next frame of video data and connecting the alternate frame buffer to the digital mixer **88** for combining with the output of the rate gyros **90** and **92**. Since each frame of data must be motion corrected, the gyro signals for that frame of data must be timed to appear at the mixer **88** to mix the correct rate gyro signals with the associated frame of data. This mixing of the correct rate gyro signals with the associated frame of data is achieved by operation of the command controller **106**. Thus, the signals transmitted from the antenna **100** to the processing station includes a series of data signals on a frame by frame basis mixed with the associated rate gyro signal to correct that frame of data.

Referring to FIG. **4**, the camera and rate gyro signals transmitted from the antenna **100** are received by a processing station at an antenna **108**. This antenna is connected to a video receiver **110** which demodulates the received signal into frames of digital data where each frame is mixed with motion correction signals from the rate gyros **90** and **92**. This digital data on a frame by frame basis is applied to a digital sorter **112** which functions to separate the video signal, frame by frame, along with the motion component into one stream of data on a line **114** and the digitized rate gyro signals on lines **116** and **118** from the rate gyros **90** and **92**, respectively, into second and third data streams. Also generated by the digital sorter **112** is a frame synchronization signal on a line **120**.

The digital video signal from the camera **10** along with the motion component is applied to a two position electronic switch **122** which separates the signal frame by frame to be alternately applied to fast Fourier transform networks **124** or **126**. The station of FIG. **4** processes the video data on a frame by frame basis in parallel paths such as the processing of the remote station as illustrated in FIG. **3**. Interconnected between the fast Fourier transform network **124** and the switch **122** is a frame buffer **128** and interconnected between the network **126** and the switch is a frame buffer **130**.

Connected to the fast Fourier transform network **124** is a frame buffer **132** which in turn is connected to a multiplier **134**. In parallel therewith, an output of the Fourier transform network **126** connects to a frame buffer **136** which is then connected to a multipler **138**. As explained with reference to FIG. **2**, each frame of data from the video camera **10** is multiplied element by element, with a motion correction signal from the output of a Wiener filter.

The rate gyro signals on the lines **116** and **118** are connected to a computing network **140** which functions as previously described with reference to the computing network **54** of FIG. **2**. Connected to the network **140** is the Wiener filter **142** that operates to generate a deblurring signal for motion correction of the output of the camera **10**. This deblurring signal is applied to an electronic switch **144** having one terminal connected to the multiplier **138** and a second terminal connected to the multiplier **134**.

To synchronize the frame by frame correction of the video camera signal, the frame synchronization on line **120** is applied to the electronic switches **122** and **144**. By means of this synchronization, the correction signal for a particular frame of data will be applied to either the multiplier **138** or **134** in synchronization with the corresponding video frame data.

From the multiplier **134** the motion corrected video signal is applied to a frame buffer **148** for processing in

an inverse fast Fourier transform network **150**. Similarly, a frame of motion corrected data from the multiplier **138** is applied to a frame buffer **152** for processing in an inverse fast Fourier transform network **154**. Thus, each output of the transform networks **150** and **154** is a motion corrected frame of video data.

Connected to the inverse fast Fourier transform networks **150** and **154** is a two position electronic switch **146** which is operated in synchronization with the switches **122** and **144** by the frame synchronization signal on line **120**. By operation of the switch **146** alternate frames of video data, corrected for motion, are serially applied to a data line **156**. The data line **156** carries all frames of video signal from the camera **10** each corrected for motion by means of the outputs of the rate gyros **90** and **92**. This corrected frame by frame video signal is converted into an analog format by means of an analog to digital converter **158** having as an output a motion corrected video signal connected to a monitor **160**. The monitor **160** displays the image seen by the camera **10** with the motion component greatly reduced.

Although the previous description has made reference to a remote pilotless vehicle, it will be understood that the invention is not limited to such an application. Video cameras are used in many applications where the video output of a camera includes a motion component. The systems of FIGS. **2**, **3** and **4** will provide motion corrected displays for use in such applications. The distance between the camera and the processing station may require a radio link or the camera and the processing station may be hardwired interconnected. The invention is not limited to either one or the other of such operations.

While several embodiments of the present invention have been described in detail therein and shown in the accompanying drawings, it will evident that various further modifications are possible without departing from the scope of the invention.

We claim:

1. A method for correcting a video image for motion induced blurring, comprising the steps of:
- measuring the motion of a video camera and generating a motion signal,
- generating a video camera signal from the video camera, the video camera signal including a blurring component,
- computing a video deblurring signal from the motion signal, and
- combining the video deblurring signal with the video camera signal to generate a motion corrected video signal.

2. A method of correcting a video image for motion induced blurring as set forth in claim **1** wherein the step of computing includes computing a motion blurring signal and using the motion blurring signal to generate a Fourier transform of the video deblurring signal.

3. A method of correcting a video image for motion induced blurring as set forth in claim **1** wherein the step of combining the video deblurring signal with the video camera signal includes:
- generating a Fourier transform of the video camera signal,
- multiplying the output of the Fourier transform with a Fourier transform of a Wiener filter, and
- generating an inverse Fourier transform of a signal resulting from the step of multiplying, the result of the inverse Fourier transform providing the motion corrected video signal.

4. A method of correcting a video image for motion induced blurring as set forth in claim **1** wherein the generated motion signal and the generated video camera signal are in an analog format, and including the step of:
- converting the analog motion signal and the analog video camera signal into a digital format for the step of computing and the step of combining.

5. A method for correcting a video image for motion induced blurring, comprising the steps of:
- measuring the motion of a video camera along a first axis perpendicular to a bore sight of the camera to generate a first motion signal,
- measuring the motion of a video camera along a second axis perpendicular to the bore sight of the camera and perpendicular to the first axis to generate a second motion signal,
- generating a video camera signal from the video camera, the video camera signal including a blurring component,
- computing a video deblurring signal from the first motion signal and the second motion signal, and
- combining the video deblurring signal with the video camera signal to generate a motion corrected video signal.

6. A method of correcting a video image for motion induced blurring as set forth in claim **5** wherein the step of computing includes computing an equivalent motion blurring component signal from the first and second motion signals.

7. A method of correcting a video image for motion induced blurring as set forth in claim **6** wherein the step of computing further includes filtering the equivalent motion blurring component signal to compute the video deblurring signal.

8. A method of correcting a video image for motion induced blurring as set forth in claim **7** wherein the step of filtering the equivalent motion blurring component signal is completed by Wiener filtering.

9. A method for remotely correcting a video image for motion induced blurring, comprising the steps of:
- measuring the motion of a video camera and generating a motion signal,
- generating a video camera signal from the video camera, the video camera signal including a blurring component,
- mixing the video camera signal with the motion signal into a transmission signal for radio link transmission to a processing station,
- sorting the transmission signal at the processing station into a received motion signal and a received video camera signal,
- computing a video deblurring signal from the received motion signal, and
- combining the video deblurring signal with the received video camera signal to generate a motion corrected video signal.

10. A method for remotely correcting a video image as set forth in claim **9** wherein the step of computing includes computing a motion correction signal, and filtering the motion correction signal to generate the video deblurring signal.

11. A method for remotely correcting a video image as set forth in claim **10** wherein filtering the motion correction signal includes performing a Wiener filtering operation of the motion correction signal.

12. A method for remotely correcting a video image as set forth in claim 9 wherein the step of measuring the motion of the video camera includes measuring the rate of motion of the camera and generating a rate motion signal for mixing with the video camera signal.

13. A method for remotely correcting a video image for motion induced blurring, comprising the steps of:

measuring the motion of a video camera at a remote location along a first axis perpendicular to a bore sight of the camera to generate a first motion signal,

measuring the motion of the video camera along a second axis perpendicular to the bore sight of the camera and perpendicular to the first axis to generate a second motion signal,

generating a video camera signal from the video camera, the video signal including a blurring component,

mixing the video camera signal with the first motion signal and the second motion signal into a transmission signal for radio link transmission to a processing station,

sorting the transmission signal at the processing station into a first received motion signal, a second received motion signal and a received video camera signal,

computing a video deblurring signal from the first received motion signal and the second received motion signal, and

combining the video deblurring signal with the received video camera signal to generate a motion corrected video signal.

14. A method for remotely correcting a video image as set forth on claim 13 wherein the step of combining the video deblurring signal with the received video camera signal includes:

generating a Fourier transform of the received video camera signal,

multiplying the results of the Fourier transform with the video deblurring signal to generate a multiplication signal, and

generating an inverse Fourier transform of the multiplication signal to generate the motion corrected video signal.

15. A method for remotely correcting a video image as set forth in claim 14 wherein the step of computing a video deblurring signal includes:

computing an equivalent of the blurring component from the first received motion signal and the second received motion signal, and

filtering the equivalent blurring component to generate the video deblurring signal.

16. A method for remotely correcting a video image as set forth in claim 13 wherein the video camera is mounted on a remote pilotless vehicle, and the steps of measuring the motion of the video camera along a first axis and measuring the motion of the video camera along a second axis includes generating a first rate motion signal and a second rate motion signal.

17. Apparatus for correcting a video image for motion induced blurring, comprising:

a video camera including means for generating a video camera signal, the video camera signal having a motion blurring component,

means for measuring the motion of said camera and generating a motion signal,

signal correction means connected to said video camera for receiving the video camera signal and connected to the means for measuring for receiving the motion signal, said signal correction means responsive to the video camera signal and the motion signal for combining into a motion corrected video signal.

18. Apparatus for correcting a video image for motion induced blurring as set forth in claim 17 wherein said signal correcting means includes a filter responsive to the motion signal for generating video deblurring signal, and

means for combining the video deblurring signal with the video camera signal to generate the motion corrected video signal.

19. Apparatus for correcting a video image for motion induced blurring as set forth in claim 17 wherein said means for measuring includes:

means for measuring the motion of the video camera along a first axis perpendicular to the bore sight of the camera to generate a first motion signal, and

means for measuring the motion of the video camera along a second axis perpendicular to the bore side of the camera and perpendicular to the first axis to generate a second motion signal, the first motion signal and the second motion signal comprising the generated camera motion signal.

20. Apparatus for correcting a video image for motion induced blurring as set forth in claim 19 wherein said signal correcting means includes:

means for computing a video deblurring signal from the first motion signal and the second motion signal, and

means for combining the video deblurring signal with the video camera signal to generate the motion corrected video signal.

21. Apparatus for correcting a video image for motion induced blurring as set forth in claim 20 wherein said means for computing a video deblurring signal includes:

means for computing an equivalent motion blurring component in response to the first motion signal and the second motion signal, and

means for filtering the equivalent motion blurring component to generate the video deblurring signal.

22. Apparatus for correcting a video image for motion induced blurring as set forth in claim 21 wherein said means for filtering includes a Wiener filter.

23. Apparatus for correcting a video image for motion induced blurring as set forth in claim 22 wherein said Wiener filter generates the video deblurring signal in accordance with the expression:

$$\frac{H_B}{|H_B|^2 + N_n/N_s},$$

where, H_B is the equivalent motion blurring component, and N_n/N_s is a noise-to-signal ratio.

24. Apparatus for correcting a video image for motion induced blurring, comprising:

a video camera at a remote location and including means for generating a video camera signal, the video camera signal having a motion blurring component,

means for measuring the motion of said camera and generating a motion signal,

means for mixing the video camera and the motion signal to generate a video/motion signal,

a transmitter responsive to the video/motion signal for generating a transmission signal for transmission to a processing station,

a receiver at the processing station receiving the transmission signal for sorting into a received motion signal and a received video camera signal, and

processing means responsive to the received motion signal and the received video camera signal for combining into a motion corrected video image.

25. Apparatus for correcting a video image for motion induced blurring as set forth in claim 24 wherein said processing means includes a plurality of processing channels each responsive to the received motion signal for an identified frame of data and the received video signal for the identified frame of data from said remote location for combining into a motion corrected video signal for the remote location.

26. Apparatus for correcting a video image for motion induced blurring as set forth in claim 24 wherein said processing means includes a filter responsive to the received motion signal for generating a video deblurring signal, and means for combining the video deblurring signal with the received video signal to generate the motion corrected video image.

27. Apparatus for correcting a video image for motion induced blurring as set forth in claim 26 wherein said filter comprising a Wiener filter generating the video deblurring signal in accordance with the expression:

$$\frac{H_B}{|H_B|^2 + N_n/N_s},$$

where, H_B is the equivalent of the motion blurring component, and N_n/N_s is a noise-to-signal ratio.

28. Apparatus for correcting a video image for motion induced blurring as set forth in claim 24 including a command receiver at said remote location responsive to a command signal, and

a command controller connected to the command receiver and generating a synchronization signal to said video camera and control signals to said means for mixing.

* * * * *

EXHIBIT 1016

US006335760B1

(12) **United States Patent**
Sato

(10) **Patent No.: US 6,335,760 B1**
(45) **Date of Patent: *Jan. 1, 2002**

(54) **IMAGE SIGNAL REPRODUCTION DEVICE**

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(73) Assignee: **Asahi Kogaku Kogyo Kabsushiki Kaisha**, Tokyo (JP)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/046,560**

(22) Filed: **Mar. 24, 1998**

(30) **Foreign Application Priority Data**

Mar. 27, 1997 (JP) 9-092957

(51) **Int. Cl.**[7] **H04N 7/12**
(52) **U.S. Cl.** **348/397.1**; 348/443; 345/132
(58) **Field of Search** 386/109, 27, 405, 386/412, 409, 219, 322, 396, 112, 124; 348/397, 390, 405, 412, 409, 219, 322, 396, 124, 441, 443, 458, 554, 552; 358/300, 447; 345/132; 367/108; 382/240

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Primary Examiner—Chris Kelley
Assistant Examiner—Gims Philippe
(74) *Attorney, Agent, or Firm*—Greenblum & Bernstein, P.L.C.

(57) **ABSTRACT**

An image signal reproduction device, provided in an electronic still camera, comprises a CPU, an image signal processing circuit, a memory card, in which a compressed image signal is recorded, and a display device having a liquid crystal display (LCD) and a resolution recognition unit. A clock pulse, outputted from the CPU, is received by the resolution recognition unit, so that a recognition pulse, corresponding to the inherent resolution of the LCD, is outputted from the resolution recognition unit to the image signal processing circuit. The compressed image signal is read from the memory card, and reproduced to some extent corresponding to the resolution of the LCD.

22 Claims, 12 Drawing Sheets

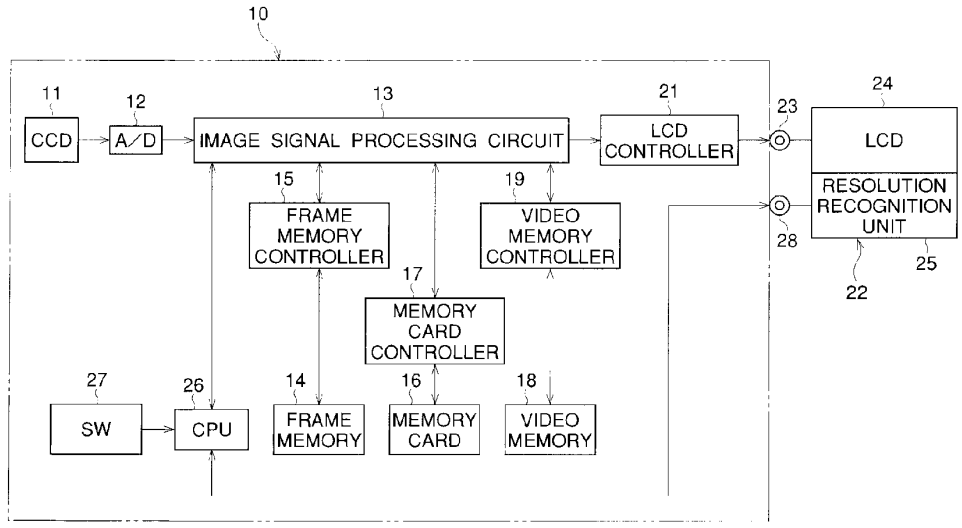


FIG. 1

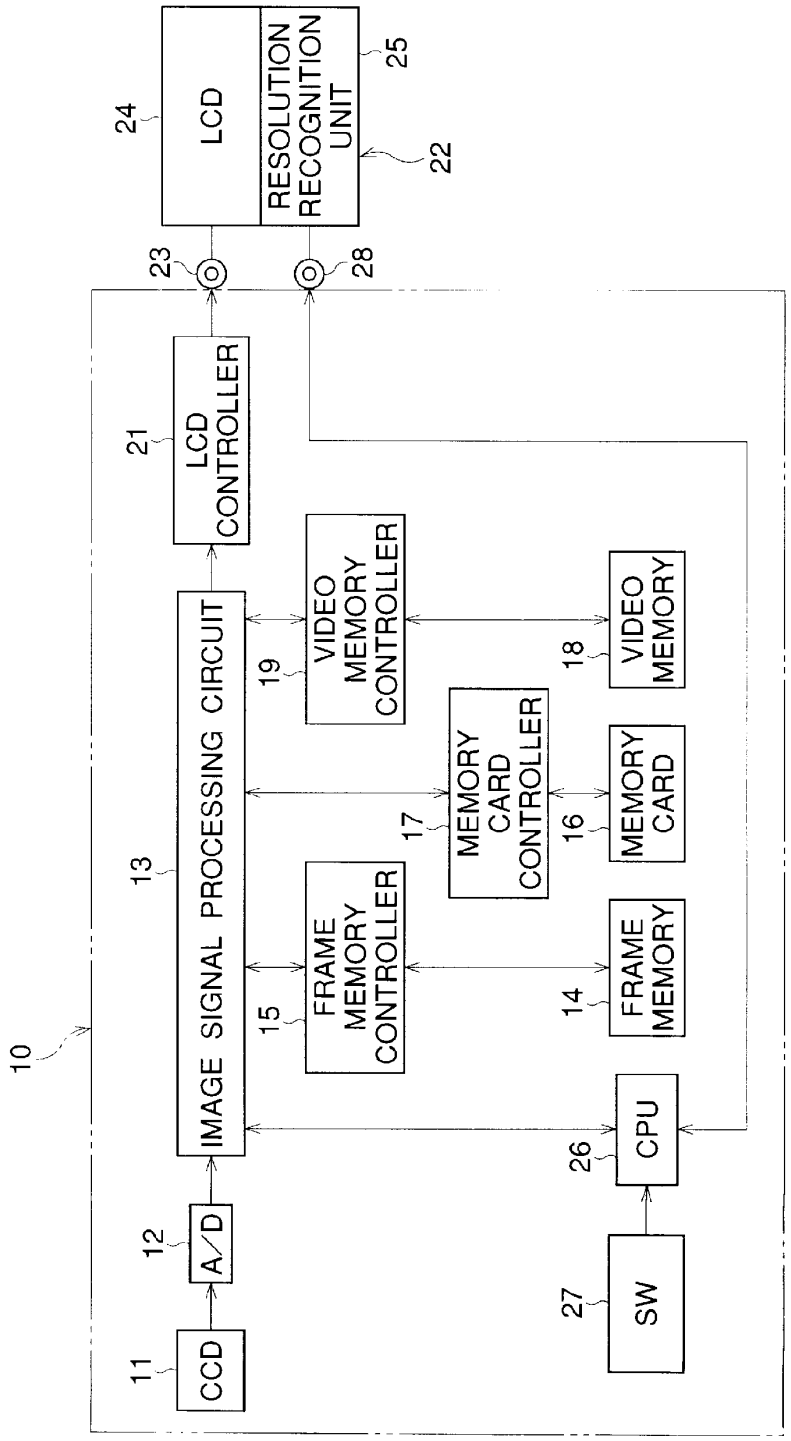

10
11
CCD
12
A/D
13
IMAGE SIGNAL PROCESSING CIRCUIT
14
FRAME MEMORY
15
FRAME MEMORY CONTROLLER
16
MEMORY CARD
17
MEMORY CARD CONTROLLER
18
VIDEO MEMORY
19
VIDEO MEMORY CONTROLLER
21
LCD CONTROLLER
22
RESOLUTION RECOGNITION UNIT
23
24
LCD
25
26
CPU
27
SW
28

FIG. 2

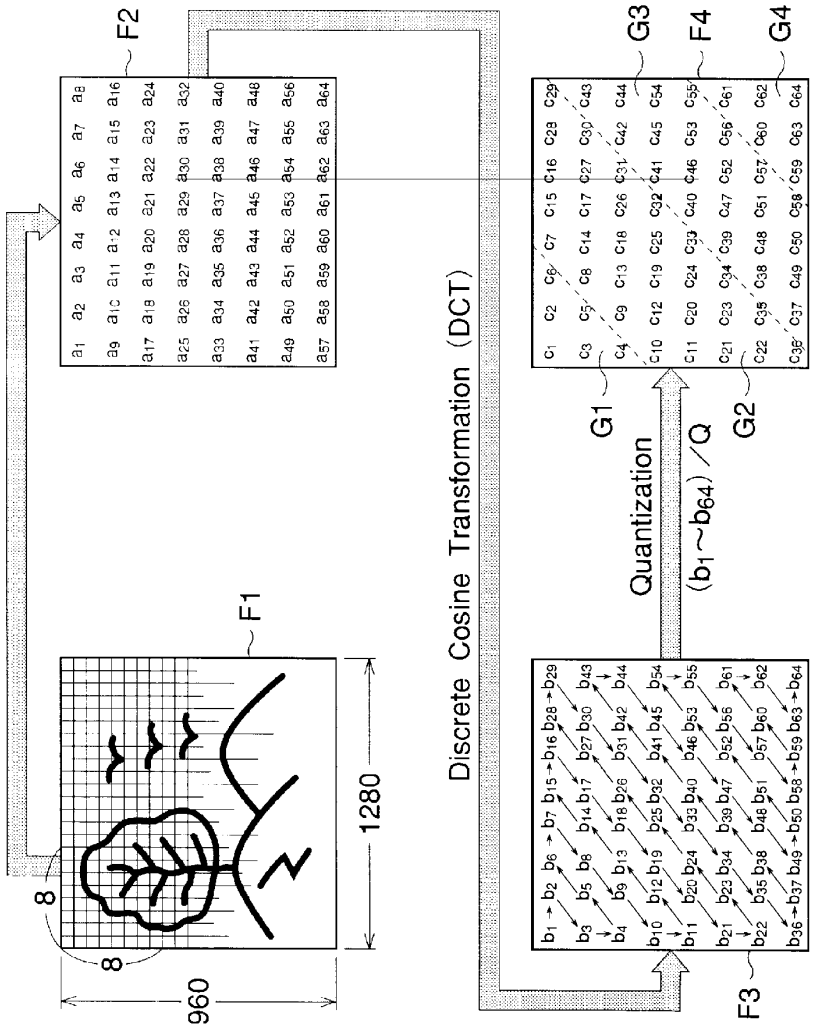

F1
F2
F3
F4
G1
G2
G3
G4
8
8
960
1280
Discrete Cosine Transformation (DCT)
Quantization
$(b_1 \sim b_{64})/Q$

FIG. 3

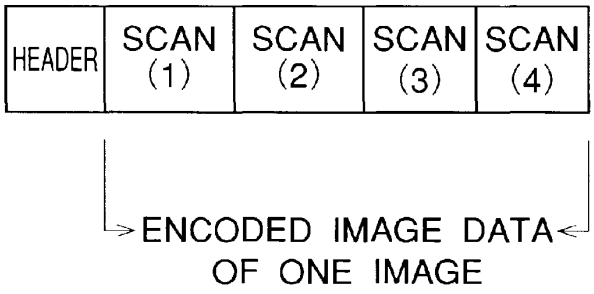

HEADER
SCAN (1)
SCAN (2)
SCAN (3)
SCAN (4)
ENCODED IMAGE DATA OF ONE IMAGE

FIG. 4

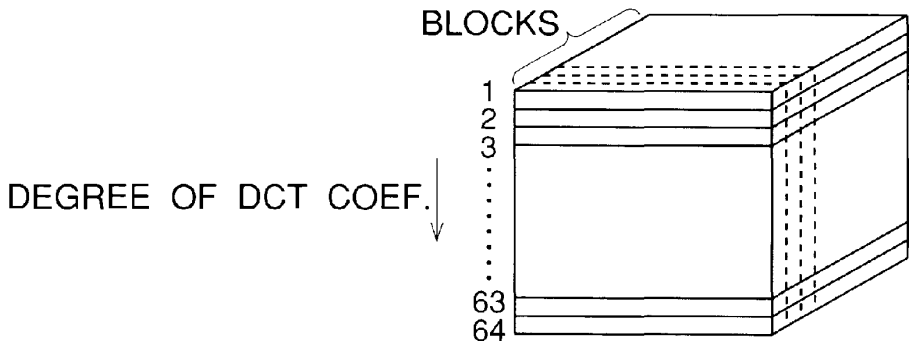

BLOCKS
DEGREE OF DCT COEF.
1
2
3
63
64

FIG. 5

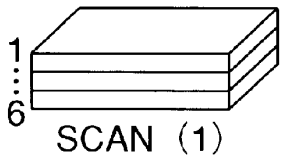


FIG. 6

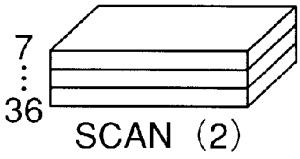


FIG. 7

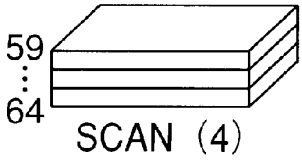


FIG. 8

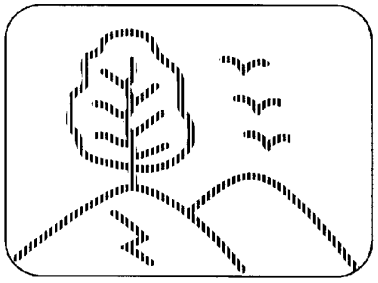


FIG. 9

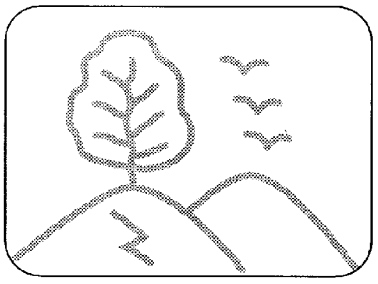


FIG. 10

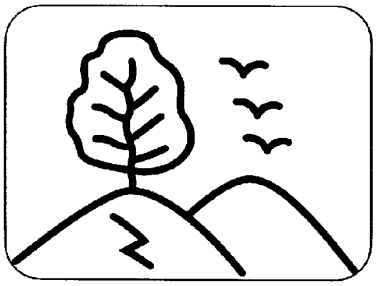


FIG. 11

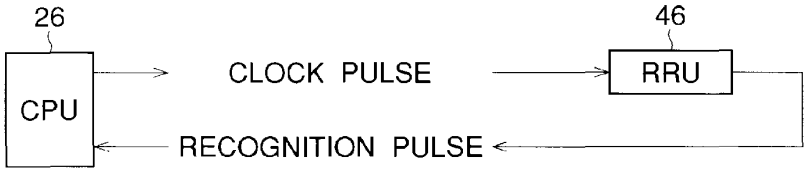

26
46
CPU
CLOCK PULSE
RRU
RECOGNITION PULSE

FIG. 12

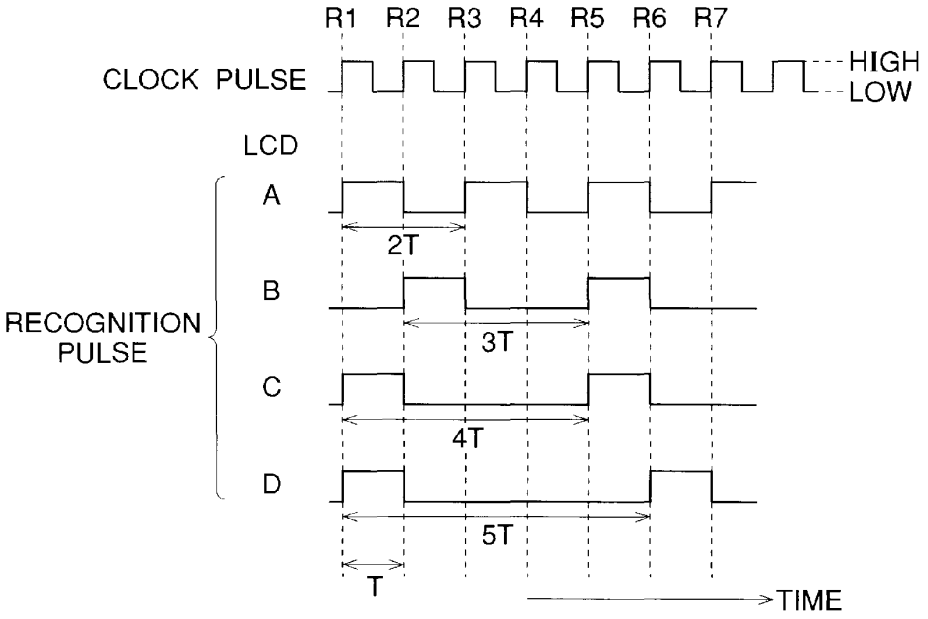

R1 R2 R3 R4 R5 R6 R7
CLOCK PULSE
HIGH
LOW
LCD
A
2T
B
3T
RECOGNITION PULSE
C
4T
D
5T
T
TIME

FIG. 13

NUMBER OF PIXELS IN THINNING	NUMBER OF SCANS		RESOLUTION
7	N1	⟷	CORRESPONDING TO TYPE D
3	N2	⟷	CORRESPONDING TO TYPE C
1	N3	⟷	CORRESPONDING TO TYPE B
0	N4	⟷	CORRESPONDING TO TYPE A

$N1 < N2 < N3 < N4$

FIG. 14A

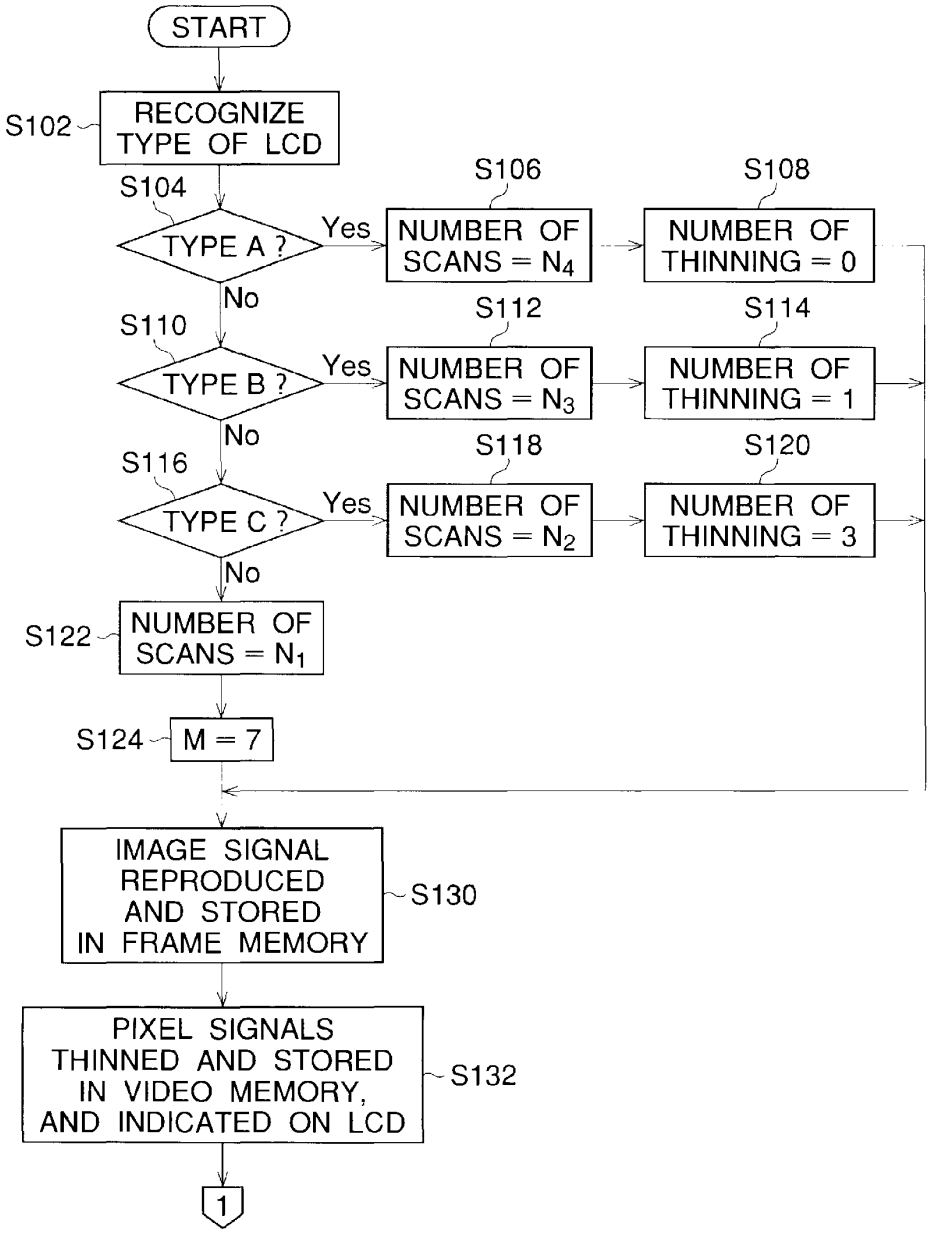

START
S102
RECOGNIZE TYPE OF LCD
S104
TYPE A ?
Yes
S106
NUMBER OF SCANS = N_4
S108
NUMBER OF THINNING = 0
No
S110
TYPE B ?
Yes
S112
NUMBER OF SCANS = N_3
S114
NUMBER OF THINNING = 1
No
S116
TYPE C ?
Yes
S118
NUMBER OF SCANS = N_2
S120
NUMBER OF THINNING = 3
No
S122
NUMBER OF SCANS = N_1
S124
M = 7
IMAGE SIGNAL REPRODUCED AND STORED IN FRAME MEMORY
S130
PIXEL SIGNALS THINNED AND STORED IN VIDEO MEMORY, AND INDICATED ON LCD
S132
1

FIG. 14B

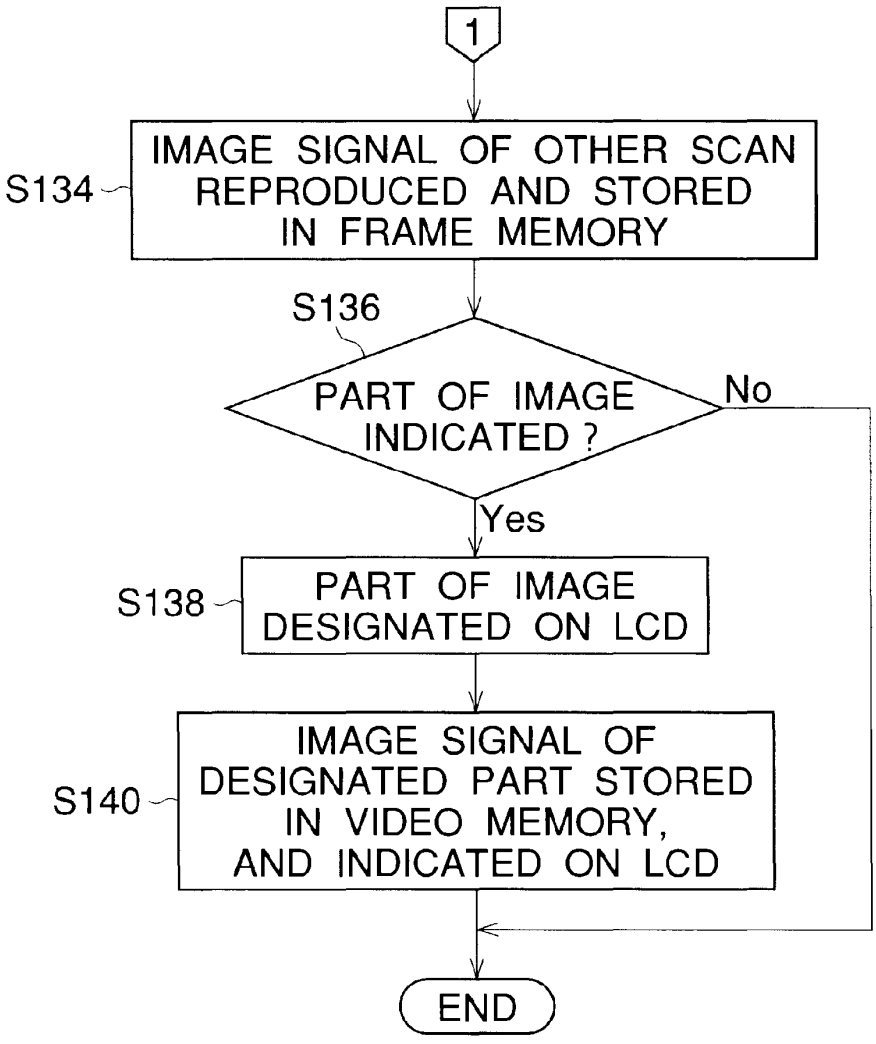

1
S134
IMAGE SIGNAL OF OTHER SCAN REPRODUCED AND STORED IN FRAME MEMORY
S136
PART OF IMAGE INDICATED ?
No
Yes
S138
PART OF IMAGE DESIGNATED ON LCD
S140
IMAGE SIGNAL OF DESIGNATED PART STORED IN VIDEO MEMORY, AND INDICATED ON LCD
END

FIG. 15

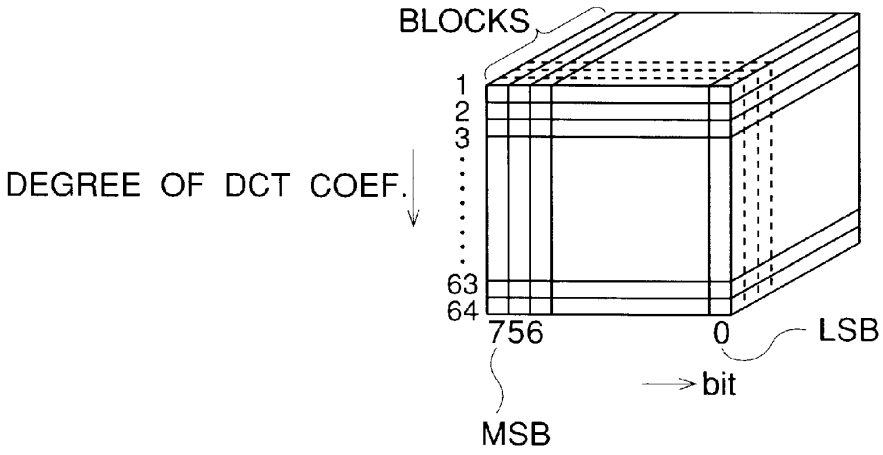
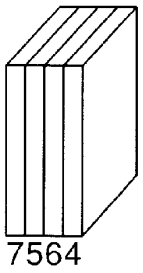
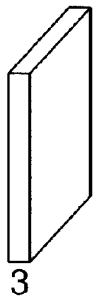


FIG. 16



SCAN (1)

FIG. 17



SCAN (2)

FIG. 18



SCAN (X)

FIG. 19

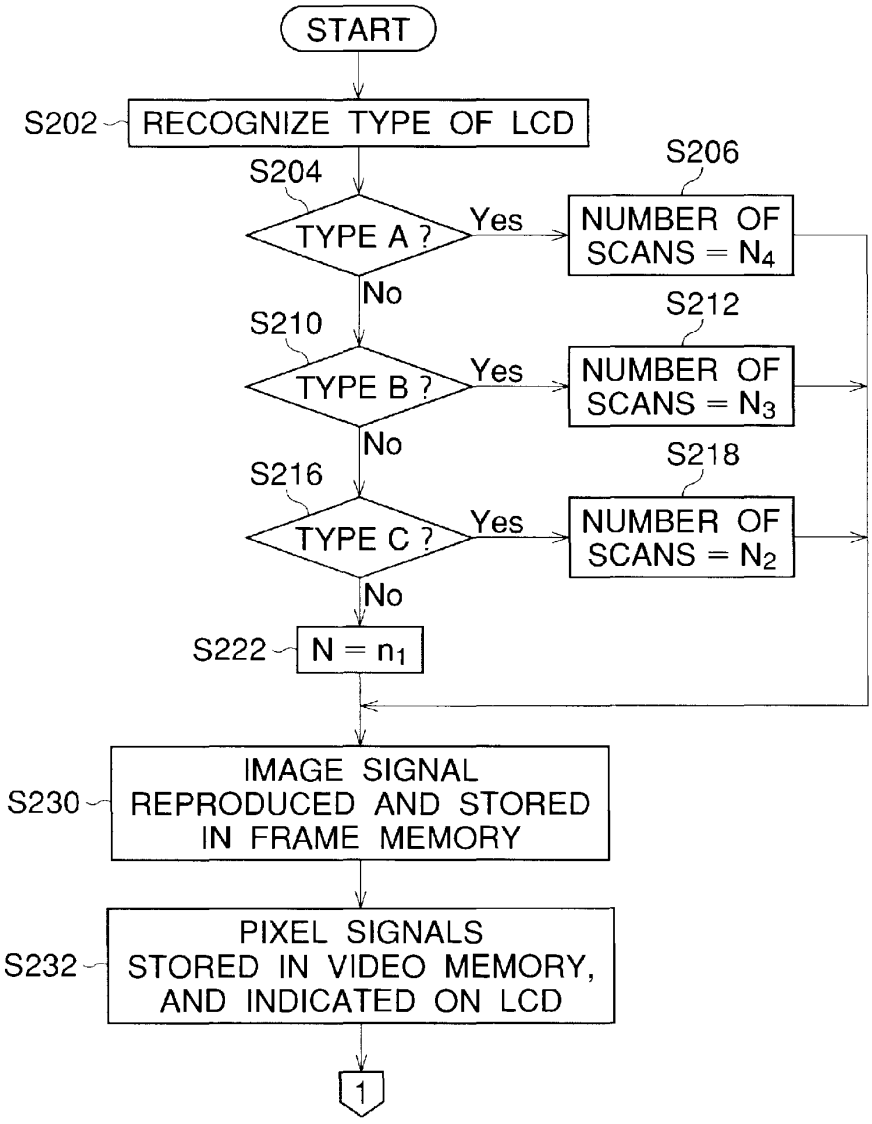

START
S202
RECOGNIZE TYPE OF LCD
S204
TYPE A ?
Yes
S206
NUMBER OF SCANS = N_4
No
S210
TYPE B ?
Yes
S212
NUMBER OF SCANS = N_3
No
S216
TYPE C ?
Yes
S218
NUMBER OF SCANS = N_2
No
S222
N = n_1
S230
IMAGE SIGNAL REPRODUCED AND STORED IN FRAME MEMORY
S232
PIXEL SIGNALS STORED IN VIDEO MEMORY, AND INDICATED ON LCD
1

IMAGE SIGNAL REPRODUCTION DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image reproduction device, which, based on an image signal outputted by a CCD, for example, reproduces and indicates an image on a display.

2. Description of the Related Art

Recently, an electronic camera, in which a CCD is mounted, has been developed. An image signal obtained by the electronic camera is usually compressed and recorded as image data on a recording medium. The compressed image signal is read from the recording medium, and then expanded or reproduced. The reproduced image signal is converted to a predetermined format, so that the image is indicated by an indicating device, such as a display.

In an image reproduction device, which reproduces an image from image data of a compressed image signal, a progressive method is utilized in which, after a rough image having a low resolution or gradation is reproduced, the resolution or gradation is gradually increased to a final resolution or gradation. Due to this method, when image data of a specified image is retrieved from an image data base, for example, the contents of the image can be recognized at an early stage since a rough image is indicated by a display.

However, if a full resolution of the image is greater than an indicating performance of the display, thus restricting the complete indication of the image, unnecessary image reproduction processing time is utilized in generating the full resolution image.

SUMMARY OF THE INVENTION

Therefore, an object of the invention is to provide an image reproduction device in which a resolution or gradation of an image can be changed in accordance with an indicating performance of a display.

According to the present invention, there is provided an image signal reproduction device comprising an image signal expansion processor, a display and a resolution setting processor.

The image signal expansion processor expands a compressed image signal to reproduce an image with a predetermined resolution. The display, which indicates the image, includes an inherent resolution which is a maximum permissible resolution. The resolution setting processor sets the predetermined resolution, which is incremented from a lower resolution to a higher resolution. The predetermined resolution set by the resolution setting processor is lower than or equal to the inherent resolution.

Further, according to the present invention, there is provided an image signal reproduction device comprising an image signal expansion processor for expanding a compressed image signal to reproduce an image with a predetermined resolution, a resolution setting processor incrementally setting the predetermined resolution to be lower than or equal to a maximum permissible resolution, and a display indicating the image, the display including an inherent resolution equal to the maximum permissible resolution.

Furthermore, according to the present invention, there is provided an image signal reproduction device comprising an image signal expansion processor, a display and a gradation setting processor.

The image signal expansion processor expands a compressed image signal to reproduce an image with a predetermined gradation. The display, which indicates the image, includes an inherent gradation which is a maximum permissible gradation. The gradation setting processor sets the predetermined gradation, which is incremented from a lower gradation to a higher gradation. The predetermined gradation set by the gradation setting processor is lower than or equal to the inherent gradation.

Further, according to the present invention, there is provided an image signal reproduction device comprising an image signal expansion processor for expanding a compressed image signal to reproduce an image with a predetermined gradation, a gradation setting processor incrementally setting the predetermined gradation to be lower than or equal to a maximum permissible gradation, and a display indicating the image, the display including an inherent gradation equal to the maximum permissible gradation.

Still further, according to the present invention, there is provided an image signal reproduction device comprising a display indicating an image, which is obtained by expanding a compressed image signal stepwisely from a lower resolution to a higher resolution, a resolution information outputting processor, a resolution selecting processor and an image signal expansion processor.

The resolution information outputting processor outputs resolution information which corresponds to resolutions of the image which can be indicated by the display. The resolution selecting processor selects one of the resolutions based on the resolution information. The image signal expansion processor expands the compressed image signal, and changes the amount of the compressed image signal, which is to be expanded, in accordance with the selected resolution.

Further, according to the present invention, there is provided an image signal reproduction device comprising a display indicating an image, which is obtained by expanding a compressed image signal stepwisely from a lower gradation to a higher gradation, a gradation information outputting processor, a gradation selecting processor and an image signal expansion processor.

The gradation information outputting processor outputs gradation information which corresponds to gradations of the image which can be indicated by the display. The gradation selecting processor selects one of the gradations based on the gradation information. The image signal expansion processor expands the compressed image signal, and changes the amount of the compressed image signal, which is to be expanded, in accordance with the selected gradation.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood from the description of the preferred embodiments of the invention set forth below, together with the accompanying drawings, in which:

FIG. **1** is a block diagram showing an electronic still camera having an image reproduction device to which a first embodiment of the present invention is applied;

FIG. **2** is a view schematically showing an image compression process;

FIG. **3** is a view showing a format with which encoded image data are recorded in a memory card;

FIG. **4** is a view schematically showing image data contained in all of the Scans;

FIG. **5** is a view schematically showing image data contained in Scan (**1**);

FIG. **6** is a view schematically showing image data contained in Scan (**2**);

FIG. **7** is a view schematically showing image data contained in Scan (**4**);

FIG. **8** is a view showing an image indicated by an LCD, when only the image signal corresponding to the image data of Scan (**1**) is reproduced;

FIG. **9** is a view showing an image indicated by the LCD when the image signal corresponding to the image data of Scans (**1**) and (**2**) is reproduced;

FIG. **10** is a view showing an image indicated by the LCD, when the image signal corresponding to the image data of all of the Scans is reproduced;

FIG. **11** is a view showing an operation of a CPU and a resolution recognition unit;

FIG. **12** is a timing chart showing clock pulses and recognition pulses;

FIG. **13** is a view showing a relationship between Number of Scans and a resolution of a reproduced image;

FIGS. **14**A and **14**B represent a flow chart of an image indicating process by which an image is indicated by the LCD;

FIG. **15** is a view schematically showing image data contained in all of the Scans, in a second embodiment;

FIG. **16** is a view schematically showing image data contained in Scan (**1**) of the second embodiment;

FIG. **17** is a view schematically showing image data contained in Scan (**2**) of the second embodiment;

FIG. **18** is a view schematically showing image data contained in Scan (x) of the second embodiment; and

FIG. **19** is a part of a flow chart of an image indicating process by which an image is indicated by the LCD, in the second embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be described below with reference to embodiments shown in the drawings.

FIG. **1** shows a block diagram of an electronic still camera **10** having an image reproduction device to which a first embodiment of the present invention is applied.

In the electronic still camera **10**, an optical image obtained by a photographing optical system (not shown) is formed on a light receiving surface of a CCD (charge coupled device) **11**, so that the optical image is photoelectrically-converted to an electric charge signal by the CCD **11**. The electric charge signal, which is an analog image signal, having been outputted from the CCD **11**, is converted by an A/D converter **12** to a digital image signal.

An image signal processing circuit **13** is provided for subjecting the digital image signal to various kinds of image processing. A frame memory **14**, provided for storing the digital image signal, is connected to a frame memory controller **15**, which is connected to the image signal processing circuit **13**. The digital image signal outputted from the A/D converter **12** is temporarily stored in the frame memory **14**, through the frame memory controller **15**, and is subsequently read from the frame memory **14**, to be compressed by the image signal processing circuit **13**.

A memory card **16** is provided for storing the compressed image signal as image data. The memory card **16** is connected to a memory card controller **17**, which is connected to the image signal processing circuit **13**. The image data are processed by the memory card controller **17**, so that the image data are converted to a predetermined format for the memory card **16**. Note that the memory card **16** can be detached from the electronic still camera **10**.

The image data stored in the memory card **16** are read therefrom, through the memory card controller **17**, and are expanded by the image signal processing circuit **13**. The expanded image data are stored in the frame memory **14**. Then, the expanded image data are read from the frame memory **14**, so that an image signal for monitoring is generated by the image signal processing circuit **13** in accordance with the expanded image data. The image signal for monitoring is stored in a video memory **18**.

The video memory **18** is connected to a video memory controller **19**, which is connected to the image signal processing circuit **13**. Thus, the image signal is stored in and read from the video memory **18**, through the video memory controller **19**. The image signal read from the video memory **18** is inputted into an LCD controller **21**, in which a synchronization signal is added to and an image signal processing, such as a gamma correction, is performed on the image signal, so that a video image signal is generated. The video image signal is then inputted into a display device **22** via an input terminal **23** provided in the display device **22**.

The display device **22** includes a liquid crystal display (LCD) **24** and a resolution recognition unit **25**, which is provided for recognizing an inherent resolution of the LCD **24**. The inherent resolution is a maximum permissible resolution of the LCD **24**.

An operation of the electronic still camera **10** is controlled by a microcomputer (CPU) **26**. A switch **27** is connected to the CPU **26** so that an operation of the electronic still camera **10** is controlled. The image signal processing circuit **13** is operated in accordance with a command signal outputted by the CPU **26**, and information regarding the image signal is transferred between the image signal processing circuit **13** and the CPU **26**. The CPU **26** is connected to the resolution recognition unit **25** via an input-output terminal **28** provided in the display device **22**, so that information regarding the resolution of the LCD **24** is transferred between the CPU **26** and the resolution recognition unit **25**.

The image compression process performed in the image signal processing circuit **13** is described below with reference to FIG. **2**.

An image of one frame F1 has 1280×960 pixels, for example, and is divided into a plurality of pixel blocks F2, each of which is composed of 8×8 pixels. A pixel value a_k ($1 \leqq k \leqq 64$) in the pixel block F2 corresponds to a luminance value or a color differential data of the pixel, and is a positive integer.

A discrete cosine transformation (DCT) or an orthogonal transformation is carried out for each pixel block F2, so that an image corresponding to the pixel block F2 is broken down into a plurality of spatial frequency components, and thus, DCT coefficients b_k are obtained. The greater the suffix "k", the higher the spatial frequency. The DCT coefficients b_k are arranged in a zigzag order, in a coefficient block F3, in such a manner that DCT coefficients corresponding to the lower spatial frequencies are located towards a top-left of the coefficient block F3, and DCT coefficients corresponding to the higher spatial frequencies are located towards a bottom-right of the coefficient block F3.

The DCT coefficients b_k are positive integers, and each of the DCT coefficients b_k is quantized by using a quantization table Q, containing 64 quantization coefficients, so that quantized DCT coefficients c_k are obtained, as shown by the reference F4. Usually, quantized DCT coefficients c_k corresponding to the lower spatial frequencies possess some values other than 0, whereas some quantized DCT coefficients c_k corresponding to the higher spatial frequencies are 0.

The quantized DCT coefficients c_k included in the block F4 are divided into a plurality of groups G1, G2, G3 and G4, in accordance with the spatial frequencies. The first group G1 contains the quantized DCT coefficients c_k of the lowest spatial frequencies, and the spatial frequencies increase in order of the second, third and fourth groups G2, G3 and G4.

The quantized DCT coefficients c_k, for each of the groups G1, G2, G3 and G4, are encoded, thus generating encoded image data for each of the groups G1, G2, G3 and G4, which are then recorded, with a predetermined format, in the memory card **16**. Thus, in this embodiment, a spectral selection system (i.e. s—s system), in which quantized DCT coefficients are encoded for every group, is utilized.

FIG. **3** shows the format with which the encoded image data are recorded in the memory card **16**. Each of the Scans corresponds to encoded image data obtained by encoding quantized DCT coefficients, included in each of the groups G1, G2, G3 and G4. Scan (**1**) includes the encoded image data of the group G1, the quantized DCT coefficients corresponding to the lowest spatial frequencies, and Scan (**4**) includes the encoded image data of the group G4, the quantized DCT coefficients corresponding to the highest spatial frequencies. A header is provided at a top portion of the encoded image data, enabling storage of various parameters.

The image expansion process, performed in the image signal processing circuit **13**, is described below with reference to FIGS. **4** through **10**. FIGS. **4** through **7** schematically show image data, and FIGS. **8** through **10** show images displayed by the LCD **24** (see FIG. **1**) during the expansion process.

As shown in FIG. **4**, the image data of one frame (reference F1 in FIG. **2**), divided, for example, into 8×8 pixel blocks, can be represented by, in this case, 64 spatial frequencies, following the determination of the DCT coefficients of the image data contained in each of the blocks. A degree of 1 corresponds to the lowest spatial frequency component of the DCT coefficients, which includes the quantized DCT coefficient c_1 (FIG. **2**). A degree of 2 corresponds to the second lowest spatial frequency component, which includes the quantized DCT coefficient c_2. A degree of 3 corresponds to the third lowest spatial frequency component, which includes the quantized DCT coefficient C_3. A degree of 64 corresponds to the highest spatial frequency component, which includes the quantized DCT coefficient c_{64}.

Initially, the encoded image data of Scan (**1**), which are obtained by encoding the quantized DCT coefficients of the degrees **1** through **6**, are read from the memory card **16**. Then, the image data corresponding to Scan (**1**) are expanded, and stored in the frame memory **14**. The expanded image data, for each of the blocks, are successively read from the frame memory **14**, and are processed by the image processing circuit **13** to reproduce an image signal, thus enabling an image, which has a lower resolution as shown in FIG. **8**, to be indicated on the LCD **24**.

Then, the encoded image data of Scan (**2**), which are obtained by encoding the quantized DCT coefficients of degrees **7** through **36**. are read from the memory card **16**. The image data corresponding to Scan (**2**) are expanded, and also stored in the frame memory **14**. The expanded image data corresponding to Scans (**1**) and (**2**), for each of the blocks, are read successively from the frame memory **14**, and are processed by the image processing circuit **13** to reproduce an image signal, enabling an image, which has a higher resolution than that shown in FIG. **8**, to be indicated on the LCD **24**, as shown in FIG. **9**.

Thus, when the image data corresponding to Scans (**1**), (**2**), (**3**) and (**4**) are reproduced for each of the blocks, an image, which has the highest resolution, is displayed on the LCD **24**, as shown in FIG. **10**.

In an expansion system described above, in which an image having a lower resolution is first reproduced and then the resolution is gradually increased, the expansion process may be performed more than is necessary, when the resolution of the LCD **24** (e.g. 640×480 pixels) is lower than that of the fully reproduced image signal (e.g. 1280×960 pixels), stored in the frame memory **14**. Namely, the expansion process becomes inefficient in terms of time and power consumption.

In this embodiment, the display device **22** has the resolution recognition unit **25**, so that the inherent resolution of the LCD **24** can be recognized by the CPU **26**, and thus an inefficient use of the expansion process is prevented.

With reference to FIG. **11**, an operation of the resolution recognition unit **25** is described below.

The resolution recognition unit **25** comprises a counter, to which clock pulses are inputted from the CPU **26**. Every time a predetermined number of clock pulses is received by the resolution recognition unit **25**, which performs a counting routine, a recognition pulse is outputted therefrom. The predetermined number of clock pulses is referred to as a count number hereinafter, being set in accordance with the performance (i.e. the inherent resolution) of the LCD **24** (see FIG. **1**).

FIG. **12** is a timing chart, showing the clock pulse, the recognition pulse, and time, which elapses from left to right. The clock pulse is continuously changed between a high level and a low level with a constant period. The resolution recognition unit **25** is operated in accordance with a rise of the clock pulse, i.e. when the clock pulse becomes high. The rise is indicated by references R1, R2 . . . R7, in FIG. **12**. Note that a period from a rise of the clock pulse to a next rise of the clock pulse is defined as the pulse spacing, T.

The count number is set in such a manner that, when the LCD **24** has the inherent resolution of 1280×960 pixels, i.e. when the LCD **24** is of a type A, the recognition pulse has a pulse spacing of 2T.

When the LCD **24** has the inherent resolution of 640×480 pixels, i.e. when the LCD **24** is of a type B, the period of the recognition pulse is 3T. When the LCD **24** has the inherent resolution of 320×240 pixels, i.e. when the LCD **24** is of a type C, the period of the recognition pulse is 4T. When the LCD **24** has the inherent resolution of 160×120 pixels, i.e. when the LCD **24** is of a type D, the period of the recognition pulse is 5T.

Thus, the resolution recognition unit **25** outputs the recognition pulse, which has a predetermined period corresponding to the inherent resolution, when the clock pulse is inputted therein. The recognition pulse is inputted into the CPU **26**, enabling the type of the LCD **24**, i.e. the inherent resolution of the LCD **24**, to be recognized. Therefore, a reproduction of the image can be performed by the image signal processing circuit **13** (see FIG. **1**), in accordance with the inherent resolution of the LCD **24**.

FIG. **13** shows a relationship between Number of Scans and the resolution of the reproduced image. The number of Scans (Scan (**1**), Scan (**2**), Scan (**3**), Scan (**4**)) to be reproduced and stored in the frame memory **14** (see FIG. **1**) is determined in accordance with the inherent resolution of the LCD **24**. In the case of the LCD **24** being of type D, which has the lowest inherent resolution, Number of Scans is N1, which is the least number of Scans (only Scan (**1**)) to be

reproduced. Number of Scans increases in order of N1, N2, N3 and N4, as the inherent resolution of the LCD **24** becomes higher. Namely, Number of Scans N4 corresponds to the greatest number of reproduced Scans, in the case of the LCD **24** being of type A. The capacity of the frame memory **14** is larger than or equal to the amount corresponding to N4.

When the image signal, stored in the frame memory **14**, is read therefrom and then stored in the video memory **18** (see FIG. **1**), some pixel signals are thinned or disregarded from the image signal, in accordance with the inherent resolution of the LCD **24**, except when the inherent resolution has a value greater than a predetermined value. In the context of this specification, "thinning" is a process of reading only every [thinning number +1]th pixel, i.e., the thinning number is the number of skipped or disregarded pixels (per pixel read). The number of thinned pixels becomes greater as the inherent resolution becomes lower. Namely, in the case of the LCD **24** being of type D (160×120 pixels), pixel signals are only stored in the video memory **18** on every eighth pixel (i.e. an eight pixel separation in both the horizontal and vertical directions of the image), so that an image having a satisfactory number of pixels, which conforms to the inherent resolution of the LCD **24**, is generated, and subsequently indicated by the LCD **24**, while the expanded image data, stored in the frame memory **14**, maintains the resolution of the original image signal, i.e., in this case, 1280×960 pixels. The reason is as follows: Since the inherent resolution of the LCD **24** is 160 ×120 pixels, only ⅛ of the pixels in both the horizontal direction and the vertical direction of the original 1280×960 pixel image (FIG. **2**, F1) can be indicated by the LCD **24**.

FIGS. **14**A and **14**B show a flow chart of an image indicating process by which an image is indicated by the LCD **24**. With reference to FIGS. **1**, **14**A and **14**B, the image indicating process is described.

In Step **S102**, the clock pulses are outputted from the CPU **26** and inputted to the resolution recognition unit **25**, in which the type of LCD **24** is determined, based on the recognition pulse outputted by the resolution recognition unit **25**. For example, when the recognition pulse has a pulse spacing of 4T, it is judged that the LCD **24** is of type C.

In Step **S104**, it is determined whether or not the LCD **24** is of type A. When the LCD **24** is of type A, Step **S106** is executed in which Number of Scans is set to N4, and Step **S108** is executed in which the thinning number is set to 0. Then, the process proceeds to Step **S130**.

Conversely, when it is determined in Step **S104** that the LCD **24** is not of type A, Step **S110** is executed. It is determined in Step **S110** whether or not the LCD **24** is of type B. When the LCD **24** is of type B, Number of Scans is set to N3 in Step **S112**, and the thinning number is set to 1 in Step **S114**. Then, Step **S130** follows.

When it is determined in Step **S110** that the LCD **24** is not of type B, the process goes to Step **S116**, in which it is determined whether or not the LCD **24** is of type C. When the LCD **24** is of type C, Number of Scans is set to N2 in Step **S118**, and the thinning number is set to 3 in Step **S120**. Then, the process goes to Step **S130**.

On the other hand, when it is determined in Step **S116** that the LCD **24** is not of type C, the LCD **24** should be of type D. Therefore, Number of Scans is set to N1 in Step **S122**, and the thinning number is set to 7 in Step **S124**. Then, Step **S130** is executed.

After Number of Scans (N1, N2, N3, N4) and the thinning are set in accordance with the type of the LCD **24**, Steps **S130** and **S132** are repeatedly executed in accordance with Number of Scans, i.e. the type of the LCD **24**.

Initially, Step **S130** is executed in which the compressed image signal, stored in the memory card **16** as image data, is expanded, based on Scan (**1**), to produce expanded image data, corresponding to the original image signal with a predetermined resolution, which is then stored in the frame memory **14**. In Step **S132**, pixel signals, included in the expanded image data now stored in the frame memory **14**, are thinned both in a horizontal direction and a vertical direction, in accordance with the thinning number corresponding to the LCD **24**, and the thinned lowered resolution reproduced image signal is then stored in the video memory **18**, so that an image is indicated on the LCD **24** in accordance with the pixel signals stored in the video memory **18**.

Subsequently, in Step **S130**, if Number of Scans is greater than N1, i.e. if the LCD **24** is a type other than type D, then the image data of Scan (**2**), corresponding to G2 of F4 in FIG. **2**, are expanded and stored, along with the expanded image data of Scan (**1**) (previously expanded in N1), in the frame memory **14**. Thus, in Step **S132**, the expanded image data of Scan (**1**) and Scan (**2**), corresponding to Number of Scans N2, are combined, thinned, in accordance with the thinning number corresponding to the LCD **24**, and stored in the video memory **18**, so that a slightly enhanced image is indicated on the LCD **24**, in accordance with the thinned lowered resolution reproduced image signal stored in the video memory **18**.

Further, in Step **S130**, if Number of Scans is greater than N2, i.e. if the LCD **24** is type B or type A, then the image data of Scan (**3**), corresponding to G3 of F4 in FIG. **2**, are expanded and stored, along with the expanded image data of Scan (**1**) (previously expanded in N1) and the expanded image data of Scan (**2**) (previously expanded in N2), in the frame memory **14**. Thus, in Step **S132**, the expanded image data of Scan (**1**), Scan (**2**) and Scan (**3**), corresponding to Number of Scans N3, are combined, thinned, in accordance with the thinning number corresponding to the LCD **24**, and stored in the video memory **18**, so that a further enhanced image is displayed at the LCD **24**, in accordance with the thinned lowered resolution reproduced image signal stored in the video memory **18**.

In Step **S130**, if Number of Scans is greater than N3, i.e. if the LCD **24** is type A, then the image data of Scan (**4**), corresponding to G4 of F4 in FIG. **2**, are expanded and stored, along with the previously expanded and stored image data of Scan (**1**), Scan (**2**) and Scan (**3**), in the frame memory **14**. Thus, in Step **S132**, the expanded image data of Scan (**1**), Scan (**2**), Scan (**3**) and Scan (**4**), corresponding to Number of Scans N4, are combined and stored in the video memory **18**, so that a full resolution image, being equal to the maximum resolution of the type A display, is indicated on the LCD **24**.

Therefore, this method permits an original high resolution image to be efficiently indicated on a variety of displays, of varying inherent resolutions, and provides a "quick-search" option in accessing a specific image from a plurality of stored images.

In Step **S134**, if the original image has a higher resolution than that of Number of Scans, the image data of a Scan subsequent to the final Scan of the set Number of Scans are expanded and also stored in the frame memory **14**. As shown in FIGS. **3** through **7**, when the quantized DCT coefficients included in the block F4 are divided into four groups and Number of Scans is set as N4, nothing is performed in Step **S134**. Conversely, when the quantized DCT coefficients are

divided into more than four groups or Number of Scans is set as less than N4, the image data of a subsequent Scan, which would be disregarded in Steps S130 and S132, are processed in Step S134.

In Step S136, since the expanded image data now stored in frame memory 14 correspond to an image of higher resolution than the inherent resolution of the LCD 24, it is determined whether or not a part of the expanded image data are to be thinned, thereby producing an enlargement of a part of the original image which may be indicated on the LCD 24. When a part of the image is not to be indicated, this program ends, with. the image corresponding to Number of Scans N1, N2, N3 or N4 being displayed. Conversely, when a part of the image is to be indicated, Step S138 is executed in which the part of the image is designated using a mouse or cursor on the LCD 24, for example. In Step S140, the image data corresponding to the designated part are read from the frame memory 14, thinned, in accordance with a thinning number corresponding to the LCD 24, and stored in the video memory 18, so that the enlarged part of the image is indicated on the LCD 24. Thus, this program ends.

As described above, in the first embodiment, since the display device 22 outputs a recognition pulse, indicating the inherent resolution of the LCD 24, in response to a clock pulse outputted by the CPU 26, the inherent resolution can be easily recognized by the CPU 26. Therefore, the CPU 26 can increment a resolution, with which the image is to be reproduced by the LCD 24, from a lower resolution to a higher resolution, which is lower than or equal to the inherent resolution. As as result, unnecessary image reproduction processing is eliminated, and time wastage is prevented in the reproduction process. Further, if necessary, a part of the image can be enlarged and indicated on the LCD 24.

A second embodiment of the present invention will be described below with reference to FIGS. 15 through 19. An electrical construction of the second embodiment is substantially the same as that shown in FIG. 1 except that the resolution recognition unit 25 is replaced by a gradation recognition unit 25'. The image compression process performed in the image signal processing circuit 13 is similar to that shown in FIG. 2. However, in the second embodiment, a gradation of an image is increased step by step when the image data are successively expanded, as opposed to the resolution of an image being successively increased step by step in the first embodiment.

The gradation of an image depends upon a number of bits by which the image signal is expressed. For example, as for an 8 bit image signal, the luminance range is divided into 256 ($=2^8$) levels. When an image signal of 8 bits is compressed, the gradation is expressed by an 8-digit binary code. In FIG. 15, the rightmost bit (0) is the least significant bit (LSB), and the leftmost bit (7) is the most significant bit (MSB). The MSB of the DCT coefficient corresponds to the crudest gradation of an image signal, and the LSB of the DCT coefficient corresponds to the finest gradation of an image signal.

In this embodiment, the image signal is treated for each bit. Namely, Scan (1) (see FIG. 3) corresponds to image data obtained by encoding the high-order bits of the DCT coefficients including the MSB. The last Scan (x) corresponds to image data obtained by encoding the low-order bits of the DCT coefficients including the LSB. Namely, the image signal is compressed for each of the bits, with regards to all of the spatial frequencies, from the most significant bit to the least significant bit. Thus, in the second embodiment, a successive approximation system (i.e. s-a system), in which quantized DCT coefficients are encoded sequentially from the MSB to the LSB, is utilized.

When the compressed image signal is reproduced, the image data of Scan (1) are read. Then, the image data, corresponding to only Scan (1) and including the MSB, are expanded, and the expanded image data are stored in the frame memory 14 (see FIG. 1). Thus, the image corresponding to Scan (1) is indicated on the display device 22 (see FIG. 1).

Then, the image data of Scan (2) are expanded, so that the expanded image data corresponding to Scan (2) are stored in the frame memory 14, in addition to the expanded image data of Scan (1). Namely, the image corresponding to Scans (1) and (2), which has a gradation finer than the image corresponding to only Scan (1), is indicated on the display device 22. Thus, when the image data of Scan (x) are expanded, the image having the highest gradation can be obtained.

Here, it is supposed that there are four kinds of LCDs, i.e. a type A, a type B, a type C and a type D, where the gradations of the LCDs of the types A, B, C and D, correspond to 8 bits, 6 bits, 4 bits and 2 bits, respectively. Number of Scans (N1, N2, N3 and N4) for each of the LCDs is determined in accordance with the gradations. Namely, similarly to that shown in FIG. 13, Number of Scans increases in order from N1 to N4, and corresponds to the LCD types D, C, B and A, respectively.

The operation, by which the CPU 26 (see FIG. 1) recognizes the type of the LCD, is the same as that of the first embodiment (see FIGS. 11 and 12). Namely, when the display device 22 is provided with the LCD 24 of the type B, a recognition pulse having a pulse spacing of 3T is outputted from the resolution recognition unit 25 to the CPU 26, in response to a clock pulse outputted by the CPU 26. The CPU 26 recognizes, based on the recognition pulse, that the LCD 24 is of type B, i.e. that the gradation of the LCD 24 is 6 bits, so that Number of Scans N3 is selected by the CPU 26. In the image signal processing circuit 13, image data, to a bit value corresponding to Number of Scans N3, are expanded and stored in the frame memory 14, so that 6 bit expanded image data are produced. Thus, an image signal of one image is recorded in the video memory 18 and is outputted to the LCD controller 21, so that the image is indicated on the LCD 24.

FIG. 19 shows a flow chart of an image indicating process by which an image is indicated by the LCD 24, the flow chart corresponding to FIG. 14A of the first embodiment. "100" is added to each of the reference numerals corresponding to that of FIG. 14A. The content of each Step is basically the same as that shown in FIG. 14A, except that, in Step S232, pixel signals are not thinned.

Similar to the first embodiment, according to the second embodiment, since the display device 22 outputs a recognition pulse, indicating the inherent gradation of the LCD 24, in response to a clock pulse outputted by the CPU 26, the inherent gradation can be easily recognized by the CPU 26. Therefore, only the image data of the Scans (i.e. Scan (1), Scan (2), . . . Scan (x) of FIGS. 16 through 18) necessary to reproduce the image to the required number of bits or to the maximum number of bits of the LCD 24 can be expanded, and thus, unnecessary image reproduction processing is eliminated, enabling prevention of time wastage in the reproduction process.

Although the embodiments of the present invention have been described herein with reference to the accompanying

drawings, obviously many modifications and changes may be made by those skilled in this art without departing from the scope of the invention.

The present disclosure relates to subject matter contained in Japanese Patent Application No. 9-92957 (filed on Mar. 27, 1997) which is expressly incorporated herein, by reference, in its entirety.

What is claimed is:

1. An image signal reproduction device connectible to a plurality of displays, said image signal reproduction device comprising:

an image signal expansion processor for expanding a compressed image signal from a lower resolution to a higher resolution of said image, said image signal expansion processor converting said compressed image signal to a decompressed image signal;

a display connection through which an inherent resolution of a display connectible to the display connection is transmitted from the display to the image signal reproduction device, a plurality of different inherent resolutions being capable of being transmitted via said display connection;

a resolution setting processor that checks the display connection and sets a predetermined resolution lower than or equal to the transmitted inherent resolution; and

an image signal reproduction circuit that controls said image signal expansion processor to expand said compressed image signal until a decompression corresponding to said predetermined resolution is reached and reproduces said image at said predetermined resolution so that each display connectible to the display connection, when connected thereto, displays said image at a predetermined resolution lower than or equal to the connected display's inherent resolution.

2. An image signal reproduction device according to claim 1, wherein said compressed image signal is obtained by processing original image data with a discrete cosine transformation, so that the original image data are broken down into spatial frequency components which are DCT coefficients, quantizing said DCT coefficients to generate quantized DCT coefficients, dividing said quantized DCT coefficients into a plurality of groups, and encoding said quantized DCT coefficients for each of said groups.

3. An image signal reproduction device according to claim 2, where in said image signal expansion processor expands said compressed image signal for each of said groups, in such a manner that images are reproduced successively from a low resolution image to a high resolution image.

4. An image signal reproduction device according to claim 1, wherein said display comprises an information output processor outputting information indicating said inherent resolution, and said resolution setting processor recognizes said inherent resolution in accordance with said information transmitted through the display connection.

5. An image signal reproduction device according to claim 4, wherein said resolution setting processor outputs a clock pulse of a constant period, and said information output processor outputs said information in association with said clock pulse.

6. An image signal reproduction device according to claim 1, wherein said display is connected to an electronic camera.

7. An image signal reproduction device connectible to a plurality of displays, said image signal reproduction device comprising:

an image signal expansion processor for expanding a compressed image signal from a lower resolution to a higher resolution of said image, said image signal expansion processor converting said compressed image signal to a decompressed image signal;

a display connection through which a maximum displayable resolution of a display connectible to the display connection is transmitted from the display to the image signal reproduction device, a plurality of different maximum displayable resolutions being capable of being transmitted via said display connection;

a resolution setting processor that checks the display connection and incrementally sets a predetermined resolution lower than or equal to the transmitted maximum displayable resolution; and

an image signal reproduction circuit that controls said image signal expansion processor to expand said compressed image signal until a decompression corresponding to said predetermined resolution is reached and reproduces said image at said predetermined resolution so that each display connectible to the display connection, when connected thereto, displays said image at a predetermined resolution lower than or equal to the connected display's maximum displayable resolution.

8. An image signal reproduction device connectible to a plurality of displays, said image signal reproduction device comprising:

an image signal expansion processor for expanding a compressed image signal from a coarser gradation to a finer gradation of said image, said image signal expansion processor converting said compressed image signal to a decompressed image signal;

a display connection through which an inherent gradation of a display connectible to the display connection is transmitted from the display to the image signal reproduction device, a plurality of different inherent gradations being capable of being transmitted via said display connection;

a gradation setting processor that checks the display connection and sets a predetermined gradation coarser than or equal to the transmitted inherent gradation; and

an image signal reproduction circuit that stops said expansion by said image signal expansion processor at a step corresponding to said predetermined gradation and reproduces said image at said predetermined gradation so that each display connectible to the display connection, when connected thereto, displays said image at a predetermined gradation coarser than or equal to the connected display's inherent gradation.

9. An image signal reproduction device according to claim 8, wherein said compressed image signal is obtained by processing original image data with a discrete cosine transformation, so that the original image data are broken down into spatial frequency components which are DCT coefficients, quantizing said DCT coefficients to generate quantized DCT coefficients, dividing said quantized DCT coefficients into a plurality of groups, and encoding said quantized DCT coefficients for each of said groups.

10. An image signal reproduction device according to claim 9, wherein said image expansion processor expands said compressed image signal for each of said groups, in such a manner that images are reproduced successively from a crude gradation image to a fine gradation image.

11. An image signal reproduction device according to claim 8, wherein said display comprises an information

output processor outputting information indicating said inherent gradation, and said gradation setting processor recognizes said inherent gradation in accordance with said information.

12. An image signal reproduction device according to claim 11, wherein said gradation setting processor outputs a clock pulse of a constant period, and said information output processor outputs said information in association with said clock pulse.

13. An image signal reproduction device according to claim 11, wherein said display is connected to an electronic camera.

14. An image signal reproduction device connectible to a plurality of displays, said image signal reproduction device comprising:

an image signal expansion processor for expanding a compressed image signal from a coarser gradation to a finer gradation of said image, said image signal expansion processor converting said compressed image signal to a decompressed image signal;

a display connection through which a maximum displayable gradation of a display connectible to the display connection is transmitted from the display to the image signal reproduction device, a plurality of different maximum displayable gradations being capable of being transmitted via said display connection;

a gradation setting processor that checks the display connection and incrementally sets a predetermined gradation coarser than or equal to the transmitted maximum displayable gradation; and

an image signal reproduction circuit that stops said expansion by said image signal expansion processor at a step corresponding to said predetermined gradation and reproduces said image at said predetermined gradation so that each display connectible to the display connection, when connected thereto, displays said image at a predetermined gradation coarser than or equal to the connected display's maximum displayable gradation.

15. An image signal reproduction system comprising:

a display indicating an image, which is obtained by expanding a compressed image signal, said display including a resolution information outputting processor outputting resolution information which corresponds to resolutions which said display is capable of displaying; and

an image signal reproduction device, comprising:

a display connection through which said resolution information is transmitted from the resolution information outputting processor of the display to the image signal reproduction device, a plurality of different resolutions being capable of being transmitted via said resolution information via said display connection;

a resolution selecting processor that checks the display connection and selects one of said resolutions based on said resolution information output by said resolution information outputting processor and transmitted through the display connection;

an image signal expansion processor expanding said compressed image signal, said image signal expansion processor changing the amount of said compressed image signal to be expanded in accordance with the selected resolution by expanding said compressed image signals from a lower resolution to a higher resolution of said image, said image signal expansion processor converting said compressed image signal to a decompressed image signal; and

an image signal reproduction circuit that controls said image signal expansion processor to expand said compressed image signal until a decompression corresponding to said selected resolution is reached and reproduces said image at said selected resolution so that the display connected to the display connection displays said image at the selected resolution selected from said resolution information, transmitted through said display connection, which corresponds to said resolutions which said display is capable of displaying.

16. An image signal reproducing device according to claim 15, wherein said image signal expansion processor comprises:

a first image processor generating a reproduced image signal, said first image processor dividing said compressed image signal, which has been obtained by orthogonally-converting a first image signal and arranging the orthogonally-converted image signal in an order depending on spatial frequency, into a plurality of groups from a lower spatial frequency to a higher spatial frequency, and expanding said compressed image signal contained in said groups while changing a number of said groups in accordance with said resolution of said image which can be indicated by said display, so that said reproduced image signal is generated; and

a second image processor generating a final image signal, said second image processor thinning a predetermined number of pixels, in accordance with said resolution of said image which can be indicated by said display, from said reproduced image signal, to generate said final image signal, which is indicated by said display.

17. An image signal reproducing device according to claim 16, wherein said first image processor performs an expansion process sequentially from a group corresponding to said lower spatial frequency to a group corresponding to said higher spatial frequency, and, as a resolution of said display decreases, changes the group to which said expansion is performed to the other group corresponding to a lower spatial frequency and decreases the number of said groups to which said expansion is performed.

18. An image signal reproduction system comprising:

a display indicating an image, which is obtained by expanding a compressed image signal, said display including a gradation information outputting processor outputting gradation information which corresponds to gradations which said display is capable of displaying; and

an image signal reproduction device, comprising:

a display connection through which said gradations information is transmitted from the gradation information outputting processor in the display to the image signal reproduction device, a plurality of different gradations being capable of being transmitted via said gradation information via said display connection;

a gradation selecting processor that checks the display connection and selects one of said gradations based on said gradation information output by said gradation information outputting processor and transmitted through the display connection;

an image signal expansion processor expanding said compressed image signal, said image signal expansion processor changing the amount of said compressed image signal to be expanded in accordance with the selected gradation by expanding said compressed image signals from a coarser gradation to a finer

gradation of said image, said image signal expansion processor converting said compressed image signal to a decompressed image signal; and

an image signal reproduction circuit that stops said expansion by said image signal expansion processor at a decompression corresponding to said selected gradation and reproduces said image at said selected gradation so that the display connected to the display connection displays said image at the selected gradation selected from said gradation information, transmitted through said display connection, which corresponds to said gradations which said display is capable of displaying.

19. An image signal reproducing device according to claim **18**, wherein said image signal expansion processor comprises:

a first image processor generating a reproduced image signal, said first image processor dividing said compressed image signal, which has been obtained by orthogonally-converting a first image signal and arranging the orthogonally-converted image signal in an order depending on spatial frequency, into a plurality of groups from a lower spatial frequency to a higher spatial frequency, and expanding said compressed image signal contained in said groups while changing a number of said groups in accordance with said gradation of said image which can be indicated by said display, so that said reproduced image signal is generated; and

a second image processor generating a final image signal, said second image processor thinning a predetermined number of luminance bits per pixel, in accordance with said gradation of said image which can be indicated by said display, from said reproduced image signal, to generate said final image signal, which is indicated by said display.

20. An image signal reproducing device according to claim **19**, wherein said first image processor performs an expansion process sequentially from a group corresponding to said lower spatial frequency to a group corresponding to said higher spatial frequency, and, as a gradation of said display decreases, changes the group to which said expansion is performed to the other group corresponding to a lower spatial frequency and decreases the number of said groups to which said expansion is performed.

21. An image signal reproduction system comprising:

a memory storing a compressed image as a plurality of scans arranged from a lower spatial frequency to a higher spatial frequency, said image having a predetermined image resolution;

a display device outputting at least one predetermined display resolution that said display is capable of displaying and that is less than said predetermined image resolution; and

an image signal reproduction device comprising:

a display connection through which the at least one predetermined display resolution, output by the display device, is transmitted from the display device to the image signal reproduction device;

a resolution setting processor that checks the display device and receives said at least one predetermined display resolution output from the display device, said resolution setting processor being capable of checking and receiving a plurality of different display resolutions from the display device;

an image signal expansion processor that reads said at least one predetermined display resolution of said display device output by the display device and transmitted through the display connection and that expands said compressed image signal by expanding a number of scans at least one less than a total number of said plurality of scans, said expanded number of scans being sufficient to form an image of said at least one predetermined display resolution, said image signal expansion processor further converting said expanded number of scans into an image signal of said at least one predetermined display resolution and said display indicating said image signal at said at least one predetermined display resolution, so that the display connected to the display connection displays said image at the received at least one predetermined display resolution, transmitted to said resolution setting processor, that is less than said predetermined image resolution.

22. An image signal reproduction system comprising:

a memory storing a compressed image as a plurality of scans arranged from a lower spatial frequency to a higher spatial frequency, said image having a predetermined image gradation;

a display device outputting at least one predetermined display gradation that said display is capable of displaying and that is less than said predetermined image gradation; and

an image signal reproduction device comprising:

a display connection through which the at least one predetermined display gradation, output by the display device, is transmitted from the display device to the image signal reproduction device;

a resolution setting processor that checks the display device and receives said at least one predetermined display gradation output from the display device, said resolution setting processor being capable of checking and receiving a plurality of different display gradations;

an image signal expansion processor that reads said at least one predetermined display gradation of said display device output by the display device and transmitted through the display connection and that expands said compressed image signal by expanding a number of scans at least one less than a total number of said plurality of scans, said expanded number of scans being sufficient to form an image of said at least one predetermined display gradation, said image signal expansion processor further converting said expanded number of scans into an image signal of said at least one predetermined display gradation and said display indicating said image signal at said at least one predetermined display gradation, so that the display connected to the display connection displays said image at the received at least one predetermined display gradation, transmitted to said resolution setting processor, that is less than said predetermined image gradation.

* * * * *

EXHIBIT 1020

US006018363A

United States Patent [19]

Horii

[11] Patent Number: 6,018,363

[45] Date of Patent: *Jan. 25, 2000

[54] **IMAGE SENSING APPARATUS WITH OPTICAL-AXIS DEFLECTING DEVICE**

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[73] Assignee: **Canon Kabushiki Kaisha**, Japan

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/426,834**

[22] Filed: **Apr. 24, 1995**

[30] **Foreign Application Priority Data**

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May 20, 1994 [JP] Japan 6-106645
May 20, 1994 [JP] Japan 6-106646

[51] **Int. Cl.**[7] **H04N 5/225**; H04N 5/335; H04N 5/228

[52] **U.S. Cl.** **348/219**; 348/220; 348/222; 348/279; 348/335; 348/369

[58] **Field of Search** 348/207, 208, 348/219–220, 222, 224, 228, 229, 230, 264, 266, 270, 271, 272, 273, 274, 275, 276, 277, 279, 335, 344, 369, 340, 343; H04N 5/225, 9/07, 5/335, 5/228

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Primary Examiner—Tuan Ho
Assistant Examiner—Ngoc-Yen Vu
Attorney, Agent, or Firm—Fitzpatrick, Cella, Harper & Scinto

[57] **ABSTRACT**

An image taking apparatus includes an image taking sensor **10** having a high-resolution mode and a normal mode; synchronous signal generators **7** and **8** for generating synchronous signals corresponding to the high-resolution mode and the ordinary mode, respectively; a first memory **17** for storing image signals taken in the high-resolution mode; a second memory **35** for storing image signals taken in the normal mode; and a video signal encoder **33** for processing the image signals stored in the second memory **35** in accordance with a predetermined image signal system, wherein, in the high-resolution mode, image signals are stored in the first memory **17** to output digital image signals, and, in the normal mode, image signals are stored in the second memory **35**, video signals **34** being output from the encoder **33**.

8 Claims, 18 Drawing Sheets

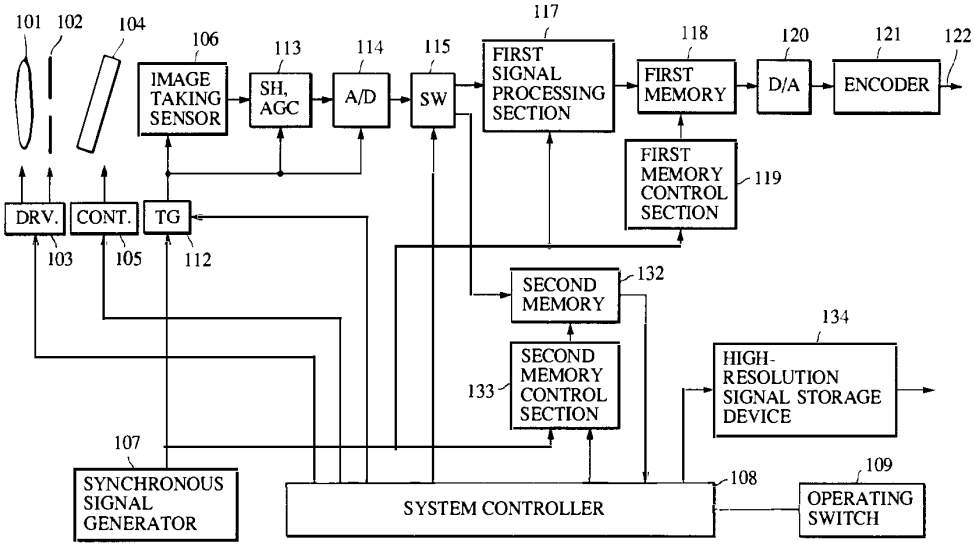


FIG. 1

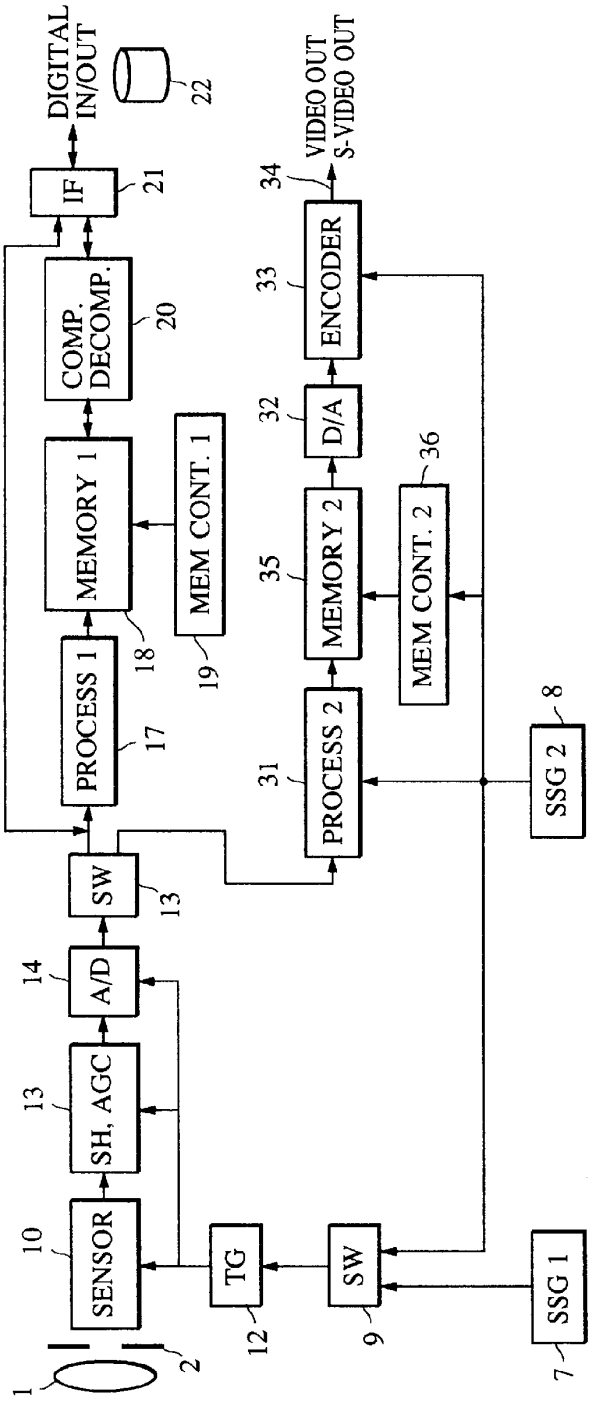

DIGITAL IN/OUT
22
IF
21
COMP. DECOMP.
20
MEMORY 1
18
MEM CONT. 1
19
PROCESS 1
17
SW
13
A/D
14
SH, AGC
13
SENSOR
10
TG
12
SW
9
SSG 1
7
SSG 2
8
PROCESS 2
31
MEMORY 2
35
MEM CONT. 2
36
D/A
32
ENCODER
33
VIDEO OUT
S-VIDEO OUT
34
1
2

FIG. 2

Cy	Ye	Cy	Ye	Cy	Ye	Cy	Ye
Gr	Mg	Gr	Mg	Gr	Mg	Gr	Mg
Cy	Ye	Cy	Ye	Cy	Ye	Cy	Ye
Mg	Gr	Mg	Gr	Mg	Gr	Mg	Gr
Cy	Ye	Cy	Ye	Cy	Ye	Cy	Ye
Gr	Mg	Gr	Mg	Gr	Mg	Gr	Mg
Cy	Ye	Cy	Ye	Cy	Ye	Cy	Ye
Mg	Gr	Mg	Gr	Mg	Gr	Mg	Gr

FIG. 3

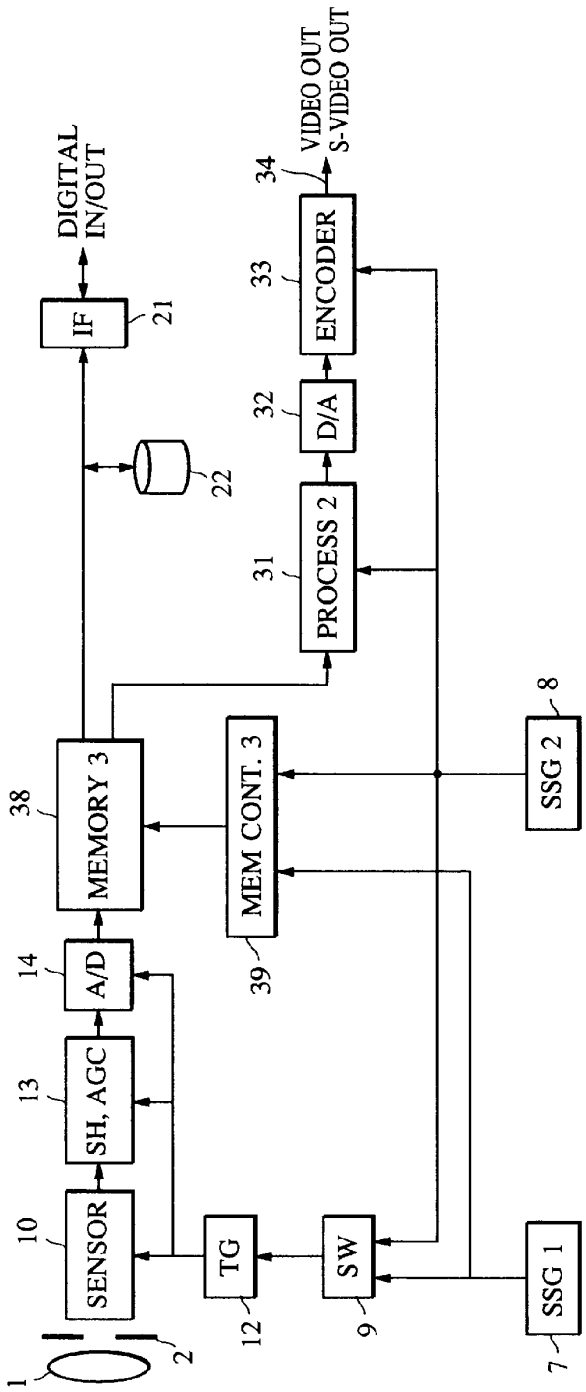

1
2
SENSOR
10
SH, AGC
13
A/D
14
MEMORY 3
38
TG
12
SW
9
SSG 1
7
MEM CONT. 3
39
SSG 2
8
PROCESS 2
31
D/A
32
ENCODER
33
34
VIDEO OUT
S-VIDEO OUT
IF
21
DIGITAL
IN/OUT
22

FIG. 4

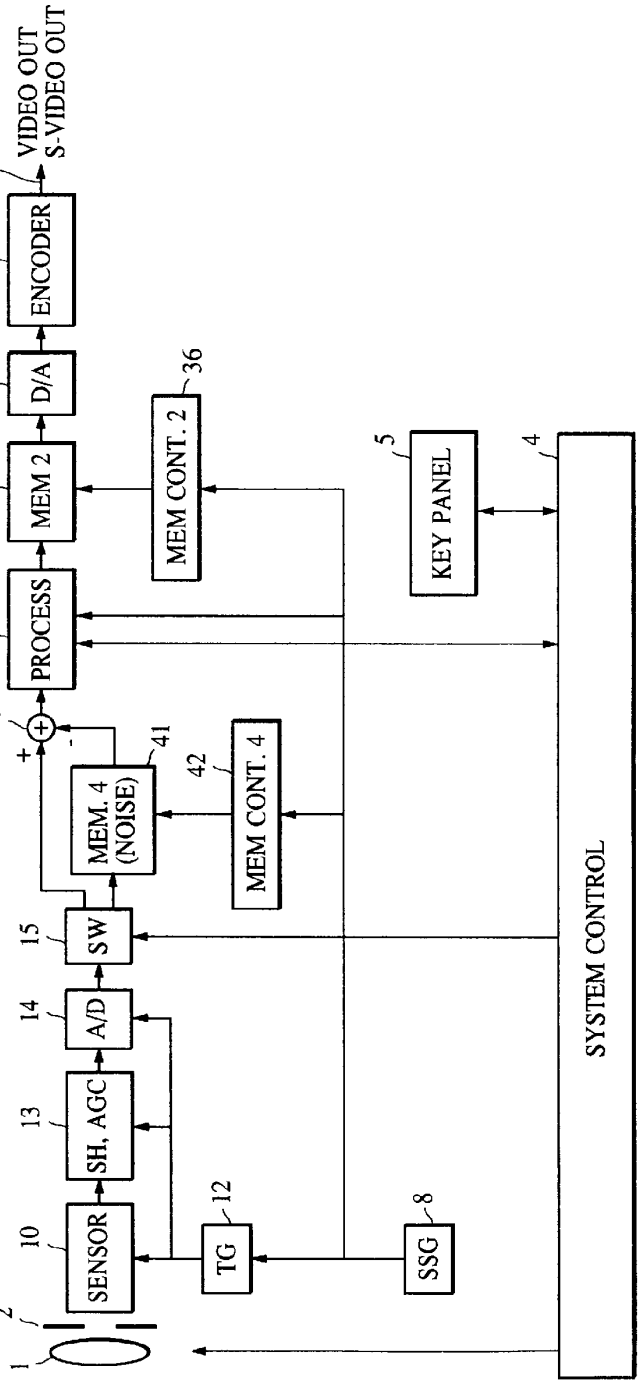

VIDEO OUT
S-VIDEO OUT
ENCODER
D/A
MEM 2
PROCESS
MEM CONT. 2
KEY PANEL
SYSTEM CONTROL
MEM. 4 (NOISE)
MEM CONT. 4
SW
A/D
SH, AGC
SENSOR
TG
SSG
1
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FIG. 5

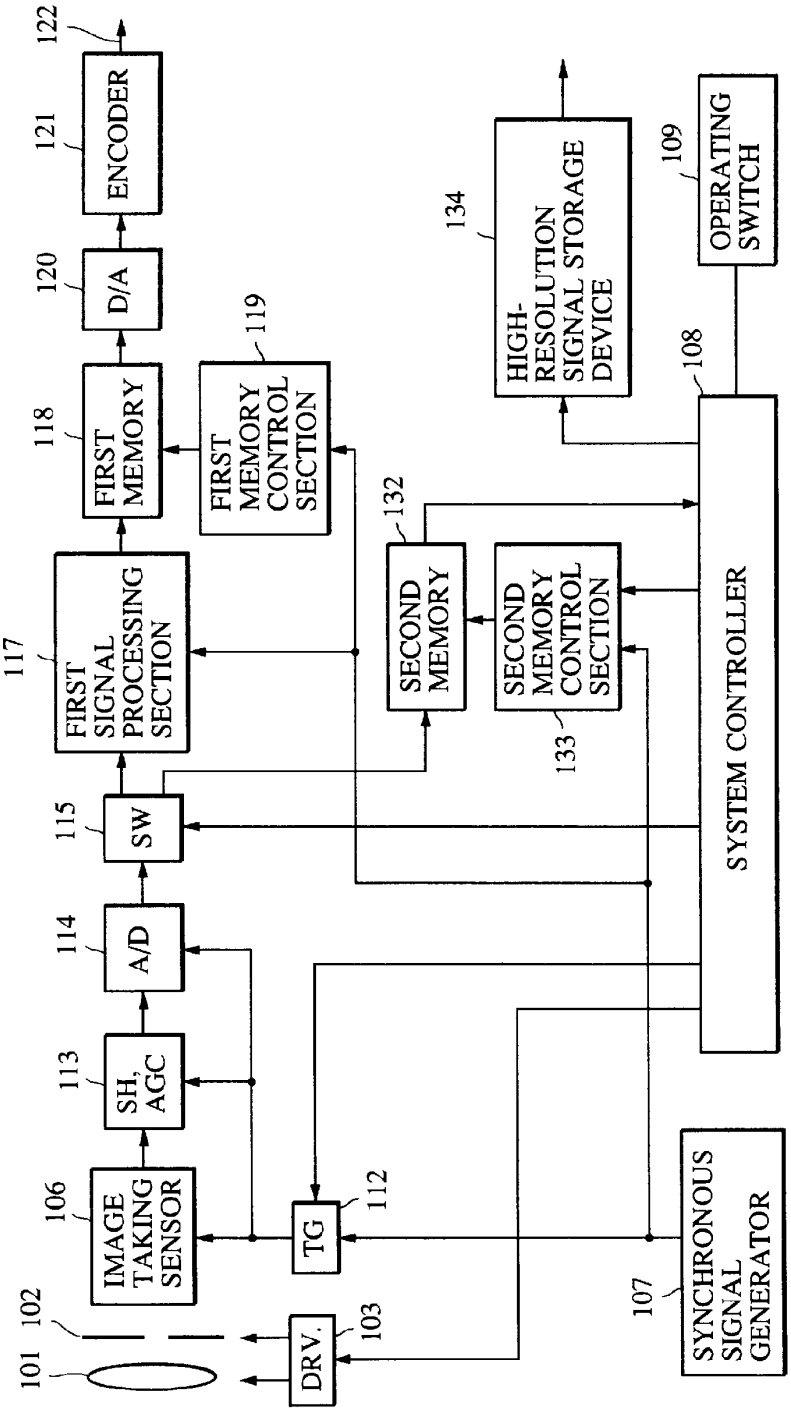

101
102
DRV.
103
IMAGE TAKING SENSOR
106
TG
112
SH, AGC
113
A/D
114
SW
115
FIRST SIGNAL PROCESSING SECTION
117
FIRST MEMORY
118
FIRST MEMORY CONTROL SECTION
119
D/A
120
ENCODER
121
122
SECOND MEMORY
132
SECOND MEMORY CONTROL SECTION
133
HIGH-RESOLUTION SIGNAL STORAGE DEVICE
134
SYSTEM CONTROLLER
108
OPERATING SWITCH
109
SYNCHRONOUS SIGNAL GENERATOR
107

FIG. 6

$Cy_{1,1}$	$Ye_{2,1}$	$Cy_{3,1}$	$Ye_{4,1}$	$Cy_{5,1}$	$Ye_{6,1}$	$Cy_{7,1}$	$Ye_{8,1}$
$Gr_{1,2}$	$Mg_{2,2}$	$Gr_{3,2}$	$Mg_{4,2}$	$Gr_{5,2}$	$Mg_{6,2}$	$Gr_{7,2}$	$Mg_{8,2}$
$Cy_{1,3}$	$Ye_{2,3}$	$Cy_{3,3}$	$Ye_{4,3}$	$Cy_{5,3}$	$Ye_{6,3}$	$Cy_{7,3}$	$Ye_{8,3}$
$Mg_{1,4}$	$Gr_{2,4}$	$Mg_{3,4}$	$Gr_{4,4}$	$Mg_{5,4}$	$Gr_{6,4}$	$Mg_{7,4}$	$Gr_{8,4}$
$Cy_{1,5}$	$Ye_{2,5}$	$Cy_{3,5}$	$Ye_{4,5}$	$Cy_{5,5}$	$Ye_{6,5}$	$Cy_{7,5}$	$Ye_{8,5}$
$Gr_{1,6}$	$Mg_{2,6}$	$Gr_{3,6}$	$Mg_{4,6}$	$Gr_{5,6}$	$Mg_{6,6}$	$Gr_{7,6}$	$Mg_{8,6}$
$Cy_{1,7}$	$Ye_{2,7}$	$Cy_{3,7}$	$Ye_{4,7}$	$Cy_{5,7}$	$Ye_{6,7}$	$Cy_{7,7}$	$Ye_{8,7}$
$Mg_{1,8}$	$Gr_{2,8}$	$Mg_{3,8}$	$Gr_{4,8}$	$Mg_{5,8}$	$Gr_{6,8}$	$Mg_{7,8}$	$Gr_{8,8}$

FIG. 7

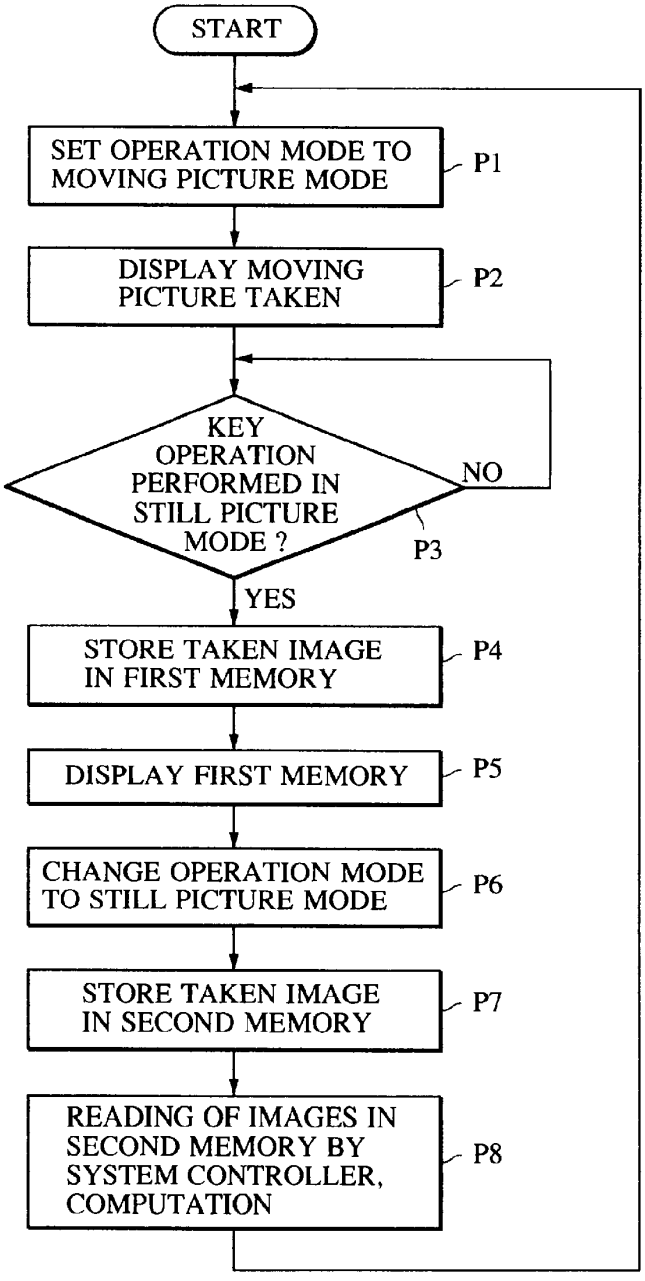

START
SET OPERATION MODE TO MOVING PICTURE MODE
P1
DISPLAY MOVING PICTURE TAKEN
P2
KEY OPERATION PERFORMED IN STILL PICTURE MODE ?
NO
P3
YES
STORE TAKEN IMAGE IN FIRST MEMORY
P4
DISPLAY FIRST MEMORY
P5
CHANGE OPERATION MODE TO STILL PICTURE MODE
P6
STORE TAKEN IMAGE IN SECOND MEMORY
P7
READING OF IMAGES IN SECOND MEMORY BY SYSTEM CONTROLLER, COMPUTATION
P8

FIG. 8

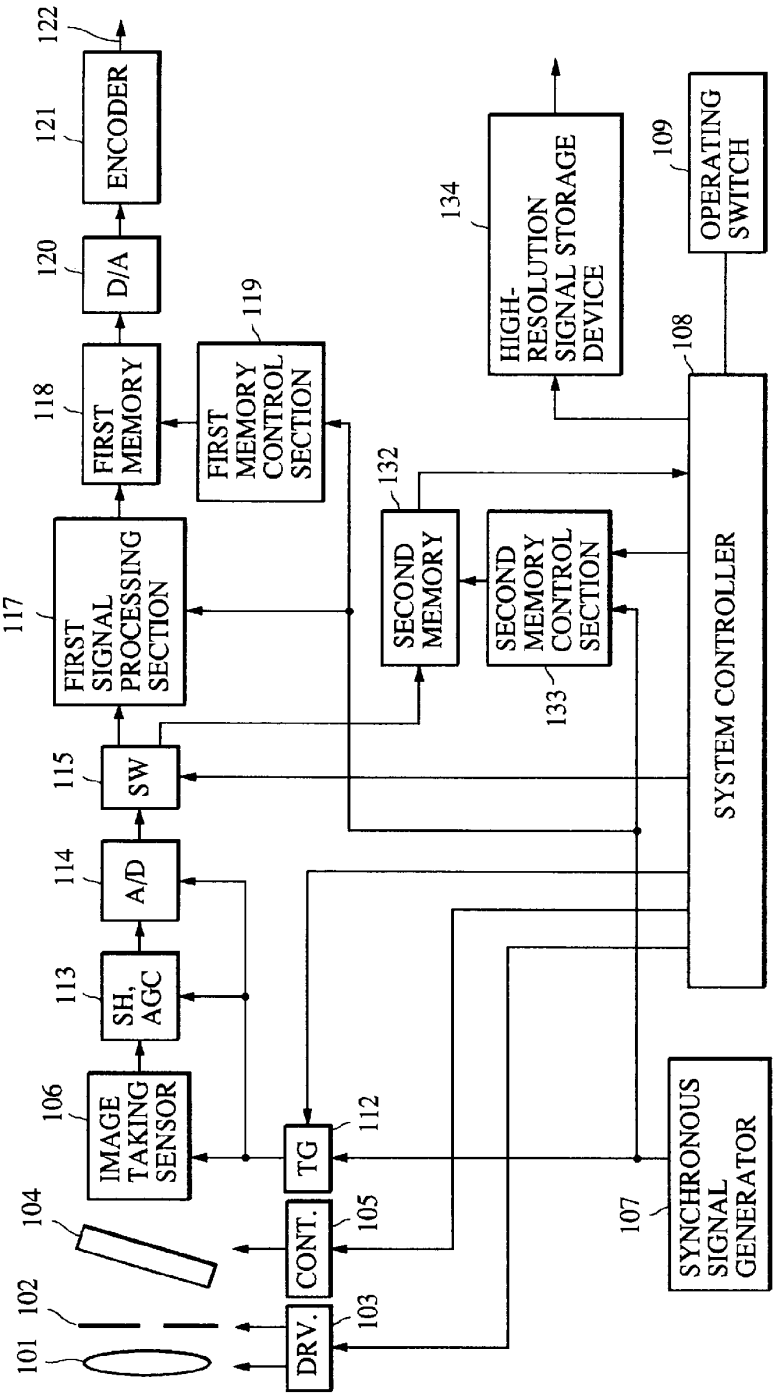

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DRV.
CONT.
TG
IMAGE TAKING SENSOR
SH, AGC
A/D
SW
FIRST SIGNAL PROCESSING SECTION
FIRST MEMORY
FIRST MEMORY CONTROL SECTION
D/A
ENCODER
SECOND MEMORY
SECOND MEMORY CONTROL SECTION
HIGH-RESOLUTION SIGNAL STORAGE DEVICE
OPERATING SWITCH
SYSTEM CONTROLLER
SYNCHRONOUS SIGNAL GENERATOR

FIG. 9

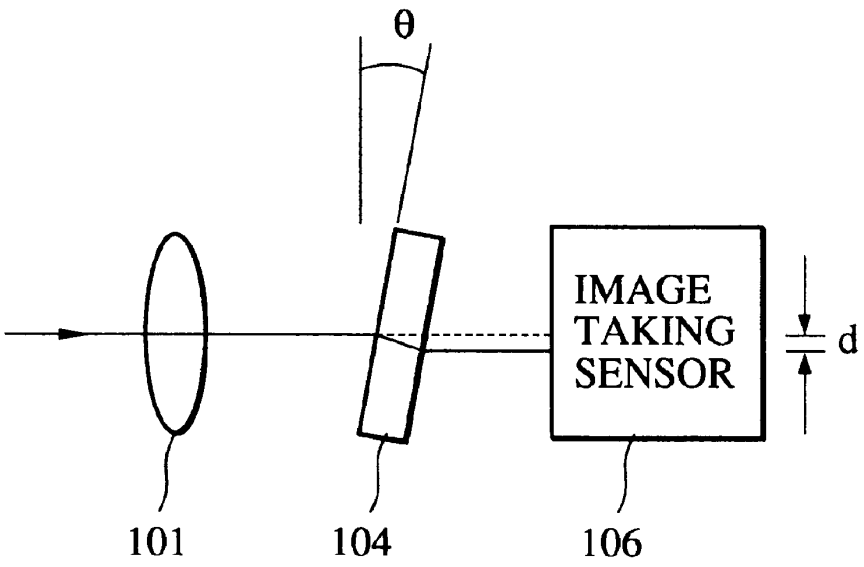


FIG. 10(a)

C	Y	C	Y	C	Y
G	M	G	M	G	M
C	Y	C	Y	C	Y
M	G	M	G	M	G
C	Y	C	Y	C	Y
G	M	G	M	G	M

FIG. 10(b)

	C	Y	C	Y	C	Y
	G	M	G	M	G	M
	C	Y	C	Y	C	Y
	M	G	M	G	M	G
	C	Y	C	Y	C	Y
	G	M	G	M	G	M

FIG. 10(c)

	C	Y	C	Y	C	Y
	G	M	G	M	G	M
	C	Y	C	Y	C	Y
	M	G	M	G	M	G
	C	Y	C	Y	C	Y
	G	M	G	M	G	M

FIG. 10(d)

C	Y	C	Y	C	Y
G	M	G	M	G	M
C	Y	C	Y	C	Y
M	G	M	G	M	G
C	Y	C	Y	C	Y
G	M	G	M	G	M

FIG. 11

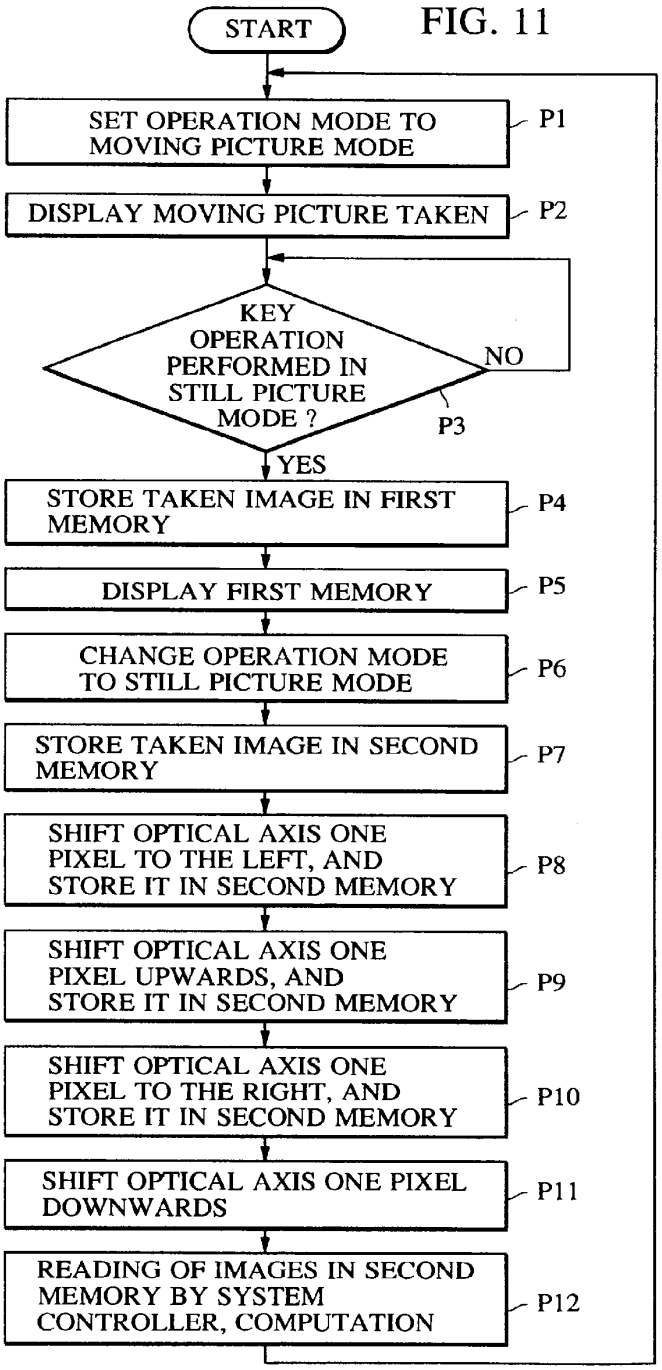

START
SET OPERATION MODE TO MOVING PICTURE MODE
P1
DISPLAY MOVING PICTURE TAKEN
P2
KEY OPERATION PERFORMED IN STILL PICTURE MODE ?
NO
P3
YES
STORE TAKEN IMAGE IN FIRST MEMORY
P4
DISPLAY FIRST MEMORY
P5
CHANGE OPERATION MODE TO STILL PICTURE MODE
P6
STORE TAKEN IMAGE IN SECOND MEMORY
P7
SHIFT OPTICAL AXIS ONE PIXEL TO THE LEFT, AND STORE IT IN SECOND MEMORY
P8
SHIFT OPTICAL AXIS ONE PIXEL UPWARDS, AND STORE IT IN SECOND MEMORY
P9
SHIFT OPTICAL AXIS ONE PIXEL TO THE RIGHT, AND STORE IT IN SECOND MEMORY
P10
SHIFT OPTICAL AXIS ONE PIXEL DOWNWARDS
P11
READING OF IMAGES IN SECOND MEMORY BY SYSTEM CONTROLLER, COMPUTATION
P12

FIG. 12

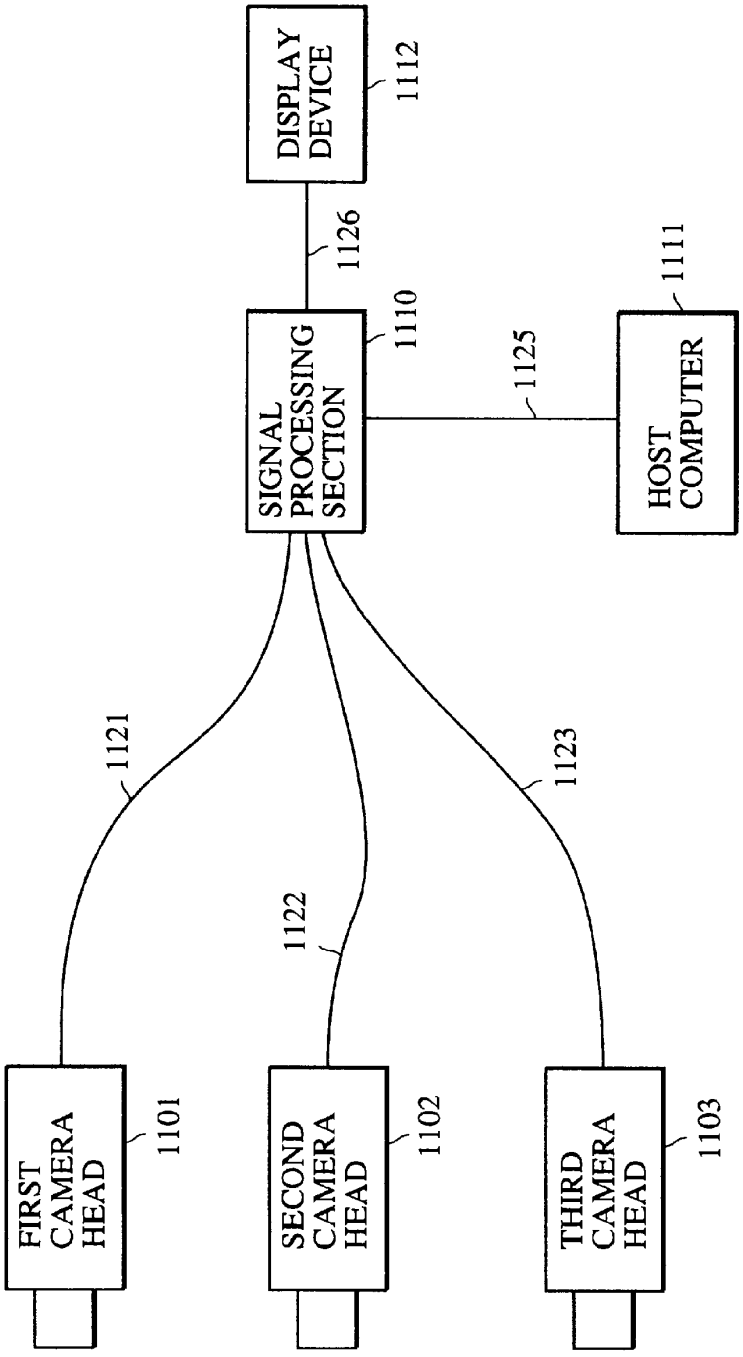

DISPLAY DEVICE
1112
1126
SIGNAL PROCESSING SECTION
1110
1125
HOST COMPUTER
1111
1121
1122
1123
FIRST CAMERA HEAD
1101
SECOND CAMERA HEAD
1102
THIRD CAMERA HEAD
1103

FIG. 13

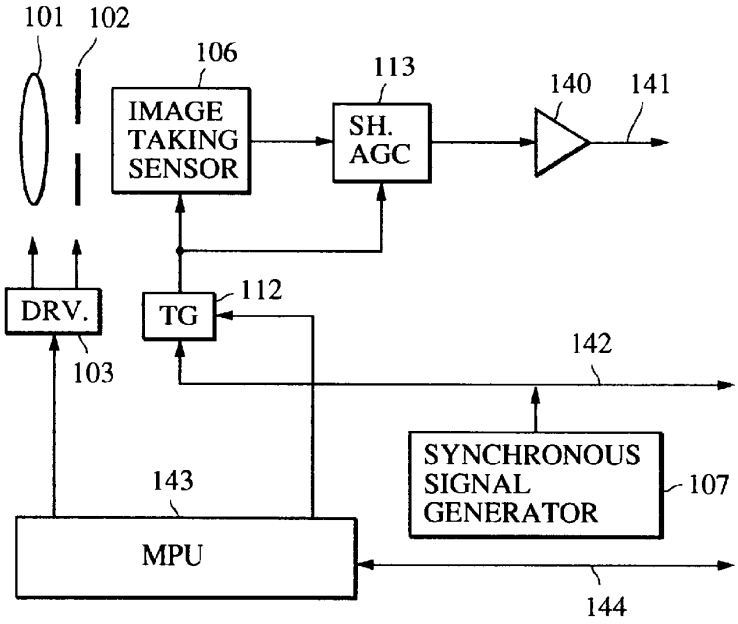

101
102
106
IMAGE TAKING SENSOR
113
SH. AGC
140
141
DRV.
103
TG
112
142
SYNCHRONOUS SIGNAL GENERATOR
107
143
MPU
144

FIG. 14

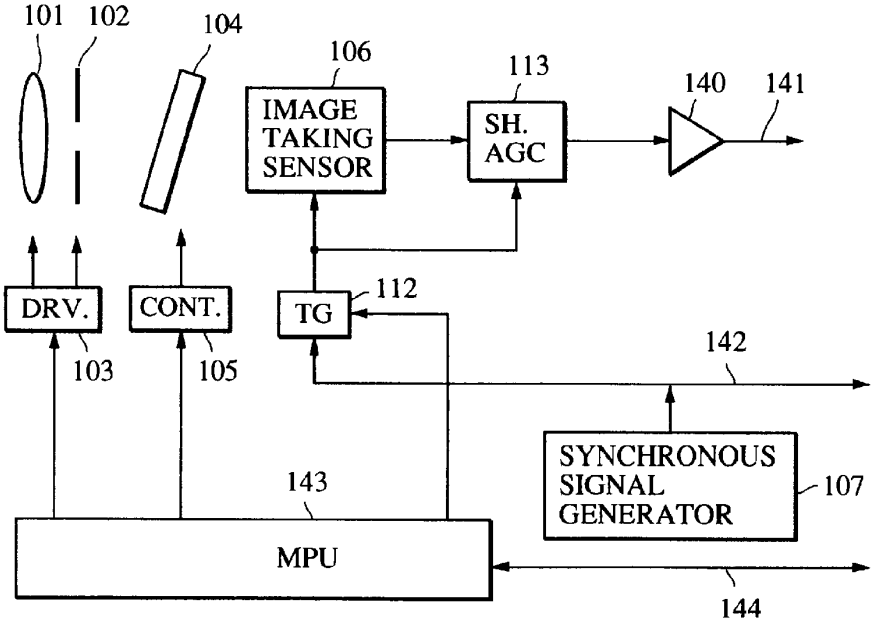

101
102
104
106
IMAGE TAKING SENSOR
113
SH. AGC
140
141
DRV.
103
CONT.
105
TG
112
142
SYNCHRONOUS SIGNAL GENERATOR
107
143
MPU
144

FIG. 15

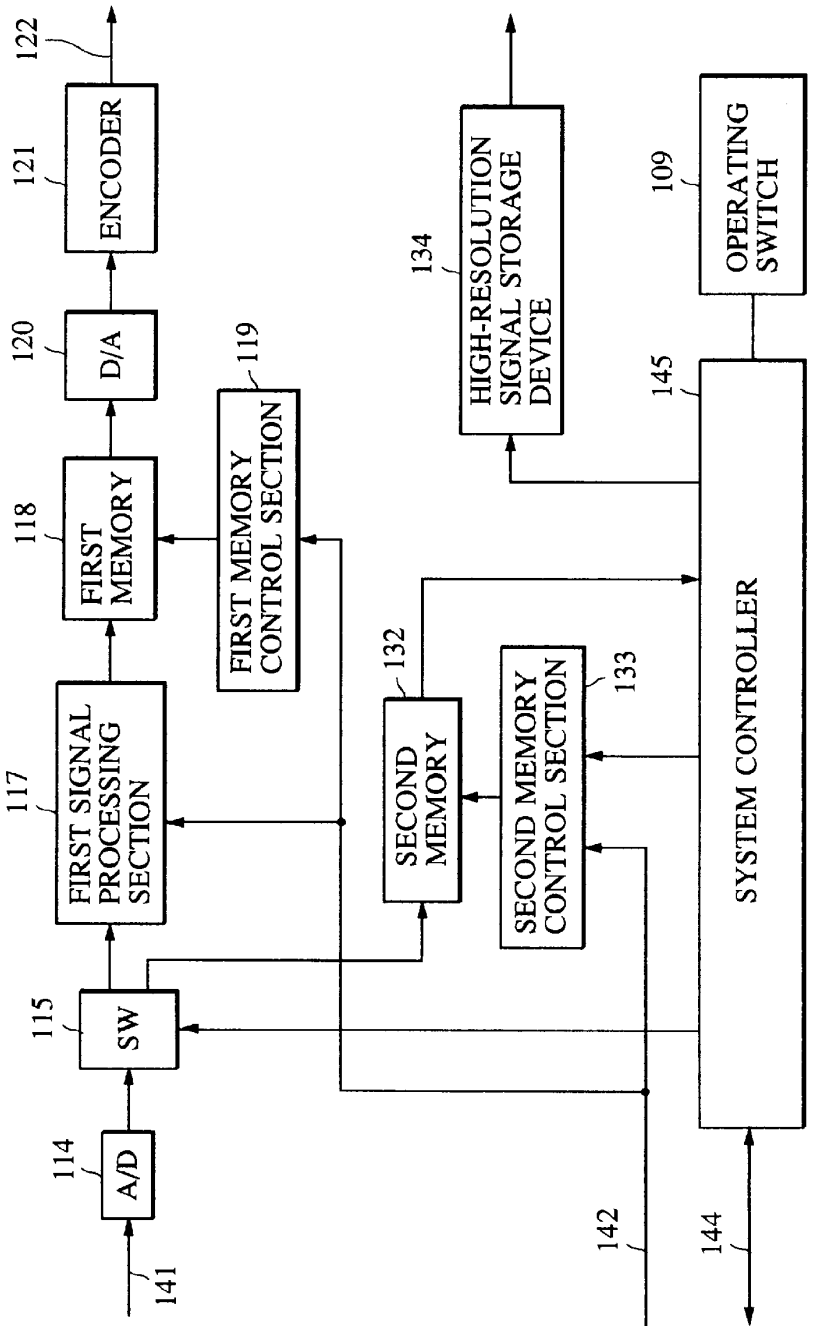

122
ENCODER
121
D/A
120
FIRST MEMORY
118
FIRST MEMORY CONTROL SECTION
119
FIRST SIGNAL PROCESSING SECTION
117
SW
115
A/D
114
141
HIGH-RESOLUTION SIGNAL STORAGE DEVICE
134
OPERATING SWITCH
109
145
SECOND MEMORY
132
SECOND MEMORY CONTROL SECTION
133
SYSTEM CONTROLLER
142
144

FIG. 16

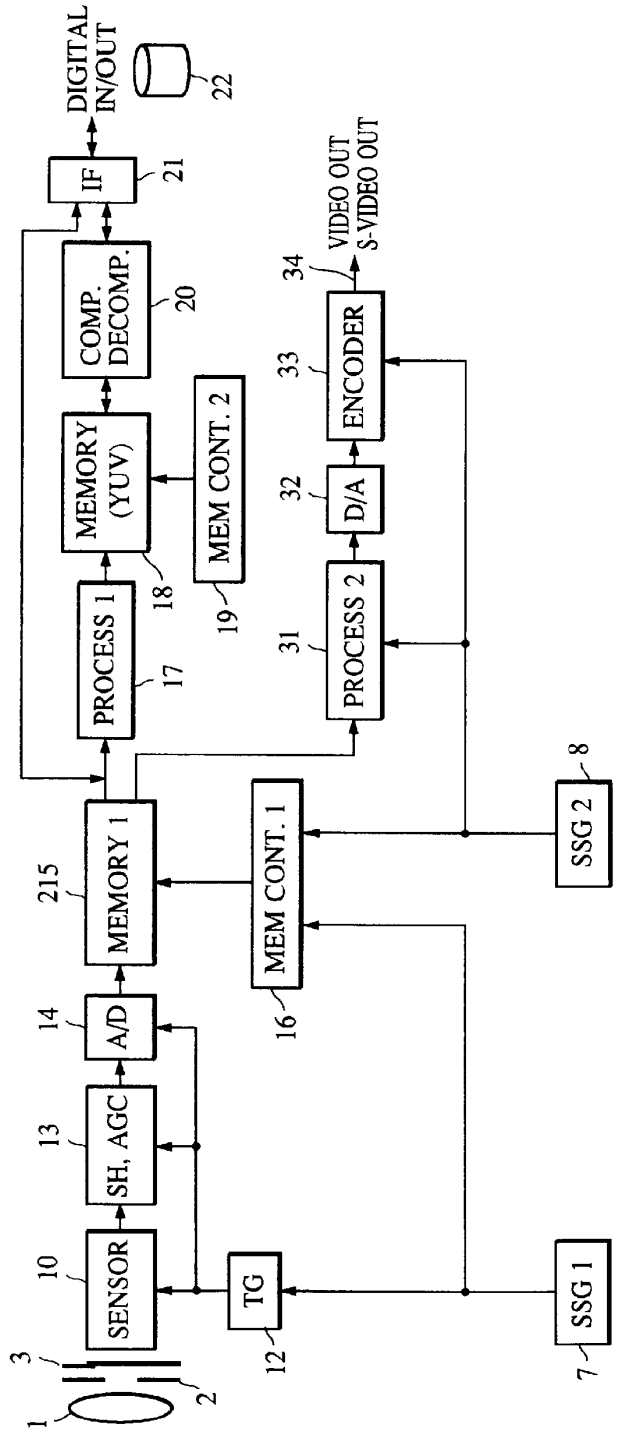

DIGITAL IN/OUT
22
IF
21
COMP. DECOMP.
20
MEMORY (YUV)
18
MEM CONT. 2
19
PROCESS 1
17
MEMORY 1
215
A/D
14
SH, AGC
13
SENSOR
10
3
1
2
TG
12
MEM CONT. 1
16
PROCESS 2
31
D/A
32
ENCODER
33
VIDEO OUT
S-VIDEO OUT
34
SSG 2
8
SSG 1
7

FIG. 17

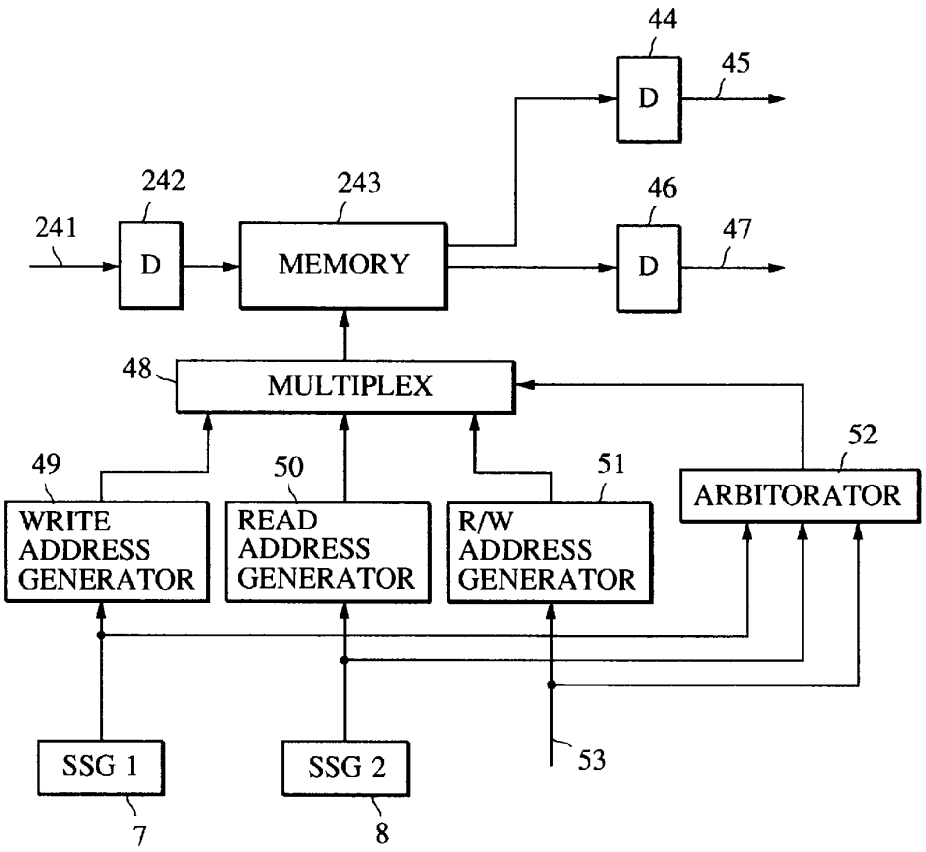

44
45
D
242
243
46
241
D
MEMORY
D
47
48
MULTIPLEX
52
49
50
51
ARBITORATOR
WRITE ADDRESS GENERATOR
READ ADDRESS GENERATOR
R/W ADDRESS GENERATOR
SSG 1
SSG 2
53
7
8

FIG. 18

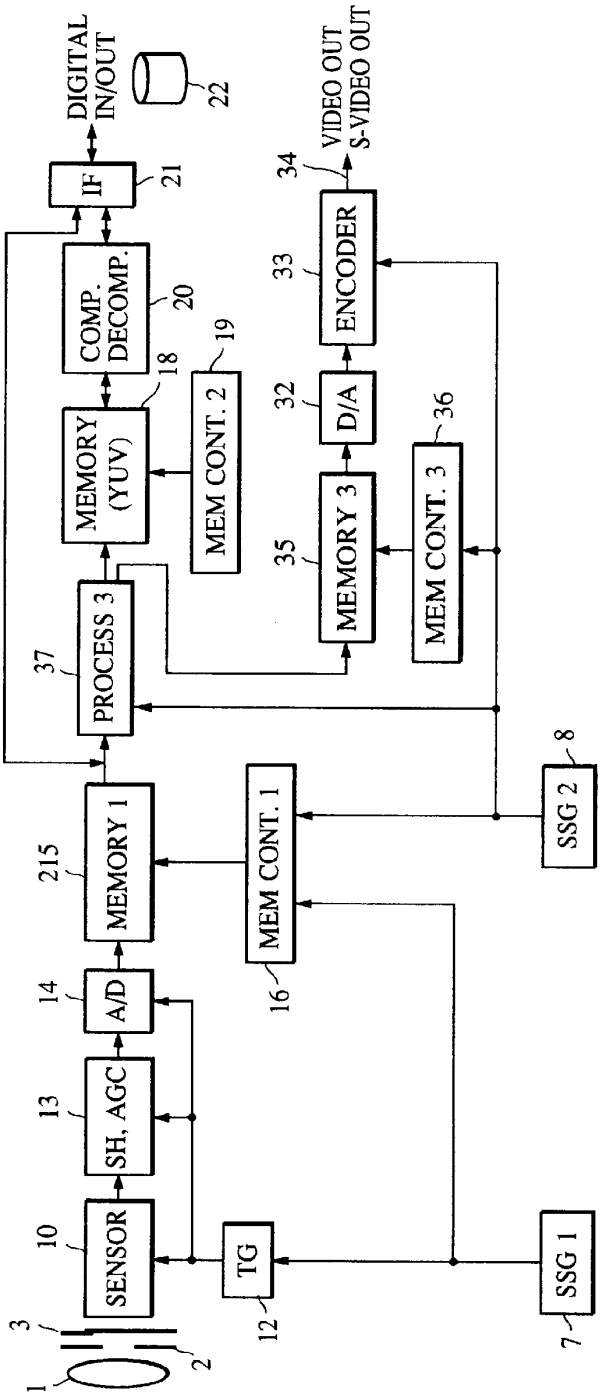

1
2
3
SENSOR
10
SH, AGC
13
A/D
14
MEMORY 1
215
MEM CONT. 1
16
TG
12
SSG 1
7
SSG 2
8
PROCESS 3
37
MEMORY 3
35
MEM CONT. 3
36
D/A
32
ENCODER
33
VIDEO OUT
S-VIDEO OUT
34
MEMORY (YUV)
18
MEM CONT. 2
19
COMP. DECOMP.
20
IF
21
DIGITAL IN/OUT
22

FIG. 19

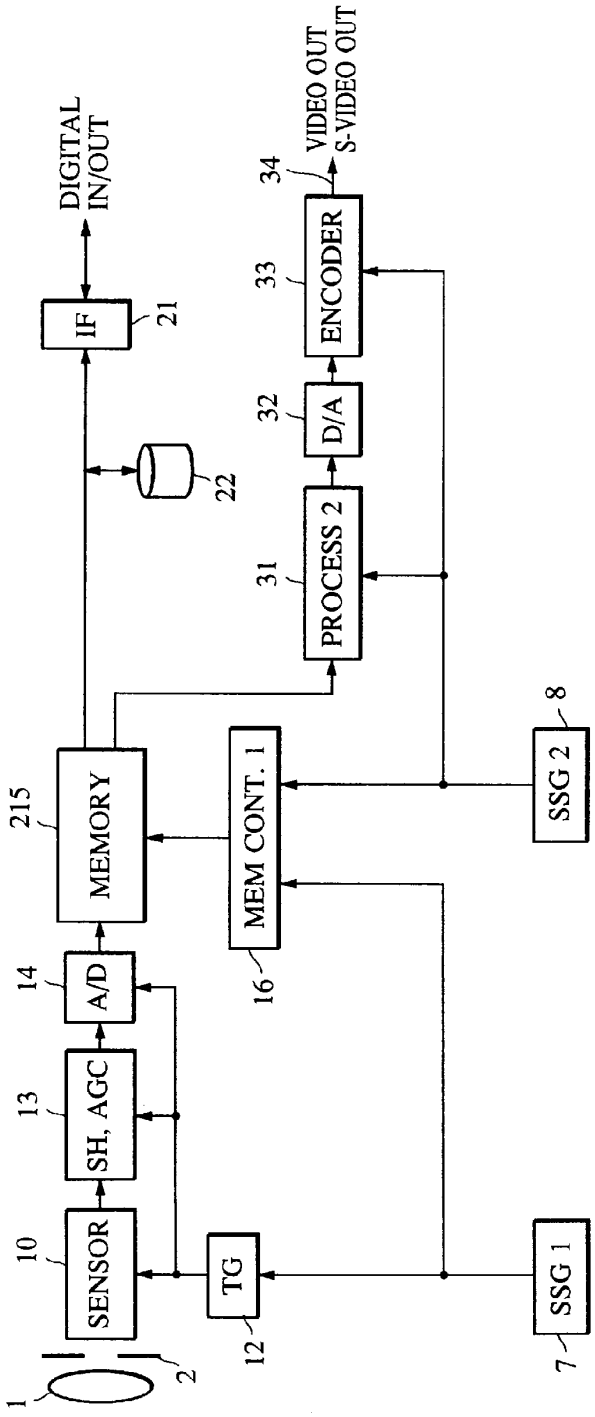

DIGITAL IN/OUT
IF
21
22
VIDEO OUT
S-VIDEO OUT
34
ENCODER
33
D/A
32
PROCESS 2
31
MEMORY
215
MEM CONT. 1
16
SSG 2
8
A/D
14
SH, AGC
13
SENSOR
10
TG
12
SSG 1
7
1
2

IMAGE SENSING APPARATUS WITH OPTICAL-AXIS DEFLECTING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image taking apparatus, such as a video camera, that is equipped with an image taking device, such as a charge-coupled device (hereinafter referred to as "CCD").

2. Description of the Related Art

Conventional image taking apparatuses equipped with an image taking device, such as CCD, are used as a means for supplying information to a video monitor, a VTR (video tape recorder), etc. In such an image taking apparatus, a video signal (NTSC, PAL signal, etc.) is obtained by driving the image taking device in accordance with the frequency of the video signal. The number of pixels in one frame, that is, the number of effective pixels of the image taking device, is determined by the number of lines, frequency characteristics, etc. of the video signal. Thus, it is possible to check the taken image in real time by means of a video monitor or the like.

Recently, however, image taking devices which provide a still higher level of resolution than obtainable with video signals have been developed. In image taking apparatuses using such a high-resolution image taking device, it is possible to take images at high resolution due to the large number of pixels.

However, conventional image taking apparatuses using such a high-resolution image taking device, in which it is possible to take images at high resolution due to the large number of pixels, require, on the other hand, a monitor, printer, etc. adapted to high resolution. Thus, the taken image cannot be easily checked by a video monitor or the like as in the prior art.

SUMMARY OF THE INVENTION

The present invention has been made with a view toward solving the above problem in the prior art. It is an object of the present invention to provide an image taking apparatus which is capable of taking images at high resolution and which allows a standard image video signal to be output to a video monitor or the like and monitored.

To achieve this object, in accordance with an embodiment of the present invention, there is provided an image taking apparatus comprising: an image taking device for effecting photoelectric conversion of images; synchronous signal generating means for generating a synchronous signal for operating the image taking device in correspondence with each of a high-resolution mode and a normal mode; storage means for storing image signals obtained by processing the output from the image taking device; image signal output means for outputting the image signals stored in the storage means after processing them in accordance with a predetermined image signal system; and control means for selecting either the high-resolution mode or the normal mode to perform image taking, the number of pixels of the image taking device being large enough to enable images to be taken at high resolution, the control means supplying the synchronous signal from the synchronous signal generating means to the image taking device in correspondence with either the high-resolution mode or the normal mode to perform image taking, wherein, in the high-resolution mode, the image signals are stored in the storage means and digital image signals, and wherein, in the normal mode, the image signals are stored in the storage means and video signals are output from the image signal output means.

Due to the above construction, the image taking device, having a number of pixels which is large enough to enable image taking to be performed at high resolution, can take images in either the high-resolution mode or the normal mode in accordance with the synchronous signal output from the synchronous signal generating means and corresponding to the selected mode, and, in both modes, the image signals, obtained by processing the output from the image taking device, are stored in the storage means.

In the high-resolution mode, digital image signals having a high level of resolution are output. In the normal mode, video image signals processed in accordance with a predetermined image signal system are output by the image signal output means.

As described above, either the high-resolution mode or the normal mode can be selected for image taking, and image signals for image display according to the selected mode can be output. Further, in both modes, the taken images are recorded or stored, and, by reading these images and subjecting them to the requisite image signal processing, it is possible to check the images on a monitor.

In accordance with another embodiment of the present invention, there is provided an image taking apparatus comprising: an image taking sensor having at least first and second image taking modes and adapted to operate in two or more image taking modes; first signal processing means for effecting a predetermined signal processing on image signals output from the image taking sensor; storage means for storing the image signals output from the image taking sensor; second signal processing means for effecting a predetermined signal processing on the image signals stored in the storage means; and control means which, in the first image taking mode, causes the image signals supplied from the image taking sensor to be processed by the first signal processing means and which, in the second image taking mode, causes the image signals stored in the storage means to be processed by the second signal processing means.

In still another aspect of the present invention, there is provided an image taking apparatus comprising: an optical lens; an image taking sensor having at least first and second image taking modes and adapted to operate in two or more image taking modes; first image processing means for processing image signals taken by the image taking sensor; an A/D converter for A/D-converting the image signals taken by the image taking sensor; storage means for storing the image signals converted into digital signals by the A/D converter; second signal processing means for processing the digital image signals stored in the storage means; mode switching means for switching the mode for processing the image signals taken by the image taking sensor between the first and second image taking modes; and control means, which, when the first image taking mode is selected by the mode switching means, causes signal processing to be performed by the first signal processing means, and which, when the second image taking mode is selected by the mode switching means, causes signal processing to be performed by the second signal processing means.

In a still further aspect of the present invention, the image taking sensor simultaneously reads image taking data in an amount corresponding to two vertically adjacent lines, outputting a signal obtained by adding image signals corresponding to two vertically adjacent pixels when in the first image taking mode, and, when in the second image taking mode, outputs a signal for each pixel, without performing addition of image data.

In a still further aspect of the present invention, the image taking sensor is an image taking sensor using a complementary color mosaic filter.

In a still further aspect of the present invention, the image taking sensor is a CCD image taking device.

In a still further aspect of the present invention, there is provided an image taking apparatus comprising: an optical lens; optical-axis moving means for moving the optical axis of a light entering through the optical lens; optical-axis movement control means for controlling the operation of the optical-axis moving means; an image taking sensor having at least first and second image taking modes and adapted to operate in two or more image taking modes; first image processing means for performing a predetermined signal processing on image signals taken by the image taking sensor; an A/D converter for A/D-converting the image signals taken by the image taking sensor; storage means for storing the image signals converted into digital signals by the A/D converter; second signal processing means for performing a predetermined signal processing on the digital image signals stored in the storage means; and control means, which, in the first image taking mode, causes the predetermined signal processing to be performed by the first signal processing means, and which, in the second image taking mode, causes image taking to be performed a plurality of times while causing the optical-axis moving means to be controlled by the optical-axis movement control means, storing the thereby obtained image signals in the storage means, and, at the same time, causes the predetermined signal processing to be performed by the second signal processing means.

In a still further aspect of the present invention, the image taking sensor simultaneously reads image taking signals corresponding to two vertically adjacent lines, outputting a signal obtained by adding image signals corresponding to two vertically adjacent pixels when in the first image taking mode, and, when in the second image taking mode, ontputs a signal for each pixel, without performing addition of image signals.

In a still further aspect of the present invention, the image taking sensor is an image taking sensor using a complementary color mosaic filter.

In a still further aspect of the present invention, the image taking sensor is a CCD image taking device.

In a still further aspect of the present invention, the optical-axis moving means is a variable-apex-angle prism.

In a still further aspect of the present invention, the optical-axis moving means is a lens shift,

In a still further aspect of the present invention, the optical-axis moving means consists of a plane-parallel-plate rotating system.

In a still further aspect of the present invention, there is provided an image taking apparatus according to claims **1** through **11**, wherein an image taking unit including an optical lens and an image taking sensor is separated from a signal processing unit which receives signals from the image taking unit and performs signal processing on the signals, with the two units being capable of being connected together through a cable.

In the image taking apparatus of the present invention, comprised of the technical means described above, the image taking sensor can be operated in either of the first and second image taking modes, and, at the same time, the signal processing at the subsequent stage is conducted in accordance with either of the two image taking modes, whereby not only can the normal signal processing be conducted and the results thereof displayed on the monitor, but also the outpnt of each of the pixels of the image taking sensor is extracted to perform another kind of signal processing, snch as resolution enhancement.

Further, by arranging the optical axis moving means directly before the image taking sensor, it is possible to perform image taking with pixel shift. Further, by executing signal processing for pixel shift on the image signals obtained by the image taking, it is possible to perform image taking at high resolution.

Further, it is possible to separate the camera head from the signal processing section, and the camera head is replaceable, whereby combination of an ordinary image taking camera, a camera adapted to pixel shift, etc. can be easily effected.

In still another aspect of the present invention, there is provided an image taking apparatus comprising: an image taking device having a predetermined number of pixels and adapted to effect photoelectric conversion on images formed by an optical lens; an A/D converter for effecting A/D conversion on image signals taken by the image taking device; a memory for storing image data obtained by the A/D conversion; a first color processing section for effecting color conversion on the image data stored in the memory; a first synchronous signal generator for generating a synchronous signal for controlling the image taking device, the A/D converter, the memory and the first color processing section; a second synchronous signal generator for generating a synchronous signal having a frequency different from that of the synchronons signal generated by the first synchronous signal generator; and a second color processing section which reads the image data stored in the memory with the synchronous signal generated by the second synchronous signal generator and performs color conversion on the image data.

The image taking device is driven by the synchronous signal of the first synchronous signal generator, and the image signal thereby obtained is A/D-converted and temporarily stored in the memory. The image signal thus stored is read by means of the synchronous signal of the first synchronous signal generator and color-converted by the first color processing section. Further, the memory is read with the synchronous signal of the second synchronous signal generator. Thus, even in the case of an image taking device having a large number of pixels and providing a high level of resolution, it is possible to check the taken image immediately after the image taking by means of the image signal which has been color-converted by the second color processing section.

Other objects and features of the present invention will become apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing a first embodiment of the present invention;

FIG. **2** illustrates a filter arrangement in an image taking sensor;

FIG. **3** is a block diagram showing a second embodiment of the present invention;

FIG. **4** is a block diagram showing a third embodiment of the present invention;

FIG. **5** is a block diagram showing an image taking apparatus according to a fourth embodiment of the present invention;

FIG. **6** is a diagram showing an example of a complementary-color-mosaic-filter arrangement in a single-plate image taking sensor;

FIG. **7** is a flowchart illustrating the operation of the fourth embodiment;

FIG. **8** is a block diagram showing an image taking apparatus according to a fifth embodiment of the present invention;

FIG. **9** illustrates a optical axis movement by a plane-parallel plate;

FIG. **10** shows an example of an image taking with pixel shift;

FIG. **11** is a flowchart illustrating the operation of the fifth embodiment;

FIG. **12** is a block diagram showing an image taking apparatus according to a sixth embodiment of the present invention;

FIG. **13** is a block diagram showing the construction of a first camera head section;

FIG. **14** is a block diagram showing the construction of a second camera head section;

FIG. **15** is a block diagram showing the construction of a camera signal processing section;

FIG. **16** is a block diagram showing a seventh embodiment of the present invention;

FIG. **17** illustrates the construction of a first memory and that of a first memory controller in detail;

FIG. **18** is a block diagram showing an eighth embodiment of the present invention; and

FIG. **19** is a block diagram showing a ninth embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The image taking apparatus of the present invention will now be described with reference to specific embodiments.

(First Embodiment)

FIG. **1** is a block diagram showing the first embodiment of the present invention.

In FIG. **1**, numeral **1** indicates a lens; numeral **2** indicates an aperture; numeral **7** indicates a first synchronous signal generator; numeral **8** indicates a second synchronous signal generator adapted to operate at video rate; numeral **9** indicates a switch for switching between the synchronous signals; numeral **10** indicates an image taking sensor; numeral **12** indicates a timing generator for generating timing pulses for operating the image taking sensor **10**; numeral **13** indicates an SH,AGC circuit for performing sample-and-hold on the output of the image taking sensor **12** to effect AGC (automatic gain control); numeral **14** indicates an A/D converter; numeral **15** indicates a switch for switching the output of the A/D converter **14**; numeral **17** indicates a first color processing section for conducting color processing; numeral **18** indicates a first memory for storing color-converted luminance two-color difference (YUV) data; numeral **19** indicates a first memory controller for controlling the first memory **18**; numeral **20** indicates a compressor/expander for compressing/expanding luminance two-color difference (YUV) data; numeral **21** indicates an interface; numeral **22** indicates a storage device; numeral **31** indicates a second color processing section for performing color processing; numeral **32** indicates a D/A converter; numeral **33** indicates a video signal encoder; numeral **34** indicates a video output signal; numeral **35** indicates a second memory for storing the luminance two-color (YUV) data color converted by the second color processing section **31**; and numeral **36** indicates a second memory controller for controlling the second memory **35**.

The image taking sensor **10** is a solid-state image sensing device, such as CCD, and has a number of effective pixels of 1536×988, which is large enough to provide high resolution. This image taking sensor is a single-plate color sensor in which a complementary color mosaic filter (Cy, Mg, Ye, Gr) is attached to a chip. FIG. **2** shows an example of the layout of the complementary color mosaic filter (Cy, Mg, Ye, Gr) attached to the chip. In the image taking sensor **10**, the switch **9** effects switching between synchronous signals having different frequencies that are respectively generated by the first and second synchronous signal generators **7** and **8**, thereby enabling the image taking sensor **10** to operate in two image taking modes.

The second image taking mode will be explained first. The second synchronous signal generator **8** generates a synchronous signal for video signals (NTSC, PAL and the like). It effects thinning-out by reducing the apparent number of pixels through addition of pixels of the same filter arranged close to each other, or by skipping over part of the pixels when reading them from the image taking sensor **10**. Alternatively, it reads only a particular storage area. In this way, it has the same access to data in the same way as in the case of video CCD, and reads 768×494 pixels in accordance with a video signal.

In accordance with the synchronous signal generated by the second synchronous signal generator **8**, the timing generator **12** generates driving pulses for the image taking sensor **10**. The image signal taken by the image taking sensor **10** is subjected to sample-and-hold and AGC (automatic gain control) for removing switching noise and extracting the signal component at the SH,AGC circuit **13**, and converted to digital data by the 10-bit A/D converter **14**. The image signal converted to digital data by the A/D converter **14** is transmitted through the switch **15**, and is color-converted to luminance two-color difference (YUV) data by the second color processing section **31**. This luminance two-color difference (YUV) data is stored in the second memory **35** under the control of the second memory controller **36**. The luminance two-color difference (YUV) data, which is temporarily stored in the memory **35**, is converted to an analog signal by the D/A converter **32**, and modulated into a video signal by the encoder **33** to be output as the video signal **34** and displayed on a video monitor (not shown) or the like.

Here, the luminance two-color difference (YUV) data color-converted by the second color processing section **31** is first stored in the second memory **35**, and then read to be transmitted to the D/A converter **32**. However, it is also possible to transmit the luminance two-color difference (YUV) data, color-converted by the second color processing section **31**, directly to the D/A converter **32** and simultaneously input it to the memory **35**.

Next, the first image taking mode will be described. The first synchronous signal generator **7** is a synchronous signal generator for high-resolution image taking. In accordance with the synchronous signal generated by the first synchronous signal generator **7**, the timing generator **12** generates driving pulses for the image taking sensor **10**. Then, as in the second image taking mode, the image signal taken by the image taking sensor **10** is subjected to sample-and-hold and AGC (automatic gain control) for removing switching noise and extracting the signal component at the SH,AGC circuit **13**, and converted to digital data by the 10-bit A/D converter

14. The image signal converted to digital data by the A/D converter **14** passes through the switch **15**, and is color-converted to luminance two-color difference (YUV) data by the first color processing section **17**. This luminance two-color difference (YUV) data is stored in the first memory **18** under the control of the first memory controller **19**. The luminance two-color difference (YUV) data, which is stored in the first memory **18**, is compressed by the compressor/expander **20** as needed, and transmitted to an external file or a computer (not shown) through the interface **21**.

It is also possible for the image signal converted to digital data by the A/D converter **14** to be transmitted to an external file or a computer (not shown) through the interface **21**.

Due to the above construction, it is possible to output image signals in accordance with a standard video system through selection of the second image taking mode. Further, by selecting the first image taking mode, it is possible to output a high-resolution image signal. In whichever mode, the image signals are stored in the memory.

(Second Embodiment)

FIG. **3** is a block diagram showing the second embodiment of the present invention. The components which are the same as or equivalent to those of the first embodiment are indicated by the same reference numerals and a description of such components will be omitted.

In FIG. **3**, numeral **38** indicates a third memory for storing the output of the image taking sensor **10** as it is, and numeral **39** indicates a third memory controller for controlling the third memory **38**.

As in the first embodiment, the synchronous signal generated by the first or second synchronous signal generator **7** or **8** is switched by the switch **9** to drive the image taking sensor **10**. The image signal taken by the image taking sensor **10** is subjected to sample-and-hold and AGC (automatic gain control) for removing switching noise and extracting the signal component at the SH,AGC circuit **13**, and converted to digital data by the 10-bit A/D converter **14** to be stored in a third memory **38**. Here, the third memory **38** has a capacity that is large enough to store both high-resolution image data (1536×988 pixels) read by the image taking sensor **10** in accordance with the first synchronous signal generator **7** and low-resolution image data (768×494 pixels) read by the image taking sensor **10** in accordance with the second synchronous signal generator **8**.

In the second image taking mode, the second synchronous signal generator **8** is selected by the switch **9**. When the image taking sensor **10** is taking images in accordance with the second synchronous signal generator **8**, the A/D-converted image data is stored in the third memory **38**, and, at the same time, transmitted to the second color processing section **31**. Then, as in the first embodiment, it is color-converted to luminance two-color difference (YUV) data by the second color processing section **31**, and the luminance two-color difference (YUV) data obtained by color conversion is converted to an analog signal by the D/A converter **32**, and modulated into a video signal by the encoder **33** before it is output as the video signal **34** and displayed on a video monitor (not shown) or the like.

Next, to be described will be the operation to be performed when the first image taking mode for high-resolution image taking is selected and the switch **9** selects the first synchronous signal generator **7**.

When the first synchronous signal generator **7** is selected, the image data, which has been read by the image taking sensor **10** in accordance with the second synchronous signal generator **8** and stored in the third memory **38**, ceases to be treated in this way. The images that have been stored before the switching are read in accordance with the second synchronous signal generator **8**. The image sensor **10** is then driven in accordance with the first synchronous signal generator **7**. The image signals taken by the image taking sensor **10** are subjected to sample-and-hold and AGC (automatic gain control) for removing switching noise and extracting the signal components at the SH,AGC circuit **13**, and converted to digital data by the 10-bit A/D converter **14** before it is stored in the third memory **38**. The storage area used when storing the data in the third memory **38** is different from the area used in the second image taking mode so that the image data that has been stored prior to the mode switching may not be zapped.

When the image taking at high resolution has been completed, the high-resolution image data stored in the third memory **38** is stored in the storage device file **22**, or transmitted to a computer (not shown) through the interface **21** to undergo color processing. At the same time, the image taking mode is restored to the second image taking mode, and the switch **9** is switched to the side of the second synchronous signal generator **8**. The image taking sensor **10** is operated in accordance with the second synchronous signal generator **8**, and the video signal **34** is output while storing the data in the third memory **38**.

As described above, the second embodiment has a construction which is simplified as compared to that of the first embodiment, and it is possible to output video signals and high-resolution digital signals. It is also possible to signals of both types.

(Third Embodiment)

FIG. **4** is a block diagram showing the third embodiment of the present invention. The components which are the same as or equivalent to those of the above-described embodiments are indicated by the same reference numerals.

In FIG. **4**, numeral **1** indicates a lens; numeral **2** indicates an aperture; numeral **4** indicates a system controller for overall control; numeral **5** indicates an operating panel; numeral **10** indicates an image taking sensor; numeral **8** indicates a synchronous signal generator; numeral **12** indicates a timing generator for generating timing pulses for operating the image taking sensor **10**; numeral **13** indicates an SH,AGC circuit for performing sample-and-hold on the output of the image taking sensor **12** to thereby effect AGC (automatic gain control); numeral **14** indicates an A/D converter; numeral **15** indicates a switch for switching the output of the A/D converter **14**; numeral **41** indicates a fourth memory for storing noise components (noise memory); numeral **42** indicates a fourth memory controller for controlling the fourth memory (noise memory); numeral **43** indicates a computing unit to which image signals are input from the image taking sensor **10** and which subtracts therefrom the noise components stored in the fourth memory (noise memory) **41** before outputting them; numeral **31** indicates a second color processing section for performing color processing; numeral **32** indicates a D/A converter; numeral **33** indicates a video signal encoder; numeral **34** indicates a video output signal; numeral **35** indicates a second memory for storing video data; and numeral **36** indicates a second memory controller for controlling the second memory **35** for video.

In FIG. **4**, the image taking sensor **10** operates in accordance with the synchronous signal generated by the sole video synchronous signal generator **8**. As in the first embodiment, the image signal output from the image taking sensor **10** is subjected to sample-and-hold and AGC (automatic gain control) for removing switching noise and extracting the signal component at the SH,AGC circuit **13**, and converted to digital data by the 10-bit A/D converter **14**.

The image signal converted to digital data by the A/D converter **14** is directed to either the fourth memory **41** or the computing unit **43** by the switch (demultiplexer). Here, in a dark noise extraction mode, in which the aperture **2** is closed, the noise components from the image taking sensor **10** are stored in the fourth memory **41** as signals. When image taking is conducted in the normal mode, the image signal is input to the computing unit **43**, and the difference between this input data and the noise data stored in the fourth memory **41** is output.

The image signal on which noise component correction has been effected, is subjected to color conversion in the color processing section **31**, and converted into luminance two-color difference (YUV) data by the color processing section **31**. In this color processing section **31**, data for auto white balancing is extracted, and subjected to computation by the system controller **4** to perform gain setting for each color, thereby setting white balance. Similarly, data for automatic focusing and data for auto iris are extracted and subjected to computation by the system controller **4** to thereby adjust the lens and the aperture.

The image signal converted to luminance two-color difference (YUV) data by the color processing section **31** is converted to an analog signal by the D/A converter **32**, and the color difference signal is modulated into a chromatic signal indicative of saturation by the encoder **33**. Here, the image signal converted to a luminance two-color difference (YUV) signal by the color processing section **31** is displayed as a video signal, and, at the same time, stored in the second memory **35**.

In a dark noise extraction mode, in which the aperture **2** is closed, video data taken in the normal image taking mode and stored in the second memory **35** is read and transmitted to the D/A converter **32** before it is output as a video signal.

As described above, this embodiment makes it possible to effectively output video signals. When applied to the video signal output section of the first and second embodiments, this embodiment enables the present invention to be carried out more effectively.

In accordance with the above-described embodiments, it is possible to take images in a high resolution mode and in a normal mode by an image taking device having a number of pixels which is large enough to enable image taking to be performed at high resolution. In both modes, the image signals obtained by processing the output from the image taking device are stored in the storage means.

In the high resolution mode, a digital image signal having high resolution is output. In the normal mode, a video image signal processed according to a predetermined image signal system is output by the image signal output means.

As described above, it is possible to select either the high resolution mode or the normal mode in performing image taking and to output an image signal for image display in accordance with the selected mode. Further, in both modes, the images taken are recorded or stored, and, by reading them and subjecting them to the requisite image taking processing, it is possible to check the images on a monitor.

Thus, in whichever mode the image taking device is operated, it is possible to display the image output on a monitor without any portion thereof being lost. Thus, in an image taking apparatus capable of image taking at high resolution, it is always possible to check images on a monitor. Further, due to the compact and inexpensive additional circuit, the apparatus of this embodiment is superior to the type of apparatus in which the high resolution images are color-processed as they are, in that it makes it possible to check the framing, exposure of taken images, focusing, etc. on the spot

FIG. **5** is a block diagram showing an image taking apparatus according to the fourth embodiment of the present invention. In FIG. **5**, numeral **101** indicates an optical lens; numeral **102** indicates an aperture; numeral **103** indicates a driver for the optical system; numeral **106** indicates an image taking sensor; numeral **107** indicates a synchronous signal generator (SSG); numeral **108** indicates a system controller for controlling the operation of the entire apparatus; numeral **109** indicates an operating switch; numeral **112** indicates a timing generator (TG); numeral **113** indicates a sample-and-hold/AGC; numeral **114** indicates an A/D converter; numeral **115** indicates a changeover switch (SW); numeral **117** indicates a first signal processing section; numeral **118** indicates a first memory; numeral **119** indicates a first memory control section; numeral **120** indicates a D/A converter; numeral **121** indicates a video encoder; numeral **122** indicates a video signal; numeral **132** indicates a second memory; and numeral **133** indicates a second memory control section.

In FIG. **5**, an optical image is formed on the image taking sensor **106** by a light entering through the optical lens **101** and the aperture **102**. The image taking sensor **106** may, for example, be an area sensor having a color filter, a CCD sensor, or a MOS type sensor. It is also possible to use a bipolar image sensor (BASIS) having a bipolar transistor for each pixel.

The entire system of the image taking sensor **106** is selectively set to either the first or the second image taking mode through manual operation by using the operating switch **109**, and operates in either the first or the second image taking mode through control by the system controller **108**. The difference between the first and second image taking modes consists in a difference in the timing signal for driving the image taking sensor **106** and a difference in the subsequent processing system.

First, the operation in the first image taking mode will be described. In the first image taking mode, the image taking sensor **106** is driven by a first timing signal generated by the timing generator **112** in accordance with the synchronous signal generated by the synchronous signal generator **107**. In the first image taking mode, the image taking sensor **106** outputs image data after performing addition of two vertically adjacent pixels in the sensor, and is controlled by driving pulses generated by the timing generator **112**.

Generally speaking, the timing pulse generator for driving the image taking sensor **106** generates timing pulses that are specific to the associated image taking sensor, so that an IC adapted to each particular image taking sensor is provided. In the first image taking mode, pixel addition of two vertically adjacent pixels is conducted in the image taking sensor, and correlation double sampling and AGC (automatic gain control) are performed, the resultant data being digitized by the A/D converter **114**.

In the first image image taking mode, the image signal thus digitized is transmitted to the first signal processing section **117** by the changeover switch **115**. In the second image taking mode, it is transmitted to the second memory **132**.

In the first image taking mode, the image signal transmitted through the changeover switch **115** is conveyed to the first signal processing section **117**, where it is subjected to signal processing so as to be converted to luminance two-color difference signal (YUV). The first signal processing section **117** normally performs signal processing operations, such as color conversion, white balance, gamma conversion, aperture correction, and low-pass filtering to thereby convert the signals transmitted through the color filter of the image

taking sensor **106** and optically stored into ordinary color signals (RGB, YUV and the like).

Generally speaking, to perform a processing operation specific to each image taking sensor **106**, a signal processing IC adapted to each particular image taking sensor **106** is provided. The signal converted to a luminance two-color difference is input to the first memory **118**.

Normally, the luminance two-color signal is supplied to the D/A converter **120** without being stored in the first memory **118** and is converted to an analog signal by the D/A converter. Then, it is encoded into a video signal by the encoder **121** to be output as an output image signal **122**, such as a video signal or an S video signal.

Further, when a switch (not shown) in a still picture taking mode is depressed by using the operating switch **109**, the signal converted to a luminance two-color difference signal by the first signal processing section **117** is stored in the first memory **118** controlled by the first memory control section **119**, and, while the image taking sensor **6** is operating in the second image taking mode, the image signal stored in the first memory **118** is read and transmitted to the D/A converter **120**, and encoded by the encoder **121** before it is output as the video signal or S video signal **122**.

Next, the operation in the second image taking mode will be described. In the second image taking mode, the addition of two vertically adjacent pixels is not conducted in the image taking sensor **106**, and a storage signal corresponding to the exposure amount of each pixel is independently output. In the second image taking mode, the incident light is transmitted to the image taking sensor **106** by way of the optical lens **101** and the aperture **102**, as in the first image taking mode, and an optical image is formed thereon to thereby effect image taking. The image signal taken by the image taking sensor **106** is output in accordance with the timing provided by the timing generator **112**.

The timing generator **112** drives the image taking sensor **106** by generating timing pulses which do not cause the addition of two vertically adjacent pixels to be performed in the image taking sensor. As in the first image taking mode, the image signal output from the image taking sensor **106** is subjected to correlation double sampling and AGC by the sample-and-hold/AGC circuit **113**, and then digitized by the A/D converter **114**. Subsequently, the digitized image signal is supplied to the second memory **132** through the changeover switch **115** and stored therein.

The image data stored in the memory **132** is independent data for each of the pixels of the image taking sensor **106**. The independent image data is read by the system controller **8**, and subjected to computation to be thereby converted to a color signal, which is stored in a high resolution storage device **134** and output to the exterior as needed. This computation processing also consists in signal processing operations, such as color conversion, white balance, gamma conversion, aperture correction, and low-pass filtering to thereby convert the signals transmitted through the color filter of the image taking sensor **106** and optically stored into ordinary color signals (RGB, YUV and the like).

Further, the signal processing computation conducted here consists in color processing for a so-called image processing and color processing for printing, and can be conducted as a separate processing which has not been optimized in order to be displayed on a monitor as in the case of the first signal processing section **117**.

As shown in FIG. **5**, in the case of the image taking apparatus of this embodiment, the first signal processing section **117** is arranged on the output side of the A/D converter **114** and the changeover switch **115** and effects digital signal processing. In the present invention, however, the processing in the first signal processing section **117** is not restricted to digital processing. It is also possible to perform analog processing, performing digital processing after effecting A/D conversion at the time of input to the memory.

FIG. **6** is a diagram showing a color filter arrangement in an image taking sensor. Basically, it has the same construction as that of FIG; **2**. The color filter is a complementary color mosaic filter comprised of Cy (cyan), Mg (magenta), Ye (yellow) and Gr (green). The color filter arrangement of the complementary color mosaic is such that rows of cyan and yellow and rows of green and magenta are alternately arranged, and that the rows of green and magenta change in order for each line.

In the first image taking mode, the addition of two vertically adjacent pixels is effected in the image taking sensor **106**. A first field, which consists of the first two lines as counted from the first line, and a second field, which consists of the first two lines as counted from the second line, are output as follows:

First Field

$Cy_{1.1}+Gr_{1.2}$, $Ye_{2.1}+Mg_{2.2}$, $Cy_{3.1}+Gr_{3.2}$, $Ye_{4.1}+Mg_{4.2}$, . . .
$Cy_{1.3}+Mg_{1.4}$, $Ye_{2.3}+Gr_{2.4}$, $Cy_{3.3}+Mg_{3.4}$, $Ye_{4.3}+Gr_{4.4}$, . . .
$Cy_{1.5}+Gr_{1.6}$, $Ye_{2.5}+Mg_{2.6}$, $Cy_{3.5}+Gr_{3.6}$, $Ye_{4.5}+Mg_{4.6}$, . . .
$Cy_{1.7}+Mg_{1.8}$, $Ye_{2.7}+Gr_{2.8}$, $Cy_{3.7}+Mg_{3.8}$, $Ye_{4.7}+Gr_{4.8}$, . . .

Second Field

$Gr_{1.2}+Cy_{1.3}$, $Mg_{2.2}+Ye_{2.3}$, $Gr_{3.2}+Cy_{3.3}$, $Mg_{4.2}+Ye_{4.3}$, . . .
$Mg_{1.4}+Cy_{1.5}$, $Gr_{2.4}+Ye_{2.5}$, $Mg_{3.4}+Cy_{3.5}$, $Gr_{4.4}+Ye_{4.5}$, . . .
$Gr_{1.6}+Cy_{1.7}$, $Mg_{2.6}+Ye_{2.7}$, $Gr_{3.6}+Cy_{3.7}$, $Mg_{4.6}+Ye_{4.7}$, . . .
$Mg_{1.8}+Cy_{1.9}$, $Gr_{2.8}+Ye_{2.9}$, $Mg_{3.8}+Cy_{3.9}$, $Gr_{4.8}+Ye_{4.9}$, . . .

As stated above, in the second image taking mode, the image taking apparatus of this embodiment does not perform the addition of two vertically adjacent pixels in the image taking sensor **106** is not conducted, and the optically stored signal of each pixel is output as it is. The total data is output line by line through interlace output in the period of two fields, or separately in upper and lower halves.

FIG. **7** is a flowchart illustrating the operation of the image taking apparatus of FIG. **5**. As shown in FIG. **7**, first, in step **P1**, the image taking mode is set to the first image taking mode, which is a moving picture taking mode, by the system controller **108**, and the image taking sensor **106** is operated in this image taking mode.

Then, the image signal taken is subjected to signal processing by the signal processing means **117**, and supplied to the D/A converter **120** without being stored in the first memory **118**. Subsequently, in step **P2**, the image signal converted to an analog signal is encoded by the encoder **121**, and output as a video signal, thereby displaying the moving picture taken.

Next, in step **P3**, a judgment is made as to whether the operating switch **109** has been manipulated or not, and the moving picture taking mode is maintained until the operation in a still picture taking mode is performed by the operating switch **109**. When the operating switch of the second image taking mode, which is the still picture taking mode, is depressed, the image being taken in the moving picture taking mode is stored in the first memory **118** (step **P4**), and, at the same time, read and displayed (step **P5**).

As a result of the above operation, in the next step **P6**, the display is changed from the moving image which has been taken by the image taking sensor **106** to the still image stored in the first memory **118**. After this, the image taking mode is switched to the still picture taking mode, that is, the second image taking mode.

In the second image taking mode, the image taking sensor **106** operates in the still picture taking mode, and the

changeover switch **115** is switched to the side where the input image signal is transmitted to the second memory **132**. The image signal taken by the image taking sensor **106** in this still picture taking mode is stored in the second memory **132** as independent data on each pixel (step **P7**).

Then, the image data stored in the second memory **132** is read by the system controller **8** and subjected to computation processing to be thereby converted to luminance two-color difference data or RGB data (step **P8**). Here, the signal processing computation is advantageous when separately performing color processing for a so-called image processing, or color processing for printing, that is, a processing that is not a signal processing optimized for the purpose of monitor display as in the case of first signal processing section **117**, for example, a processing for realizing an enhanced resolution.

In this embodiment, the second signal processing section is formed by a software based on the system controller **108** to perform a processing as mentioned above. However, it is also possible to realize the above signal processing section in the form of a hardware.

FIG. **8** shows the fifth embodiment of the present invention. In FIG. **8**, numeral **104** indicates a rotatable plane parallel plate for moving the optical axis; and numeral **105** indicates control means for controlling the rotatable plane parallel plate **104**. Apart from the above, the image taking apparatus of this embodiment has the same construction as that shown in FIG. **5**.

In the image taking apparatus of FIG. **8**, the rotatable plane parallel plate **104** is arranged between the group consisting of lens **101** and the aperture **102** and the image taking sensor **106**. This rotatable plane parallel plate **104** is rotated around two axes perpendicular to the optical axis. This makes it possible to move the optical image formed on the image taking sensor **106**. By controlling the angle of rotation of the rotatable plane parallel plate **104** by the control means **105**, it is possible to move the optical image formed on the image taking sensor **106** by a desired movement amount.

FIG. **9** is a diagram showing that an optical image is moved by rotating the plane parallel plate around an axis parallel to the optical axis. Symbol θ indicates the angle of rotation of the plane parallel plate **104**, and symbol d indicates the movement amount of the optical image. The movement amount d of the optical image is a function of the refractive index n, thickness T, and angle of rotation θ of the plane parallel plate **104**.

When a particular plane parallel plate **104** is selected, the refractive index n and the thickness T are uniquely determined. Thus, the movement amount d of the optical image is a function of the angle of rotation θ only, as expressed by the following equation:

$$d = (\theta, n, T) \tag{1}$$

$$d = T\sin\theta\left(1 - \frac{\cos\theta}{\sqrt{(n^2 - \sin^2\theta)}}\right) \tag{2}$$

When the value of θ is small, the following approximation holds true:

$$d \text{ is} = T\left(1 - \frac{1}{n}\right)\sin\theta \tag{3}$$

In expression (3), when the value of θ is small, linear approximation of sin θ is substantially possible, whereby the amount of movement d of the optical image can be easily obtained from the angle of rotation θ of the plane parallel plate **104**.

$$\theta = \sin^{-1}\left\{T\left(1 - \frac{1}{n}\right)\right\} \tag{4}$$

In FIG. **8**, the operation in the first image taking mode is the same as that in the first embodiment. In the second image taking mode, the image taking sensor **106** performs no pixel addition, but the optical storage data of each pixel is output. Further, the storage in the second memory **132** is repeated a plurality of times while controlling the plane parallel plate **104** by the control means **105**.

By the above operation, image signals are taken in while effecting pixel shift, and the image signals thus taken in are subjected to computation processing, such as color processing, whereby a high-resolution image can be obtained. Actually, the movement of the plane parallel plate **104** is controlled such that the optical image on the plane parallel plate **104** moves one pixel to the left, one pixel downwards, and one pixel to the right, the image signal obtained by image taking in each position being stored in the second memory **132**.

In this way, the optical image is moved one pixel at one time, and stored in the memory at each position, whereby filter data of the four colors (Cy, Ye, Mg and Gr) is stored in the second memory **132**. Due to this arrangement, four-color data exists in each pixel, so that computation processing is possible for each pixel, thereby making it possible to enhance the resolution as compared with that of a single-plate color sensor.

Next, an image taking example when the pixel shift is effected while moving the plane parallel plate **104** will be described with reference to FIG. **10**. FIG. **10**(*a*) shows an image taking using a complementary color mosaic filter. First, image data taken in this condition is stored in the second memory **132**. FIG. **10**(*b*) shows the condition in which the plane parallel plate **104** is rotated from the position of FIG. **10**(*a*) so as to shift the image one pixel to the left. The broken line indicates the range of the moved optical image.

FIG. **10**(*c*) shows the condition in which the plane parallel plate **104** is rotated from the position of FIG. **10**(*b*) so as to shift the image one pixel upwards. FIG. **10**(*d*) shows the condition in which the plane parallel plate **104** is rotated from the position of FIG. **10**(*c*) so as to shift the image one pixel to the right. Through these four positions, it is possible to store four kinds of image data obtained by moving the optical image upwards, downwards, to the right and to the left, one pixel at one time.

FIG. **11** is a flowchart for illustrating the operation of an image taking apparatus according to the fifth embodiment.

In FIG. **11**, first, in step **P1**, the operation mode is set to the moving picture taking mode (that is, the first image taking mode), and the image taking sensor **106** is operated in this image taking mode.

The image signal taken is then subjected to signal processing by the first signal processing means **117**, and supplied to the D/A converter **120**, without being stored in he first memory **118**, thereby converting the image signal to an analog signal. The image signal thus converted to an analog signal is then supplied to the encoder **121** and encoded before it is displayed as a video signal (step **P2**).

Next, the procedure advances to step **P3**, where a judgment is made as to the still picture mode has been set through key operation or not, and this image taking mode is main-

tained until the operation mode is set to the still picture taking mode by using the operating switch **109**.

When the still picture taking mode (the second image taking mode) switch is depressed, the image which has been taken in the moving picture taking mode is stored in the first memory **118** (step P4), which is read out for display (step P5). Next, in step P6, the display is switched from the image taken by the image taking sensor **106** to the image stored in the first memory **118**, and then the moving picture taking mode is switched to the still picture taking mode (that is, the second image taking mode).

In the still picture taking mode, the image taking sensor **106** operates in the still picture taking mode, and the changeover switch **115** is switched to the position in which the image signal is transmitted to the second memory **132**. The image signal taken by the image taking sensor **106** in the still picture taking mode is stored in the second memory **132** as independent data on each pixel (step P7).

Subsequently, the procedure advances to step P8, in which the plane parallel plate **104** is rotated under the control of the control means **105** so as to shift the optical image formed on the image taking sensor **106** one pixel to the left to attain the condition of FIG. **10**(*b*), which is stored in the second memory **132**.

Similarly, in the next step, P9, the optical image is shifted one pixel upwards to attain the condition of FIG. **10**(*c*), which is stored in the second memory **132**. Similarly, the optical image is shifted one pixel to the right to attain the condition of FIG. **10**(*d*), which is stored in the second memory **132** (step P10). Finally, the optical image is shifted one pixel downwards to restore the optical image to the original position (step P11).

In this way, the plane parallel plate **104** is used to take in image data four times, while shifting the image one pixel at one time. By using the image data thus taken in four times, the system controller **108** reads the data and performs computation processing to convert the data to luminance two-color difference data or RGB data.

Unlike the signal processing conducted when forming a color image with a single plate sensor, the signal processing compntation conducted here enables a color image signal to be formed through a simple matrix compntation since every pixel is provided with four color (Cy, Mg, Ye and Gr) data. Thus, it is possible to form an image signal of a higher resolution as compared to the image signal obtained by the single place sensor.

While in this example the second signal processing section is formed by a software based on the system controller **108**, it is also possible for the second signal processing section to be realized in the form of a hardware.

Further, while in the fifth embodiment the pixel shift is conducted by using the plane parallel plate **104**, a similar pixel shift is also possible by lens shift (in which one or a plurality of lenses of a plurality of lenses are shifted perpendicularly with respect to the optical axis), or by using a variable-apex-angle prism.

Further, while in the fifth embodiment one-pixel shift is effected four times to thereby enhance resolution, it is also possible to attain a further enhancement of resolution by effecting ½ pixel shift four times both vertically and horizontally, i.e., sixteen times in total.

Next, an image taking apparatus according to a sixth embodiment of the present invention will be described. FIG. **12** is a schematic diagram showing an image taking apparatus according the sixth embodiment. According to the sixth embodiment, the image taking apparatus is divided into a camera head section and a camera signal processing section, thereby making it possible to selectively connect a plurality of camera head sections.

In FIG. **12**, numeral **1101** indicates a first camera head section; numeral **1102** indicates a second camera head section; and numeral **1103** indicates a third camera head section. Numeral **1110** indicates a camera signal processing section; numeral **1111** indicates a host computer; numeral **1112** indicates a monitor for display; nnmerals **1121**, **1122** and **1123** indicate signal cables for connecting the camera head sections to the signal processing section; numeral **1125** indicates a signal cable for connecting the host computer to the camera signal processing section; and numeral **1126** indicates a video cable.

FIGS. **13** and **14** are block diagrams showing camera head sections. FIG. **15** is a block diagram of the camera signal processing section. The camera head section of FIG. **13** is a camera head in which no pixel shift is effected, the camera head section of FIG. **14** is a camera head in which pixel shift is effected to thereby attain an enhanced resolution. In FIGS. **13**, **14** and **15**, numeral **140** indicates an amplifier; numeral **141** indicates an image signal transmission line; numeral **142** indicates a signal line for transmitting a synchronous signal generated by the synchronous signal generator **107**; numeral **143** indicates a control unit (MPU) for controlling the operation of the camera head sections; and numeral **144** is a signal line for connecting between the control unit **143** and the camera system controller **145**.

In the sixth embodiment, the camera head and the signal processing section are separated from each other, so that it is possible to freely combine a plurality of kinds of camera heads. Thus, through combinations of the camera heads and the signal processing section, it is possible to construct, for example, an image taking system in which only one image taking mode is supported, or an image taking system in which high resolution image taking is possible.

As described above, in accordance with the present invention, a plurality of moving picture taking modes are provided for the image taking sensor, and, at the same time, at least two kinds of signal processing sections are provided in correspondence with the above-mentioned plurality of moving picture taking modes to perform signal processing separately in each of these moving picture taking modes, so that it is possible to satisfactorily conduct the signal processing for monitor display and other image signal processing operations.

Further, an optical axis moving means is provided, by means of which the respective signals of the pixels of the image taking sensor can be independently extracted, thereby making it possible to perform image taking at high resolution.

Further, by separating the camera head and the signal processing section from each other, it is possible to freely combine a plurality of types of camera heads, and, through appropriate combination of these camera heads, it is possible to realize, for example, an image taking system in which only one image taking mode is supported, or an image taking system that is capable of image taking at high resolution.

Further, regarding the optical axis moving means, it can be realized without involving an increase in the size of the optical system in the case of the lens shifting method. In the case of the method using a variable-apex-angle prism, it is possible to move the optical axis to a great degree. In the case of the method in which the plane parallel plate is rotated, it is possible to effect fine changes relatively easily.

FIG. **16** is a block diagram of the seventh embodiment of the present invention. In the drawing, the components which are the same as those of FIGS. **1** through **15** are indicated by

the same reference numerals. Numeral **3** indicates a shutter, and numeral **215** indicates a first memory.

Next, the operation of this embodiment will be described. In FIG. **16**, when the shutter **12** is opened, the sensor **10** is exposed, and, in accordance with the synchronous signal generated by the first synchronous signal generator **7**, driving pulses for the sensor **10** are generated by the timing generator **12**, and the electric charge stored in the sensor **10** is read out. The SH,AGC circuit **13** eliminates switching noise from the high resolution signal read out by the sensor **10**. After sample-and-hold and AGC for extracting the signal component, the image signal is converted to digital data by the 10-bit A/D converter **14**.

The image data converted to digital data by the A/D converter **14** is stored in a first memory **215** under the control of the first memory controller **16**. Here, the image signal read from the sensor **10** is stored as it is in the first memory **215**. After this, in the first color processing section **17**, color conversion is effected to convert the data to luminance two-color difference (YUV) data, which is stored in the second memory **18** for YUV.

When reading data stored in the first memory **215** and subjecting it to color processing, a color processing circuit for video cannot be used, and it is necessary to conduct color conversion with software or provide a dedicated computation circuit like DSP. Thus, in reality, this stage take a lot of time. The image signal converted to luminance two-color difference (YUV) data is compressed by the compression/expansion section **20** as needed before it is supplied to the file of the storage device **22** through the interface **21**. When the data read from the file is compressed data, it is expanded by the compression/expansion section **20**.

Next, when previewing the image taken by the sensor **10**, the image data stored in the first memory **215** is read under the control of the first memory controller **16** in accordance with the synchronous signal generated by the ordinary synchronous signal generator for television **8**, and input to the second color processing section **31**. Here, the image of 1536×988 pixels is compressed to ½ and read as an image of 768×494 pixels. By thus reducing the number of pixels to 768×494, the same condition as in the case of a CCD sensor that is widely used in ordinary television sets is obtained.

This ½ reduction can be effected in various ways, such as thinning-out by half, a reduction in information amount by performing averaging with respect to each filter, a reduction by interpolation, or by simply reading exclusively the area corresponding to ½.

Since the input signal of the second color processing section **31** is obtained by reading image data stored in the first memory **15** in synchronization with an ordinary synchronous signal for television, it is possible to use a color conversion circuit widely used in video cameras, etc. for this color processing section. Therefore, the processing in this section can be performed in a short time. The image signal converted to luminance two-color difference (YUV) data by the second color processing section **31** is converted to an analog signal by the D/A converter **32**, and modulated into a video signal for an ordinary television system by the encoder **33** before it is output as the video signal **34** and displayed on a video monitor (not shown).

FIG. **17** is a block diagram showing the construction of the first memory **215** and that of the first memory controller **16** in detail.

In FIG. **17**, numeral **241** indicates digital image data obtained by conversion at the A/D converter **14**; numeral **242** indicates an input buffer to the first memory **215**; numeral **243** indicates a memory section of the first memory **215**; numeral **44** indicates a first output buffer of the memory section **243**; numeral **45** indicates an output signal from the memory section **243** to the first color processing section **17** of FIG. **16**; numeral **46** indicates a second output buffer of the memory section **243**; and numeral **47** indicates an output signal from the memory **243** to the second color processing section **31**.

Numeral **48** indicates an address mulitplexer for the memory section **243**; numeral **49** indicates a write address generator for generating an address signal for storing image data in the memory section **243** in accordance with the synchronous signal generated by the first synchronous signal generator **7**; and numeral **50** indicates a read address generator for generating an address for reading image data from the memory section **243** in accordance with the synchronous signal generated by the second synchronous signal generator **8**.

Numeral **51** indicates a read/write address generator for generating a read/write address for conducting color processing in the first color processing section **17** and reading and writing image data of the memory section **243** through the interface **21**; numeral **52** indicates a memory access arbitrator for avoiding conflict in access in the memory section **243**; and numeral **53** indicates a request signal for reading/writing image data of the memory section **243** through the interface **21** in order to perform color processing in the first color processing section **17**.

Next, the operation of this embodiment will be described. In FIG. **17**, the image taken by opening the shutter is A/D-converted in accordance with the synchronous signal generated by the first synchronous signal generator **7**, and the image data **241** is input to the memory section **243** through the input buffer **242** of the memory **215**. At the same time, a write address for writing into the memory section **243** is generated by the write address generator **49** in accordance with the synchronous signal generated by the first synchronous signal generator **7**, and image data transmitted through the input buffer **42** is stored in a predetermined address in the memory section **243**.

The image data stored in the memory section **243** is read from the memory section **243** in accordance with the synchronous signal generated by the second synchronous signal generator **8** and in accordance with the address generated by the read address generator **50**. In this process, a number of pixels corresponding to ½ in the X and Y-directions of the stored image data are read out.

The thinning-out to ½ can be effected, for example, by a method according to which the two address counters of X and Y are incremented by two at one time, or a method according to which the two address counters of X and Y count in the normal manner, and the data obtained is shifted by 1 bit (doubled) before it is supplied to the memory section **243**. In another method for ½ reduction, a reduction can be effected through computation instead of by thinning out. When exclusively an area corresponding to ½ is simply read, a start address for specifying the area to be read out is provided, and the X and Y-address counting is conducted with the start address as offset, thereby making it possible to read a ½ area.

By reading image data stored in the memory section **243** in accordance with the address generated by the read address generator **50**, the image data is transferred to the second color processing section **31** through the second output buffer **46**, whereby, as described with reference to FIG. **16**, the data is output through the second color processing section **31**, the D/A converter **32** and the encoder **33** as the video signal **34**, thereby making it possible to check the taken image on a video monitor.

When the framing, etc. of the taken image has been checked in this way through the television monitor, the image data stored in the memory **243** is read out in accordance with the address generated by the write/read address generator **51**, and subjected to color conversion by the first color processing section **17** through the first output buffer **44**. Here, the memory access arbitrator **52** serves to perform arbitration between the three access requests from the first synchronous signal generator **7** during image taking, the second synchronous signal generator **8** for video output, and the request signal **53** for the operation of the first color processing section **17**.

The second synchronous signal generator **8** for video output constantly generates an access request to constantly supply data to the video monitor. However, the access request from the first synchronous signal generator **7** during image taking and the request signal **53** for the processing in the first color processing section **17** are generated only once, that is, during image taking and color processing, respectively, so that no conflict in access occurs between them. Thus, it is only necessary to perform arbitration between the access by the second synchronous signal generator **8** and the other accesses. This arbitration can be easily effected by a well-known method, such as cycle stealing using a high-speed memory device.

FIG. **18** shows the eighth embodiment of the present invention. In the drawing, numeral **35** indicates a third memory; numeral **36** indicates a third memory controller for controlling the third memory **35**; and numeral **37** indicates a third color processing section for performing color processing. The third color processing section **37** has first and second color processing modes respectively corresponding to the first and second color processing sections **17** and **31**, so that it is capable of color processing in both modes. This can be realized on a software basis by using a computation processor, such as DSP.

As in the case of FIG. **16**, when the shutter **2** is opened, the sensor **10** is exposed, and driving pulses for the sensor **10** are generated by the timing generator **12** in accordance with the synchronous signal generated by the first synchronous signal generator **12**. Then, the electric charge accumulated in the sensor **10** is read out, and subjected to sample-and-hold and AGC by the SH,AGC circuit **13** for removal of switching noise and extraction of signal component. The data thus obtained is converted to digital data by the 10-bit A/D converter **14**, and stored in the first memory **215** under the control of the first memory controller **16**. Here, the image data read out from the sensor **10** is stored in the first memory **215** as it is.

The image data stored in the first memory **215** is read as image data with its amount reduced to ½ both vertically and horizontally in accordance with the synchronous signal generated by the second synchronous signal generator **8**, and subjected to color processing in the second color processing mode by the third color processing section **37** to the converted to luminance two-color difference (YUV) data before it is stored in the third memory **35**. The luminance two-color difference (YUV) data stored in the third memory **35** is read by the third memory controller **36** in accordance with the synchronous signal generated by the second synchronous signal generator **8**, and converted to an analog signal by the D/A converter **32**. After this, it is modulated by the encoder **33** and output as the video signal **34** before it is displayed on a video monitor (not shown).

Next, all the image data is read out from the first memory **215**, and subjected to color conversion in the first color processing mode by the third color processing section **37** to be converted to luminance two-color difference (YUV) data, which is stored in the second memory **18** for YUV. The image data converted to luminance two-color difference (YUV) data is compressed by the compression/expansion section **20** as needed, and converted into the file of the storage device **22** through the interface **21**.

FIG. **19** shows the ninth embodiment of the present invention. In FIG. **19**, no shutter is placed in front of the sensor **10**, and the first synchronous signal generator **7** is constantly operating, with the sensor **10** constantly performing image taking. However, since the number of pixels of the sensor **10** is large, the image signal taken cannot be read at such a speed as in the case of ordinary NTSC or PAL video signals. It is read at a rate of approximately 15 frames per second. As in the case of he image signal read from the sensor **10** is transmitted by way of the SH,AGC circuit **13** and the 10-bit A/D converter **14**, and stored in the first memory **215**. In this case, data is read from the sensor **10** constantly and continuously, so that the first memory **215** is constantly updated with new image data.

The high resolution image stored in the first memory **215** and updated is read out, with the number of pixels reduced to 768×988, in accordance with the synchronous signal generated by the second synchronous signal generator **8**, that is, the synchronous signal of an ordinary synchronous signal generator for television. The image data read out from the first memory **215** in synchronization with the synchronous signal of the second synchronous signal generator **8** is color-converted by the second color processing section **31**, and transmitted by way of the D/A converter **32** and the video signal encoder **33** before it is output as the video signal **34**.

Further, the image signal constantly taken by the sensor **10** is monitored by a video monitor (not shown) to which the above video signal **34** is supplied, and, at the same time, triggering is effected when necessary by manual operation (not shown) or the like to read the image data stored in the first memory **215** to convert it into the file or output it through the interface **21** as digital data to perform processing, such as color processing, in the exterior.

In still another embodiment, a number of taken images are stored in the file of the storage device **22** in FIGS. **16** and **19**, and, prior to reproducing the images, they are temporarily stored in memory. This data is read in accordance with the second synchronous signal generator **8**, and subjected to color processing by the second color processing section, whereby the checking and retrieval of the images filed by the images due to the output video signal **34** can be performed easily and quickly.

In accordance with the present invention, the image taking device is driven by the synchronous signal of the first synchronous signal generator, and the image signal thereby obtained is A/D-converted and temporarily stored in the memory. The image signal thus stored is read by the synchronous signal of the first synchronous signal generator and color-converted by the first color processing section. On the other hand, the memory is read with the synchronous signal of the second synchronous signal generator. Thus, even in the case of an image taking device consisting of a high-resolution sensor, it is possible to check an image immediately by a video monitor. Further, as compared to the case in which the high-resolution image is subjected to color processing as it is, the present invention is advantageous in that, due to the addition of a compact and inexpensive circuit, it is possible to immediately check the framing, the exposure of the taken image, focusing, etc. Further, when reproducing a number of taken images stored in a file, the filed image can

be checked, retrieved, etc. easily and instantly by using a video monitor before this file is read out and subjected color processing to be reconstructed as a picture.

What is claimed is:

1. An image sensing apparatus comprising:

optical-axis deflecting means for deflecting an optical axis of an optical system;

image sensing means for converting an image formed by the optical system on an image sensing plane to an image signal;

first signal processing means for performing a first predetermined signal processing on the image signal output from said image sensing means, the first predetermined signal processing including storing the image signal in a first memory;

second signal processing means for causing said optical-axis deflecting means to deflect the optical axis to a plurality of positions and for performing a second predetermined signal processing for combining the image signals on the image signals output from said image sensing means corresponding to a plurality of deflected positions of said optical-axis deflecting means, the second predetermined signal processing including storing the combined image signals in a second memory;

mode selecting means for selecting a first signal processing mode causing said first signal processing means to perform the first predetermined signal processing and a second signal processing mode causing said second signal processing means to perform the second predetermined signal processing; and

control means, in the second signal processing mode, for causing said second signal processing means to perform the second predetermined signal processing and outputting an image signal output from said first memory of said first signal processing means during performing of the second predetermined signal processing by said second signal processing means using said second memory.

2. An image sensing apparatus according to claim **1**, wherein, in the first signal processing mode, said image sensing means reads image signals corresponding to two vertically adjacent lines and outputs a signal obtained by adding image signals corresponding to two vertically adjacent pixels, and, in the second signal processing mode, said image sensing means outputs a signal for each pixel, without performing addition of image signals.

3. An image sensing apparatus according to one of claims **1** and **2**, wherein said image sensing means comprises an image sensing device and a complementary color mosaic filter.

4. An image sensing apparatus according to one of claims **1** or **2**, wherein said image sensing means comprises a CCD.

5. An image sensing apparatus according to one of claims **1** or **2**, wherein said optical-axis deflecting means comprises a variable-apex-angle prism.

6. An image sensing apparatus according to one of claims **1** or **2**, wherein said optical-axis deflecting means comprises means for shifting a lens.

7. An image sensing apparatus according to one of claims **1** or **2**, wherein said optical-axis deflecting means comprises a parallel-plate rotating system.

8. An image sensing apparatus according to claim **1**, wherein the optical system and said image sensing means are selectively separable from said first and second signal processing means while being connectable together through a cable.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,018,363

DATED : January 25, 2000

INVENTOR(S) : HIROYUKI HORII

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

IN THE DRAWINGS

Sheet 16, Figure 17, "ARBITORATOR" should read --ARBITRATOR--.

COLUMN 3

Line 49, "shift," should read --shift.--; and

Line 55, "through 11," should read --through 8,--.

COLUMN 4

Line 20, "on" should read --of--;

Line 22, "on" should read --of--;

Line 25, "on" should read --of--; and

Line 35, "on" should read --of--;

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,018,363

DATED : January 25, 2000

INVENTOR(S) : HIROYUKI HORII

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

COLUMN 5
Line 9, "a" (first occurrence) should read --an--; and
Line 11, "taking" should read --taking apparatus--.

COLUMN 8
Line 27, "to" should read --to output--.

COLUMN 10
Line 24, "a" (first occurrence) should read --an--.

COLUMN 11
Line 52, "in" should read --of--; and
Line 59, "in" should read --of--.

COLUMN 12
Line 7, "FIG; 2" should read --FIG. 2--.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,018,363

DATED : January 25, 2000

INVENTOR(S) : HIROYUKI HORII

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

COLUMN 14
Line 60, "he" should read --the--; and
Line 66, "to" should read --to whether--.

COLUMN 17
Line 17, "take" should read --takes--.

COLUMN 20
Line 15, "he" should read --the--.

COLUMN 21
Line 2, "subjected" should read --subjected to--.

Signed and Sealed this

Thirteenth Day of March, 2001

Attest:

Nicholas P. Godici

NICHOLAS P. GODICI

Attesting Officer

Acting Director of the United States Patent and Trademark Office

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(54) **Apparatus for recording and reproducing digital image and speech**

Vorrichtung zur Aufnahme und Wiedergabe von digitalem Bild und Ton

Dispositif pour enregistrer et reproduire des images et du son numériques

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- **TONOMURA Y. ET AL: 'CONTENT ORIENTED VISUAL INTERFACE USING VIDEO ICONS FOR VISUAL DATABASE SYSTEMS' JOURNAL OF VISUAL LANGUAGES AND COMPUTING, LONDON vol. 1, January 1990, pages 183 - 198, XP000195706**

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

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EP 0 802 688 B1

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to operativity of a portable digital camcorder.

[0002] The prior art relevant to the portable digital comcorder has been published as an electronic photograph system, that is, the so-called electronic still camera that is arranged to record a still image signal as a video signal in a memory composed of a semiconductor (termed as a semiconductor memory or simply a memory) as disclosed in JP-A-2-292974. With recent prevail of personal computers, recording mediums such as semiconductor memories and harddisks are progressively made lower in cost, smaller in size, and greater in capacity. At a time, the advance of signal compressing technology such as JPEG or MPEG allows even the small-sized equipment to record greater number of still images and moving ones. Taking a harddisk drive as an example, the resulting harddisk drive is kept as small as a card and has as great a capacity as about 300 Mbytes.

[0003] This type of harddisk drive enables to record about 3000 still images through the use of the JPEG compression and about 20-minutes moving picture through the use of the MPEG compression. It is thus necessary to improve the operativity of the portable equipment for retrieving, grouping, and deleting a great deal of recording data. The technique disclosed in JP-A-2-292974, however, does not provide means for retrieving a great deal of recording data quickly and easily. In actual, therefore, the technique does not have any means except the method of retrieving the great deal of recorded data as checking all images reproduced on screen from the recorded data.

[0004] In case that 3000 JPEG still images are recorded on a feasible media such as the aforementioned harddisk drive and then are retrieved as expanding those images on the screen one by one, about one second for expanding one JPEG still image is required. It means that the expansion of 3000 images needs about one hour. This method lacks in practicability. In order to retrieve a great deal of data, therefore, it is necessary to enhance the operating speed of the system.

SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to provide a camcoder which is arranged to overcome the foregoing shortcoming and enhance the operativity even if the camcoder is small-sized.

[0006] In carrying out the object, for improving the operativity of a small-sized camcoder, the present invention is achieved by a camcoder as set out in claim 1.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

Fig. 1 is a diagram showing a state transition of a program used in an apparatus according to the present invention;

Fig. 2 is a view showing an outer appearance of a portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 3 is an expanded view showing an operating switch portion provided in the portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 4 is a circuit diagram showing an arrangement of a portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 5 is a view showing a display screen provided in the portable digital camcorder in which the program of Fig. 1 is executed;

Fig. 6 is a view showing a display screen on which the recorded data is classified;

Fig. 7 is a view showing a display screen on which the recorded data is selected;

Fig. 8 is a view showing a display screen with expanded images in which the recorded data is selected;

Fig. 9 is a view showing a display screen on which the function details of the recorded data are selected;

Fig. 10 is a flowchart showing a method for selecting the function details;

Fig. 11 is a view showing a display screen on which the classifications of the recorded data are changed;

Fig. 12 is a view showing a display screen on which the displaying sequence of the recorded data is changed;

Fig. 13 is a view showing a display screen on which each date of the recorded data is changed;

Fig. 14 is a view showing a display screen on which each erasing attribute of the recorded data is changed;

Fig. 15 is a view showing a display screen on which a remaining state of the recording medium is displayed;

Fig. 16 is a flowchart showing a method for reading recorded data from a harddisk driver and reproducing it;

Fig. 17 is a view showing an imaged screen appearing if a still image recording mode is selected when recording an image;

Fig. 18 is a view showing an imaged screen appearing if a moving image recording mode is selected when recording an image; and

Fig. 19 is a view showing marks for modes;

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0008] Later, the description will be oriented to the embodiments of the present invention with reference to Figs. 1 to 19.

[0009] Fig. 1 shows a flow of a software program according to an embodiment of the present invention.

[0010] The software program shown in Fig. 1 flows

through the process of selecting a classification containing data to be played back or handled (101) and reaches the process of playing back the data (103) or flows to a function selecting items (105) in which a temporary discard (106), a complete abandon (107), a state display (112) of a storage unit, setting of protection from erasion (111), change of a display list (109), or change of a record date and hour (110) is selected. Moreover, when selecting a classification (101), the flow goes to the function selecting items (105) in which a temporary discard (106), a complete abandon (107), a state display of a storage unit (112), or automatic playback is selected. In the playback (103), a move to next data (115), a move to previous data (116), a fast playback (117), a rewind playback (118), or a temporary stop (121) is selected. In the temporary stop (121), a forward frame advance (119) or reverse frame advance (120) is selected.

[0011] Fig. 2 shows an example of an outer appearance of a portable digital comcorder 200 in which the software program shown in Fig. 1 is executed. This comcorder 200 provides a capability of recording and reproducing an NTSC or PAL TV system signal.

[0012] Fig. 3 is an expanded view showing an operating switch portion of the portable digital camcorder shown in Fig. 2. In the portable digital camcorder 200 shown in Fig. 2, with the operating switches, a digital moving signal obtained from the camera system is compressed to one MPEG (Moving Picture Expert Group) format and then is recorded on a harddisk storage medium sized to a memory card. In the playback, with the operating switches, the MPEG1 format signal recorded in a memory card is expanded and then displayed on a display unit 201 built in the camcorder itself. The display unit may be connected to the outside of the comcorder 201. The portable digital camcorder 200 shown in Fig. 2 may recorded the MPEG moving image data as well as the JPEG data for the still images and the MPEG speech format for the speech data.

[0013] Fig. 4 schematically shows a circuit arrangement of the portable digital comcorder 200. At first, the description will be oriented to the procedure of recording the moving image through the portable digital comcorder 200. When a user presses a recording switch 301, an image of an object obtained through a lens 401 is converted into the corresponding electric signal through the effect of a CCD sensor 402. The signal read out of a sensor is electrically processed through a CDS (Correlated Double Sampling) circuit for suppressing the low-frequency noises of the signal and a circuit 403 integrated with a AGC circuit for controlling an automatic gain of the signal for stabilizing the signal level. Then, the processed signal is converted into a digital signal through an ADC 404 and then is applied to a camera signal processing circuit 405.

[0014] A camera signal processing circuit (camera DSP) 405 is configured of a function of converting a digital pixel signal from the sensor into a luminance signal Y and color difference signals U and V, a function of adding a synchronous signal, a function of controlling relation between an iris and a shutter speed, a function of adjusting a white balance, and a function of digitally zooming in or out the signal. Though not illustrated in detail in Fig. 4, the camera DSP 405 is operated to feed a horizontal and a vertical driving signal pulses to the CCD sensor 402 and read the signal from the CCD sensor 402 as adjusting the timing between the synchronous signal and the pulses. Moreover, a camera control microcomputer 406 is operated to feed operating parameters for the DSP 405 to the camera DSP 405 in order to control the overall camera system.

[0015] On the other hand, the digital luminance signal Y and the digital color difference signals U and V obtained by the camera DSP 405 are sent to an MPEG1 encoder 409 through a digital bus line. The MPEG1 is a standard compression format for the digital signal for a moving image. The encoder 409 operates to compress the data according to the MPEG1 format and then convert it into the digital data. A numeral 410 denotes a working memory used in encoding the data according to the MPEG1 format. The data converted into the MPEG1 format is sent to a microcomputer 411 for controlling a transmission rate of the digital output data. The MPEG1 encoder 409, the working memory 410 and the microcomputer 411 compose the overall system for compressing the moving image.

[0016] The microcomputer 411 for controlling the transmission rate stores a constant amount of MPEG1-formatted data in a buffer memory 412. The formatted data is passed through an interface circuit 413 and a card connector 414 and reaches a harddisk drive 415. The card connector 414 is configured on the PCMCIA standards and thus contains 68 pins. The harddisk drive 415 is sized to a memory card and subject to the PC card standards defined by the PCMCIA (Personal Computer Memory Card International Association).

[0017] The foregoing description has concerned with the method for recording the moving image. In case the still image recording mode is selected by the user, the MPEG encoder 409 is switched to a JPEG compressing circuit. Then, a still image data is generated at the encoder 409 and then transferred to the microcomputer 411 for doing the same operation as described above. The MPEG compression data process and the JPEG compression data process have the same common points, so that the use of both the data formats may effectively save the circuit scale. This is a well-known method for saving the circuitry.

[0018] Further, the speech signal is converted into an analog electric signal through a microphone 418. The analog electric signal is sent to a speech ADC 419 for converting the analog electric signal into the corresponding digital data. The digital speech data is applied into the data bus through the effect of the MPEG encoder 409. Then, the microcomputer 411 performs the MPEG-format-based compression through the program run therein so that the digital speech data is added to the

moving image data or the still image data in precise time sequences.

[0019] According to this embodiment, the portable digital comcorder 200 is arranged to record the MPEG1-formatted data, the JPEG-formatted data, and the MPEG1-formatted speed data.

[0020] In recording the data, the microcomputer 411 also enables to record a data, a time, and a symbol for representing any one of the MPEG1-formatted data, the JPEG-formatted data, and the MPEG1-formatted data on a time when the recording switch 301 is pressed. At a time, the microcomputer 411 enables to record a symbol for representing a classification for retrieving the recorded data and a symbol for representing whether or not the operation of erasing the recorded data is prohibited. In recording the data, the classification symbol is recorded as "not classified" and the deletion symbol is recorded as "erasable".

[0021] In the general disk operating system, the symbol for indicating the imaging mode is discriminated using a code for a data type. The symbol for representing the classification and the symbol for representing if the data is erased are recorded in the corresponding files.

[0022] On the other hand, when recording the data, a digital signal applied to the camera DSP 405 as a monitoring signal is converted into an analog TV signal through the effect of an NTSC or PAL encoder built in the circuit 405 and then is fed at an output terminal 416 and the built-in display unit 201. The foregoing description has concerned with the MPEG1-formatted moving image data with the speech. In actual, the JPEG-formatted data or the MPEG1-formatted speech data may be solely processed in the similar manner to the above operation.

[0023] When the system stays at the playback mode, the signal flows in an opposite manner to the flow at the recording mode. Fig. 16 is a flowchart showing the reproduction of the signal. Text data indicating information of data is read from the harddisk drive 415 (step 1601). Next, the user retrieves data from a list of data displayed on the built-in display unit 201 and specifies the data to be played back with the operating switch 408 (step 1604). The list of the recorded data displayed on the display unit 201 is a feature of the invention. With the specification, a file system is started (step 1605) so that the data is read out of the harddisk drive 415 and then sent to the microcomputer 411 (step 1606).

[0024] Then, the data type is discriminated (steps 1607 and 1608). If the recorded data is the moving image, the MPEG-formatted moving image data and the MPEG-formatted speech data are both decoded (step 1609). If the recorded data is the still image, the JPEG-formatted still image data is decoded (step 1610). If the recorded data is the still image with the speech, the JPEG-formatted still image data and the MPEG-formatted speech data are both decoded (step 1611). Then, the decoded image and the decoded speech if any are displayed on the screen (step 1612).

[0025] An indication signal issued by the operating switch 408 is read by a sub-microcomputer 407 and then is sent to the microcomputer 411 through a camera-controlling microcomputer 406. The software program according to this embodiment is read out of a ROM 417 (Read-only Memory) for storing a program and then is executed. In this embodiment, the program is stored in the ROM 417. In place of the ROM 417, another storage unit such as a flash RAM or a harddisk drive may be used for the purpose.

[0026] Next, the data is transferred to the buffer memory 412 through the PCMCIA connector 414 and the interface circuit 413. The timing of the data stored in the buffer memory 412 is controlled by the microcomputer 411. Then, the data whose timing is adjusted is sent to the MPEG1 decoder 409. The decoder 409 switches the MPEG1 coding to the MPEG1 decoding or vice versa.

[0027] The data decoded by the MPEG1 decoder 409 is sent to the camera DSP circuit 405 through the digital path line. The decoded data is converted into an analog video signal through the effect of an NTSC or PAL encoder and a DAC built in the circuit 405 and then is led at an output terminal 416 and from the built-in display unit 201 to the outside of the apparatus. The foregoing description has concerned with the MPEG1-formatted moving picture data with the speech. The JPEG-formatted still image data or the MPEG1-formatted speech data may be solely processed in the same manner as described above.

[0028] The portable comcorder of this embodiment is arranged to use a harddisk unit of 260 MB for the harddisk drive 415. In case that only the JPEG-formatted still image data is recorded, about 3000 still images may be recorded. In actual, the portable comcorder of this invention enables to retrieve 3000 items of data quickly and easily using the classifying function.

[0029] Fig. 4 shows a circuit arrangement about the moving image. The corresponding circuit arrangement to that of Fig. 4 is required for the still images and the speech. That is, the portable comcorder of this embodiment is arranged to have a general-purpose means for imaging a moving object / a still object, a microphone, means for digitally converting a moving image / a still image, means for digitally converting speech, and means for digitally recording a moving image, a still image, and a speech signal.

[0030] Fig. 5 shows the screen of the built-in display unit 201 used in the embodiment of the invention, in which the diagonal length is 1.8 inch (45.7 mm), the horizontal length is 36.6 mm, and the vertical length is 27 mm. The illustrated screen arrangement uses a liquid crystal consisting of 352 pixels and 240 pixels. In order to reduce the power consumption and the size of the portable digital camcorder 200, the 1.8-inch liquid crystal is used for the built-in display unit 201. This built-in display unit 201 shows an imaging screen formed by a monitoring signal when recording the signal, a retrieval screen formed by the program when retrieving the data, and a playback

screen formed by the decoded data when playing back the data.

[0031] In recording the data, the moving image recording mode (MPEG compression recording mode) or the still image recording mode (JPEG compression recording mode) may be switched each time the mode selecting button is pressed. As the user can select the recording mode with this button, as shown in Figs. 17 and 18, the mark for each mode located in the upper left portion of the imaging screen is switched each time the mode is switched.

[0032] Fig. 17 shows the imaging screen appearing when the still image recording mode is selected when recording data. In Fig. 17, a numeral 1701 denotes a mark representing a still image mode. Fig. 18 shows the imaging screen appearing when the moving image recording mode is selected when recording data. In Fig. 18, a numeral 1801 denotes a mark representing the moving image mode. The mark for each mode appears on the screen so that the user can visually recognize the current imaging mode as he or she is pushing the mode selecting button. This mark allows the user to handle the comcorder without having to keep his eyes out of the imaging screen. It means that the digital comcorder offers convenient operativity to the user.

[0033] The mark for each mode is displayed on the retrieving screen through the effect of the program sent from a data containing unit. The retrieving screen will be discussed in detail together with the display of the mode mark. Fig. 19 shows the concrete mark for each mode. In actual, however, the marks are not limited to the illustrative ones. Any mark may be used if it can distinguish the modes from each other.

[0034] In Fig. 5, the display screen 500 consists of 20 x 9 characters at maximum, each character consisting of 16 and 24 pixels. The character size consisting of 16 x 24 pixels keeps the maximum recognizable size compatible with efficient digitizing of the character data. The blanks of a left side 501, a right side 502, an upper side 503, and a lower side 504 of the screen are secured because the display unit or the built-in display unit 201 connected to an output terminal 416 disables to display the overall area of the main screen.

[0035] A numeral 505 denotes an operating state display area where the operating state of the program of this embodiment is displayed. A numeral 506 denotes an area where the information of the recorded data and the functions to be operated for specifying the data details of the data by pressing a function switch 304 are displayed as individual items in partitioned sub-screens. A numeral 507 denotes an area where an operating procedure suggests the operating method to the user.

[0036] Fig. 6 shows a display screen 600 appearing when a program starting switch 303 is pressed by the user for starting the program of this embodiment. The display screen 600 corresponds to a classifying selection 101 of Fig. 1 for indicating the state transition of the operation. As mentioned earlier, the data recorded by the user is unconditionally recorded "unclassified" when recording the data. The figure (number of files) displayed on the "unclassified" row stands for the number of MPEG1-formatted moving image data items with the speech 602, the number of JPEG-formatted still image data pieces 603, and the number of MPEG1-formatted speech 604.

[0037] Likewise, the figure displayed on each row of a mark 605 for indicating the first classification, a mark 606 for indicating the second classification, and a mark 607 for indicating the third classification indicate the numbers of data items arbitrarily classified by the user, respectively. A mark 608 for indicating all data items at a batch indicates the total number of the data items on the "unclassified" row 601, the "first classified" row 605, the "second classified" row 606, and the "third classified" row 607.

[0038] A mark 609 for indicating the "temporary discard" means a classification for temporarily discarding the data items so that the user cannot erroneously erase the data items. With the mark 609, the user can temporarily move the "unclassified", "first classified", "second classified", and "third classified" data items to the "temporary discard" row. The figure represented on the row of the mark 609 does not contain a figure represented on the row of the mark 608 for indicating all data items at a batch.

[0039] In Fig. 6, the row of the mark 601 for indicating the unclassification is reversed to the rows of the other marks. It indicates that the mark 601 for indicating the unclassification is the selected item. In place of the reversing, another kind of way may be used such as change of a color. The software program is executed by the user so that the recorded data items whose classifying destinations are not changed are contained in the row of the mark 601 for indicating the unclassification.

[0040] When the upper arrow switch 305a of Fig. 3 is pressed by the user, the selected item is shifted upward by one row, while the lower arrow switch 305c is pressed, the selected item is shifted downward by one row.

[0041] In case that the selected item is an item on the first row of the display area 506, that is, on the mark 601 for indicating the unclassification, when the user presses the upper arrow switch 305a, the selected item is shifted to the item on the sixth row of the display area 506, that is, on the mark 609 for indicating the temporary discard. In case that the selected item is an item on the sixth row of the display area 506, that is, on the mark 609 for indicating the temporary discard, when the user presses the lower arrow arrow 503c, the selected item is shifted to the item on the first row of the display area 506, that is, on the mark 601 for indicating the unclassification.

[0042] When the user presses the right arrow switch 305b, the display screen is shifted into the screen on which the content of the classification of the selected row is represented.

[0043] Moreover, the guide indication 610 for the operating procedure is displayed so as to remind the user of the operation.

[0044] As an example, Fig. 7 shows a display screen 700 on which the mark 605 for indicating the first classification is selected so that the data items on the row of the mark 605 appear as ones to be selected if the right arrow switch 305b is pressed by the user. This function corresponds to the data selection 102 shown in Fig. 1.

[0045] The display screen 700 is a screen on which a data item is to be retrieved from a data list and played back. The data list is a feature of the present invention. On the screen 700, the data items recorded by the portable digital comcorder 200 may be listed using a mark 703 for representing a sort of data content of a recording start time 702, a moving image, a still image, and a speech, a classifying mark 704, and a mark 705 for protecting data from being erased by the erroneous operation.

[0046] The data items displayed on the screen 700 are ranged from the top to the down in the sequence of the recording year/month/day 701 and the recording start time 702. Hence, the latest recorded data is listed on the topmost row, so that the user can effectively retrieve the data. The number of the pages of the displayed lists is checked, so that the lists are displayed as pages as indicated by a numeral 707. In the page display 707, a denominator indicates all the list pages, while a numerator indicates the current one of the list pages.

[0047] The imaging status of the user such as the recording date and time and the data type are automatically recorded as the aforementioned information, so that the user can manually record these pieces of information. Since the user may optionally change the classifying destination according to his or her purpose, the user's retrieval work for the destination data is made simpler and more efficient.

[0048] These pieces of information are all composed of a list represented in characters. This does not need a time consumed in expanding the compressed image data recorded on the media. Further, if the user selects a data item using the operating button, the screen can be rewound quickly, so that the quick retrieval is made possible.

[0049] This list retrieving operation may offer comfortable operativity without having to impose stress on the user who wants to quickly select the recorded image.

[0050] The selecting classification 706 indicates a classification selected by a display screen 600. This embodiment has concerned with the user's selection of the first classification 605 on the display screen 600.

[0051] The display list of the data items on the display screens 700 and 800 is arranged in the sequence of recording the data on the harddisk drive 415, that is, in the sequence that the latest data item comes to the topmost row. Since the user may change the sequence of recording the data items on the harddisk driver 415, he or she may change the display sequence. The data immediately after imaging is recorded on the topmost row (701 of Figs. 7 and 8) of the display area 506 on the unclassified data selecting screen. If the user makes sure of the just imaged data, he or she only reproduces the data and makes sure of the topmost row of the display area 506 on the unclassified data selecting screen.

[0052] Like the display screen 600, when the user presses the upper arrow switch 305a, the selected data item is shifted upward by one row. When the user presses the lower arrow switch 305c, the selected data item is shifted downward by one row. In this embodiment, the six rows of the data items are displayed on one screen. In case the user selects the sixth data item, if the lower arrow switch 305c is pressed, the seventh data item is displayed on the first row of the display area 506. It means that the seventh data item is the selected item. The eighth, the ninth and the following data items are displayed on the second, the third, and the following rows, respectively.

[0053] On the other hand, for example, in case the seventh data item is selected, if the upper arrow switch 305a is pressed, the seventh data item is displayed on the first row of the display area 506. The second, the third, the fourth, the fifth, and the sixth data items are respectively displayed on the rows after the first one, so the selected data item is changed to the sixth data item.

[0054] That is, the n-th data item is displayed on a remainder-th row on the display area 506, in which the remainder is obtained by dividing n by 6.

[0055] In case the head data item or the tail one is selected, if the upper arrow switch 305a or the lower arrow switch 305c is pressed, like the display screen 600, the data items containing the head and the tail items are displayed as a list so that the head or the tail data item is selected. Though Fig. 6 shows the one-page screen on which the number of folders is fixed, Figs. 7 and 8 show the screen on which the pages are increased or decreased in number according to the number of data items.

[0056] If the user selects the upper arrow switch 305a and the lower arrow switch 305c shown in Fig. 3 and depresses the right arrow switch 305, the selected data is fed out of the output terminal 416 and is played back on the built-in display unit 201.

[0057] While the data is being played back, the upper arrow switch 305a, the lower arrow with 305c, and the left arrow switch 30, as shown in Fig. 3, are served as fast feed, rewind, and stop, respectively. While the data is being played back, if the left arrow switch 305d served as a stop switch is pressed by the user, the playback is stopped, and the display screen 700 is displayed again. The state transition during the data playback is denoted by a numeral 103 of Fig. 1.

[0058] Next, the description will be oriented to the display content on which reduced images are added to the recording date and time so that the content of the data may be easily recognized. In the state of the display screen 700, if the user presses the reduced image display switch 302, a reduced image 801 of the first frame of the data listed on the subject row is displayed on the display screen 800 shown in Fig. 8. This makes it possible to

surprisingly enhance the retrieval of the data. The state transition in the reduced image display function is denoted by a numeral 104 of Fig. 1.

[0059] For example, in case that the viewable area of the 1.8-inch built-in LCD display unit 201 consists of 379 dots in horizontal and 220 dots in vertical, the reduced image 801 is adjusted to consist of 64 dots in horizontal and 48 dots in vertical. (if the LCD panel consists of 352 and 240 dots, the reduced image 801 consists of 240/48 = 5 dots in vertical and 352/5 = 70.4 in horizontal. From a vertical viewpoint, the reduced image is one-fifth and from a horizontal viewpoint, the reduced image is one-fifth with a slight margin.) In this reduction, three reduced images, the recording starting year month day 701, the recording starting time 702, the mark 703 representing the content type of the data indicating the moving image, the still image, and the speech, the classification mark 704, and the mark 705 for protecting the data from being erroneously erased can be all displayed on one screen. This screen arrangement makes it possible to secure more visible reduced images on the display. Like the display screen 700, on this display screen 800, the data may be played back by pressing the operating button 305 and the like.

[0060] In this state, if the reduced image display switch 302 is pressed again, the display screen is returned to the display screen 600 for displaying the data classification. The reduced image is depicted in the RAM 410 shown in the circuit block of Fig. 4 through the effect of the control microcomputer 411 and the MPEG encoder 409.

[0061] In turn, the description will be oriented to a function selecting display screen 900 for easily changing the display state from the data selecting display screen 700. The function selecting display screen 900 includes the reduced number of operation switches and function items displayed thereon so that the ease of use in operation may be improved as viewing the screen. The operating switches 304, 305a, 305b, 305c, and 305d shown in Fig. 3 implement the operating system for selectively operating the function. The state transition on the display screen 900 is denoted by a numeral 105 of Fig. 1.

[0062] On the reduced image display screen 800, the function selecting display screen 900 is displayed by the same procedure. On the display screen 600, the display screen having the necessary functions such as "empty a garbage", "move to a garbage", "display a state", and "auto play" shown in Fig. 1 is displayed by the same procedure. In this case, the function items on the display screen 900 are not required to be identical with the function items on the data classifying display screen 600.

[0063] The flow of operation on the display screen 900 is shown in Fig. 10. The display screen 900 is displayed when the user pressed the function switch 304 on the display screen 700 (step 1001). The selective movement of each item is indicated by the upper arrow switch 305a and the switch lower arrow switch 305c. If the user pressed the upper arrow switch 305a, the selected data item is moved upward by one row. If the lower arrow switch 305c is pressed, the selected data item is moved downward by one row (step 1002). If the user presses the right arrow switch 305b (step 1003), the function of the selected data item is executed (step 1004). If the left arrow function switch 305d is pressed, the display screen 900 is returned to the data selecting display screen 700 (step 1005).

[0064] As mentioned earlier, in this embodiment, the erasion of the data is realized by moving the data to the temporary discard location and then erase the data contained in the temporary discard location. The state transition of this function is denoted by a numeral 106 of Fig. 1.

[0065] The procedure of erasing the data will be described below.

[0066] If the data is erased, the data is moved to the temporary discard location. In this case, the procedure for selectively executing "move the data to a garbage" will be described with reference to Fig. 9.

[0067] At first, on the display screen 700, the user selects the data item to be temporarily discarded with the upper arrow switch 305a and the lower arrow operating switch 305c and then depresses the function switch 304. Then, the display screen 700 is changed to the display screen 900. The user selects the "move data to a garbage" 901 with the upper arrow operation switch 305a and the lower arrow function switch 305c and then depresses the right arrow switch 305b. Then, the selected data item is moved to the garbage that is the temporary discard location. If the user presses the switch 306, the similarly selected data is moved to the garbage.

[0068] When the user selects the "empty a garbage" 902 on the display screen 900, all the data items left in the garbage are erased. The state transition of this function is denoted by a numeral 107 of Fig. 1.

[0069] In the operating system, the user is required to do two operations for erasing the data. The two operations protect the data from the user's erroneous erasion.

[0070] As mentioned earlier, when recording the data, the classifying symbol to be allocated to each data item is an unclassified one. When playing back the data, the classification may be changed by the user's operation. This classifying function is used for classifying the data item. Hence, since the user classifies the data item for each destination, the ease of use of the retrieval may be surprisingly enhanced. The state transition of this function is denoted by a numeral 108 of Fig. 1.

[0071] Later, the description will be oriented to the procedure for changing the data classification. On the display screen 700, the user selects the data item whose classification is to be changed with the upper arrow switch 305a or the lower arrow operation switch 305c and then presses the function switch 304. Then, the display screen is changed to the display screen 900. The user selects the "change a group" 905 that is a function of changing the classification with the upper arrow operation switch 305a and the lower arrow operation switch 305c and then

presses the right arrow switch 305b. Then, a display screen 1100 is displayed on which the classification of the selected data shown in Fig. 11 is changed.

[0072] If the right arrow switch 305b is pressed on the display screen 1100, the classification is cyclically changed from "unclassification" to 1 to 2 to 3 to "unclassification". In this embodiment, the update of the symbol for the classification according to the display screen is executed by the control microcomputer 411 at a time when the user presses the left arrow switch 305d and the display screen 600 appears. This is intended for enhancing the processing speed and retrying the user's operation.

[0073] As described earlier, unless the user does the following operation, the list indicated on the display screen 700 is arranged in the recording sequence of the recorded data. When playing back the data, the sequence may be changed so as to implement a simple editing function. The state transition of this function is denoted by a numeral 109 of Fig. 1.

[0074] The procedure of changing the data displaying sequence will be described below. At first, on the display screen 700, the user selects the data item whose displaying sequence is to be changed with the upper arrow switch 305a and the lower arrow switch 305c. Then, if the function switch 304 is pressed, the display screen 900 is displayed.

[0075] The user selects the "change a data display sequence" 906 that is a function of changing the display sequence with the lower arrow switch 305c and depresses the right arrow switch 305b. Then, the display screen 1200 shown in Fig. 12 is displayed, so that the display sequence of the selected data item may be changed. Next, the user specifies the location where the selected data is to be inserted with the upper arrow switch 305a and the lower arrow switch 305c. Then, if the right arrow switch 305b is pressed, the selected data item is inserted to the specified location. In this case, the sequence of the data item located after the specified location is shifted lower by one.

[0076] The portable digital camcorder 200 of this embodiment incorporates an internal clock for displaying on the display screen 700 the date and the time when the data is recorded. However, if failure such as run-down of a battery takes place while imaging an object, the recorded data and time may not be correctly displayed on the display screen 700. In this embodiment, the user may operate to optionally change the date and time when the data is recorded. The state transition of this function is denoted by a numeral 110 of Fig. 1.

[0077] Later, the description will be oriented to the procedure for changing the date and time. The user selects the data whose recording date and time are to be changed using the upper arrow switch 305a and the lower arrow switch 305c. Then, if the function switch 304 is pressed, the display screen 900 is displayed. The user selects the "change a recording date and time" 907 that is a function of changing the displaying sequence with the upper arrow switch 305a and the lower arrow switch 305c. Next, if the right arrow switch 305b is pressed, the display screen 1300 shown in Fig. 13 is displayed where the recording date and time of the selected data are to be changed.

[0078] In this state, when the user pressed the upper arrow switch 305a, the year figure 1301 is increased by 1, while the lower arrow switch 305c is pressed, the year figure 1301 is decreased by 1. When the right arrow switch 305b is pressed, the year figure 1301 is determined as a numeric value represented at the time point. Next, the user may specify the increment or decrement of the numeric value of a month figure 1302.

[0079] Likewise, if the upper arrow switch 305a is pressed, the month figure 1302 is increased by 1, while if the lower arrow switch 305c is pressed, the month figure 1302 is decreased by 1. If the right arrow switch 305b is pressed, the month figure 1302 is determined as a numerical value displayed at the time point. Next, the user may specify the increment or decrement of a numerical value of a day figure 1303.

[0080] Further, when the left arrow switch 305d is pressed, the year figure 1301 may be retried. The similar operation may be executed to set the day figure 1303, an a.m or p.m. indication 1304, a time figure 1305, and a minute figure 1306. After adjusting a value of the minute figure 1306, if the right arrow switch 305b is pressed, the change of the recording date and time is terminated and the date and time of the data is changed to a new numeric value.

[0081] In the case of specifying an numeric value that does not exist in the calendar such as February 30, the numeric value is changed to the nearest date (that is, March 1) to the value.

[0082] In this embodiment, though the user can freely erase the data, the user may provide the data with an attribute of prohibiting the erasion for preventing the data from being erased. The state transition of this function is denoted by a numeral 111 of Fig. 1.

[0083] Later, the description will be oriented to the procedure for adding the attribute of protecting the data from the erasion to the data. At first, on the display screen 700, the user selects the data whose erasing attribute is to be changed with the upper arrow switch 305a or the lower arrow switch 305c. Then, the function switch 304 is pressed, so that the display screen 700 is changed to the display screen 900. The user selects the "change a lock" 904 that is a function of changing the erasing attribute with the upper arrow switch 305a or the lower arrow switch 305c. Then, if the right arrow switch 305b is pressed, the display screen 1400 is displayed where the erasing attribute of the selected data shown in Fig. 14 is changed.

[0084] When the user pressed the right arrow switch 305b, the erasing attribute is cyclically changed from "disabled" to "enabled" to "disabled". The protecting mark 705 is displayed or not displayed according to the erasing attribute.

[0085] In this embodiment, the user can know the remaining volume of the harddisk drive 415. The state transition of this function is denoted by a numeral 112 of Fig. 1.

[0086] Hereafter, the description will be oriented to the procedure for checking the remaining volume of the harddisk drive 415. On the display screen 700, if the user presses the function switch 304, the display screen 700 is changed to the display screen 900. The user selects the "display a state" 903 that is a function of changing the displaying sequence with the upper arrow switch 305a or the lower arrow switch 305c. Then, if the right arrow switch 305b is pressed, the display screen 1500 is displayed where the remaining volume of the harddisk drive 415 shown in Fig. 15 is shown.

[0087] On the display screen 1500, a remaining time 1501 left if only the MPEG1-formatted moving image data with the speech is recorded on the harddisk drive 415, a remaining pages left if only the JPEG-formatted still image data is recorded, a remaining time 1503 left if only the MPEG1-formatted speech data is recorded, and a remaining volume 1504 represented in bytes are all displayed as a list. Since the remaining volume of the harddisk drive is listed with respect to each recordable data type, the user can more easily grasp the remaining volume of the harddisk drive 415.

[0088] In this embodiment, when playing back the data, the user needs to use only the switches 305a, 305d, 305c and 305d for playing back the data. It is epoch-making that the minimum number of operating switches are just required for playing back the data.

[0089] Another epoch-making point is the increase of the functions without increasing the operating buttons by using the functional selecting screen 900.

[0090] In this embodiment, as shown in Fig. 6, the classified number of data items is four including "unclassified". The classified number of data may take any value. On the data selecting display screen 700, the data items may be displayed as a list independently of the types of the moving image, the still image, and the speech. This embodiment may apply to the function of automatically classifying the data according to the data type with the user's specification.

[0091] Moreover, the control microcomputer 411 is operated to automatically select the data according to the imaging modes such as the moving image and the still image. For example, the user can select only the imaging mode for the still image, pick up only the image type of the still image, and reproduce it.

[0092] The foregoing description has been concerned with the specific embodiments of the invention.

[0093] For example, a non claimed example may be achieved by an image recording apparatus which includes converting means for converting a video signal into a digital signal, a codec unit for selectively performing a MPEG system or a JPEG system compression about the digital signal, for generating the compressed data, a recording unit for recording the compressed data, and a selective indicating means for a compression mode, for selectively indicating the MPEG system compression or the JPEG system compression.

[0094] This image recording apparatus may be applicably arranged to switch the compressing system of the codec unit according to the indication given by the selective indicating means.

[0095] Further, the image recording apparatus may be applicably arranged to add a code for indicating the compression system to the compressed data according to the indication given by the selective indicating means.

[0096] Further, the image recording apparatus may be applicably arranged so that the codec unit may be a circuit for performing the MPEG system and the JPEG system processing at one process.

[0097] Moreover, the image recording apparatus may be applicably arranged so that the video signal is obtained from an imaging element and the recording unit is a harddisk drive.

[0098] An other example may be also achieved by the image reproducing apparatus which includes a recording unit for receiving compressed data generated according to the MPEG system or the JPEG system and recording the compressed data, specifying means for specifying a data item to be reproduced of the compressed data recorded in the recording unit, readout means for retrieving and reading out the compressed data specified by the specifying means from the recording unit, a codec unit for selectively performing the MPEG system or the JPEG system expansion about the compressed data and generating the digital signal, and converting means for converting the digital signal generated by the codec unit into a video signal.

[0099] Moreover, the image reproducing apparatus may be applicably arranged so that the expanding system of the codec unit may be switched according to the compressed data read out of the readout means.

[0100] Further, the image reproducing apparatus may be applicably arranged so that the compressed data of the recording unit pre-contains the code indicating the compressing system and the expanding system of the codec unit may be switched according to the code for indicating the compressing system added to the compressed data read out of the readout means.

[0101] Further, the image reproducing apparatus may be applicably arranged so that the codec unit may be a circuit for performing the MPEG system and the JPEG system expansion at one process, the video signal is output to the built-in display unit, and the recording unit may be a harddisk drive.

[0102] An other example may be achieved by the image recording and reproducing apparatus for converting a video signal into a digital signal, recording the digital signal, converting the digital signal into the video signal, and reproducing the video signal, which includes a codec unit for selectively performing the MPEG system or the JPEG system compression about the digital signal for generating the compressed data in recording the data

and selectively performing the MPEG system or the JPEG system expansion about the compressed data for generating the digital signal in reproducing the data, a recording unit for recording the compressed data, selective indicating means for the compressing mode for selectively indicating the MPEG system compression or the JPEG system compression, specifying means for specifying the data to be reproduced of the compressed data recorded in the recording unit, and readout means for retrieving and reading the compressed data specified by the specifying means from the recording unit.

[0103] Moreover, the image recording and reproducing apparatus may be applicably arranged so that the codec unit may switch the compressing system according to the indication given by the selective indicating means in recording the data or the expanding system according to the compressed data read out of the readout means in reproducing the data.

[0104] Further, the image recording and reproducing apparatus may be applicably arranged so that in recording the data, the recording unit adds the code for indicating the compressing system to the compressed data according to the indication given by the selective indicating means and records the compressed data and in reproducing the data, the codec unit switches the expanding system according to the code for indicating the compressing system added to the compressed data read out of the readout means.

[0105] Moreover, the image recording and reproducing apparatus may be applicably arranged so that the codec unit may be a circuit for performing the MPEG system and the JPEG system processing at one process, the video signal to be recorded is obtained from an imaging element, the video signal to be reproduced is output to the built-in display unit, and the recording unit is a harddisk drive.

[0106] As described above, as keeping the capacity of the recording medium larger and advancing the compressing technology, the data items to be recorded on one recording medium are increased in number. This example, however, makes it possible to do the recording and the reproducing operations with quite few keys. Hence, this example offers the below-indicated effects, so that it may improve the operativity even if it is applied to the small-sized apparatus with a limited space prepared for the operation buttons or switches.

[0107] This example may display the recording date and time information and the marks for modes such as the moving image, the still image, and the still image with the speech as a list. Hence, the user can efficiently and quickly retrieve the data as grasping the content of the data. In recording the data, the marks are switchably displayed on the imaging screen each time the mode is switched so that the user can grasp the current imaging mode. Hence, the user can focus his or her attention onto the imaging screen at any mode when recording the data.

[0108] The display list is composed of a date and a time. The apparatus of this embodiment may automatically create the overall list and at once output the reduced images, so that the user can more easily grasp the content of the data.

[0109] The imaged data may be classified to the predetermined locations. Hence, the imaged data may be classified on the mode information and the date and time information according to the imaging statue and the object. This classification makes it easier for the user to retrieve the data.

[0110] Further, the displaying sequence of the list and the generating sequence of the data are allowed to be replaced depending on the mode information and the date and time information. Hence, the optimal reproducing effect can be obtained without having to depend on the recording sequence.

[0111] Then, the classification of "temporary discard" is provided for preventing the erasion of the data resulting from the user's erroneous operation and reusing the unnecessary data if it is made necessary after being deleted.

[0112] As described above, if the operation on the relatively simple graphic screen is executed to record a great deal of data, the function of this example enables to offer quicker retrieval than the conventional function of reproducing the data as expanding all image screens.

Claims

1. A digital image and speech recording and reproducing camcorder (200) comprising:

   means (401, 402, 303, 404, 405, 409, 412, 415) for recording and reproducing a digital video signal of a moving image and for recording and reproducing a digital still image;
   means (418, 419, 409, 415) for recording and reproducing a digital speech signal in synchronous to said moving image;
   display means (201) for displaying said moving image signal and said still image signal;
   means (411) for recording recording conditions containing data information about said recorded data for distinguishing said moving image signal from said still image signal and recording time information for indicating when said image or speech is recorded;
   means to graphically or literarily display said recording condition composed of at least said data information and said recording time information on a screen of said display means; and
   means to select said displayed recorded data on said screen;
   characterized in that
   the camcorder also comprises
   means for generating a reduced image (801) based on said recorded moving image or still image; and

means for generating a mark (703) based on said recorded recording conditions;
means (201) to display a plurality of said reduced images (801) in a single screen; and
means (201) to display said mark (703) for discriminating moving images and still images.

2. The digital image and speech recording and reproducing camcorder as claimed in claim 1, wherein the recording condition of said recorded data displayed on said display screen contains information about the reduced image of said recorded data.

3. The digital image and speech recording and reproducing camcorder as claimed in claim 1, wherein said display means (201) for displaying said recording condition is composed of a liquid crystal display panel having a horizontal side of 36.6 mm, a vertical side of 27 mm, and a diagonal of 45.7 mm.

4. The digital image and speech recording and reproducing camcorder as claimed in claim 1, wherein said means topographically or literarily display said recording condition are adapted so that on the display screen of said recording condition, a recording start date (1302, 1303) and a recording start time (1304, 1305, 1306) are displayed as said recording time information.

5. The digital image and speech recording and reproducing camcorder as claimed in claim 1, wherein said camcorder is adapted so that on the display screen of said display means (201), a number of recorded data items are displayed for two or more classifications for retrieval, a storage area for data is secured for each classification, and said recorded data item is saved in said storage area.

6. The digital image and speech recording and reproducing camcorder as claimed in claim 5, wherein said camcorder is adapted so that on the display screen (600) for said retrieving classification, one of said classifications is selectively operated so that the display screen may be changed into the display screen (700) for indicating the recording condition displayed graphically or literarily.

7. The digital image and speech recording and reproducing camcorder as claimed in claim 5, wherein said camcorder is adapted so that when reproducing the recorded data, if the classification is not specified, the recorded data contained in the predetermined classification of the topmost row on the display screen is displayed.

8. The digital image and speech recording and reproducing camcorder as claimed in claim 1, wherein the recording condition of said recorded data displayed on said display screen (700) contains information about the function of preventing erasion to be optionally specified by a user.

9. The digital image and speech recording and reproducing camcorder as claimed in claim 5, wherein a button for changing the display screen for displaying the number of said recorded data items in each retrieval classification into the display screen for displaying the recording condition composed of said data information and said recording time information, a button for selecting each recording data item from a list of the recording data on the display screen (700) for displaying said recording condition, a button (304) for indicating a function of playing back, stopping, fast-feeding, and rewinding the image, and a button for returning said display screen for indicating the functions into the display screen for indicating said recording condition are composed as the same button (304).

10. The digital image and speech recording and reproducing camcorder as claimed in claim 1, wherein said display means (201) are adapted so that on the display screen for graphically or literarily displaying the recording condition of said recorded data, the data items recorded later are displayed on higher locations on the display screen.

11. The digital image and speech recording and reproducing camcorder as claimed in claim 2, wherein said means for generating a reduced image (801) are adapted to form said reduced image (801) of said recorded data by thinning out the pixels obtained in actual recording in the horizontal and the vertical direction by one-fifth and said display means (201) are adapted to display said reduced images (801) on the same row as the graphic and the literary notation.

12. The digital image and speech recording and reproducing camcorder as claimed in claim 10, wherein a storage area is a temporary discard area where said recorded data is reproducible, and the overall data in said discard area may be erased by the user's specification.

13. The digital image and speech recording and reproducing camcorder as claimed in claim 10, wherein said display means (201) are adapted so that the display sequence of the recording condition for said recorded data may be changed by the user's specification, so that a specific recording condition may be moved from one to another row on said display screen.

14. The digital image and speech recording and reproducing camcorder as claimed in claim 12, wherein said display means to graphically and literarily dis-

playing the recording condition of said recorded data are adapted to display
a function (901) of moving said recorded data to said temporary discard area;
a function (902) of erasing all data from said temporary discard area;
a function (905) of changing said retrieving classification of said recorded data;
a function (906) of changing the displaying sequence of the recorded condition of said recorded data;
a function (904) of changing an erasing attribute of said recorded data;
a function (903) of displaying a remaining volume of the stored volume of said recorded data; and
a means by which any one of said displayed functions may be specified.

Patentansprüche

1. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder (200) umfassend:

   Mittel (401, 402, 303, 404, 405, 409, 412, 415) zum Aufzeichnen und Wiedergeben eines digitalen Videosignals eines Bewegtbildes und zum Aufzeichnen und Wiedergeben eines digitalen Nicht-Bewegtbildes;
   Mittel (418, 419, 409, 415) zum Empfangen und Wiedergeben eines digitalen Sprachsignals synchron zu dem Bewegtbild;
   Anzeigemittel (201) zum Anzeigen des Bewegtbildsignals und des Nicht-Bewegtbildsignals;
   Mittel (411) zum Aufzeichnen von Aufzeichnungsbedingungen, die Dateninformation enthalten über die aufgezeichneten Daten zum Unterscheiden des Bewegtbildsignals von dem Nicht-Bewegtbildsignal und Aufzeichnungszeitinformation zum Anzeigen, wann das Bild oder die Sprache aufgezeichnet worden ist;
   Mittel zum grafischen oder literarischen Anzeigen der Aufzeichnungsbedingung, die zumindest aus der Dateninformation und der Aufzeichnungszeitinformation besteht, auf einem Bildschirm der Anzeigemittel; und
   Mittel zum Auswählen der angezeigten aufgezeichneten Daten auf dem Bildschirm;
   dadurch gekennzeichnet, dass
   der Camcorder ebenfalls umfasst:

      Mittel zum Erzeugen eines reduzierten Bildes (801) basierend auf dem aufgenommenen Bewegtbild oder Nicht-Bewegtbild; und
      Mittel zum Erzeugen einer Markierung (703) basierend auf den aufgezeichneten Aufzeichnungsbedingungen;
      Mittel (201) zum Anzeigen einer Mehrzahl der reduzierten Bilder (801) auf einem einzigen Bildschirm; und
      Mittel (201) zum Anzeigen der Markierung (703) zum Unterscheiden von Bewegtbildern und Nicht-Bewegtbildern.

2. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 1, wobei die Aufzeichnungsbedingung der aufgezeichneten Daten, die auf dem Anzeigebildschirm angezeigt wird, Information enthält über das reduzierte Bild der aufgezeichneten Daten.

3. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 1, wobei die Anzeigemittel (201) zum Anzeigen der Aufzeichnungsbedingung gebildet werden aus einem Flüssigkristall-Anzeigefeld, das eine Horizontalseite von 36,6 mm, eine Vertikalseite von 27 mm und eine Diagonale von 45,7 mm aufweist.

4. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 1, wobei die Mittel, die die Aufzeichnungsbedingung topografisch oder literarisch anzeigen, angepasst sind, so dass auf dem Anzeigebildschirm der Aufzeichnungsbedingung ein Aufzeichnungsstartdatum (1302, 1303) und eine Aufzeichnungsstartzeit (1304, 1305, 1306) angezeigt werden als die Aufzeichnungszeitinformation.

5. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 1, wobei der Camcorder angepasst ist, so dass auf dem Anzeigebildschirm der Anzeigemittel (201) eine Anzahl der aufgezeichneten Datenobjekte angezeigt wird für zwei oder mehr Klassifikationen für Wiederabrufung, ein Speichergebiet für Daten gesichert wird für jede Klassifikation und das aufgezeichnete Datenobjekt gesichert wird in das Speichergebiet.

6. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 5, wobei der Camcorder angepasst ist, so dass auf dem Anzeigebildschirm (600) für die wieder abgerufene Klassifikation eine der Klassifikationen selektiv bedient wird, so dass der Anzeigebildschirm geändert werden kann in den Anzeigebildschirm (700) zum Anzeigen der Aufzeichnungsbedingung, die grafisch oder literarisch angezeigt wird.

7. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 5, wobei der Camcorder angepasst ist, so dass beim Wiedergeben der aufgezeichneten Daten, wenn die Klassifikation nicht spezifiziert ist, die aufgezeichneten Daten, die in der vorbestimmten Klassifikation der obersten Reihe enthalten sind, auf dem Anzeigebildschirm angezeigt werden.

8. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 1, wobei die Aufzeichnungsbedingung der aufgezeichneten Daten, die auf dem Anzeigebildschirm (700) angezeigt wird, Information beinhaltet über die Funktion des Verhinderns des Löschens, die durch einen Benutzer optional zu spezifizieren ist.

9. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 5, wobei eine Taste zum Ändern des Anzeigebildschirms für die Anzeige der Anzahl der aufgezeichneten Datenobjekte in jeder wieder abzurufenden Klassifikation in den Anzeigebildschirm zum Anzeigen der Aufzeichnungsbedingung, die gebildet ist aus Dateninformation und der Aufzeichnungszeitinformation, eine Taste zum Auswählen jedes Aufzeichnungsdatenobjekts von einer Liste der Aufzeichnungsdaten auf dem Anzeigebildschirm (700) zum Anzeigen der Aufzeichnungsbedingung, eine Taste (304) zum Bezeichnen einer Funktion des Abspielen, Stoppen, schnell Vorspulen und Zurückspulen des Bildes und eine Taste zum Zurückkehren des Anzeigebildschirms zum Bezeichnen der Funktionen in dem Anzeigebildschirm zum Bezeichnen der Aufzeichnungsbedingung gebildet sind aus der gleichen Taste (304).

10. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 1, wobei das Anzeigemittel (201) angepasst ist, so dass auf dem Anzeigebildschirm zum grafischen oder literarischen Anzeigen der Aufzeichnungsbedingung der aufgezeichneten Daten die Datenobjekte, die später aufgezeichnet worden sind, angezeigt werden an einem höheren Ort auf dem Anzeigebildschirm.

11. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 2, wobei die Mittel zum Erzeugen eines reduzierten Bildes (801) angepasst sind, um das reduzierte Bild (801) der aufgezeichneten Daten zu formen durch Ausdünnen der Pixel, die erhalten worden sind in der tatsächlichen Aufzeichnung, in der horizontalen und der vertikalen Richtung um ein Fünftel, und das Anzeigemittel (201) angepasst ist, um die reduzierten Bilder (801) in der gleichen Zeile anzuzeigen wie die grafische und die literarische Notation.

12. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 10, wobei ein Speichergebiet ein temporäres Ablagegebiet ist, wo die aufgezeichneten Daten reproduzierbar sind, und die Gesamtdaten in dem Ablagegebiet durch die Spezifikation des Benutzers gelöscht werden können.

13. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 10, wobei das Anzeigemittel (201) angepasst ist, so dass die Anzeigesequenz der Aufzeichnungsbedingung für die aufgezeichneten Daten geändert werden kann durch die Spezifikation des Benutzers, so dass eine spezifische Aufzeichnungsbedingung von einer Zeile zu einer anderen Zeile auf dem Anzeigebildschirm verschoben werden kann.

14. Digitaler Bild- und Sprachaufzeichnungs- und Wiedergabe-Camcorder nach Anspruch 12, wobei das Anzeigemittel zum grafischen und literarischen Anzeigen der Aufzeichnungsbedingung der aufgezeichneten Daten angepasst ist zum Anzeigen
einer Funktion (901) des Bewegens der aufgezeichneten Daten zu dem temporären Ablagegebiet;
einer Funktion (902) des Löschens aller Daten von dem temporären Ablagegebiet;
einer Funktion (905) des Ändems der Wiederabrufklassifikation der aufgezeichneten Daten;
einer Funktion (906) des Ändems der Anzeigesequenz der Aufzeichnungsbedingung der aufgezeichneten Daten;
einer Funktion (904) des Ändems eines Löschattributs der aufgezeichneten Daten;
einer Funktion (903) des Anzeigens eines verbleibenden Volumens des gespeicherten Volumens der aufgezeichneten Daten; und
ein Mittel, durch das irgendeine der angezeigten Funktionen spezifiziert werden kann.

Revendications

1. Caméscope (200) d'enregistrement et de lecture de sons et d'images numériques (200) comportant :

des moyens (401, 402, 303, 404, 405, 409, 412, 415) pour enregistrer et lire un signal vidéo numérique d'une image animée et pour enregistrer et lire une image fixe numérique,
des moyens (418, 419, 409, 415) pour enregistrer et lire un signal vocal numérique en synchronisation avec ladite image animée,
des moyens d'affichage (201) pour afficher ledit signal d'image animée et ledit signal d'image fixe,
des moyens (411) pour enregistrer des conditions d'enregistrement contenant des informations de données concernant lesdites données enregistrées pour distinguer ledit signal d'image animée dudit signal d'image fixe et enregistrer des informations d'heure pour indiquer l'heure à laquelle ladite image ou ledit son est enregistré,
des moyens pour afficher sous forme graphique ou de caractères d'écriture une condition d'enregistrement constituée au moins desdites in-

formations de données et desdites informations d'heure d'enregistrement sur un écran desdits moyens d'affichage, et
des moyens pour sélectionner lesdites données enregistrées affichées sur ledit écran,
caractérisé en ce que
le caméscope comporte également
des moyens pour générer une image réduite (801) sur la base de ladite image animée ou image fixe enregistrées, et
des moyens pour générer une marque (703) sur la base desdites conditions d'enregistrement enregistrées,
des moyens (201) pour afficher une pluralité desdites images réduites (801) sur un seul écran, et
des moyens (201) pour afficher ladite marque (703) pour discriminer images animées et images fixes.

2. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 1, dans lequel la condition d'enregistrement desdites données enregistrées affichées sur ledit écran d'affichage contient des informations concernant l'image réduite desdites données enregistrées.

3. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 1, dans lequel lesdits moyens d'affichage (201) destinés à afficher ladite condition d'enregistrement sont constitués d'un panneau d'affichage à cristaux liquides ayant un côté horizontal de 36,6 mm, un côté vertical de 27 mm, et une diagonale de 45,7 mm.

4. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 1, dans lequel lesdits moyens d'affichage sous forme topographique ou de caractères d'écriture de ladite condition d'enregistrement sont adaptés de sorte que sur l'écran d'affichage de ladite condition d'enregistrement, une date de début d'enregistrement (1302, 1303) et une heure de début d'enregistrement (1304, 1305, 1306) sont affichées en tant que lesdites informations d'heure d'enregistrement.

5. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 1, dans lequel ledit caméscope est adapté de sorte que sur l'écran d'affichage desdits moyens d'affichage (201), de nombreux éléments de données enregistrés sont affichés pour deux ou plus de deux classifications de recherche, une zone de mémorisation de données est garantie pour chaque classification, et ledit élément de données enregistré est sauvegardé dans ladite zone de mémorisation.

6. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 5, dans lequel ledit enregistreur vidéo est adapté de sorte que sur l'écran d'affichage (600) de ladite classification de recherche, l'une desdites classifications est sélectivement actionnée de sorte que l'écran d'affichage peut être changé en l'écran d'affichage (700) pour indiquer la condition d'enregistrement affichée sous forme graphique ou de caractères d'écriture.

7. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 5, dans lequel ledit enregistreur vidéo est adapté de sorte que lors d'une lecture des données enregistrées, si la classification n'est pas spécifiée, les données enregistrées contenues dans la classification prédéterminée de la rangée la plus haute sur l'écran d'affichage sont affichées.

8. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 1, dans lequel la condition d'enregistrement desdites données enregistrées affichées sur ledit écran d'affichage (700) contient des informations concernant la fonction pour empêcher qu'un effacement soit facultativement spécifié par un utilisateur.

9. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 5, dans lequel un bouton pour changer l'écran d'affichage pour afficher le nombre desdits éléments de données enregistrés dans chaque classification de recherche en écran d'affichage pour afficher la condition d'enregistrement constituée desdites informations de données et desdites informations d'heure d'enregistrement, un bouton pour sélectionner chaque élément de données d'enregistrement parmi une liste des données d'enregistrement sur l'écran d'affichage (700) pour afficher ladite condition d'enregistrement, un bouton (304) pour indiquer une fonction de reproduction, d'arrêt, de défilement rapide, et de rembobinage de l'image, et un bouton pour revenir audit écran d'affichage pour indiquer les fonctions de l'écran d'affichage pour indiquer ladite condition d'enregistrement sont constitués par le même bouton (304).

10. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 1, dans lequel lesdits moyens d'affichage (201) sont adaptés de sorte que sur l'écran d'affichage destiné à afficher sous forme graphique ou de caractères d'écriture la condition d'enregistrement desdites données enregistrées, les éléments de données enregistrés ultérieurement sont affichés sur des positions plus hautes sur l'écran d'affichage.

11. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 2, dans

lequel lesdits moyens de génération d'une image réduite (801) sont adaptés pour former ladite image réduite (801) desdites données enregistrées en amincissant les pixels obtenus dans un enregistrement réel dans la direction horizontale et la direction verticale d'un cinquième et lesdits moyens d'affichage (201) sont adaptés pour afficher lesdites images réduites (801) sur la même rangée que le graphique et la notation en caractères d'écriture.

12. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 10, dans lequel une zone de mémorisation est une zone de rejet temporaire où lesdites données enregistrées sont lisibles, et les données entières dans ladite zone de rejet peuvent être effacées par la spécification de l'utilisateur.

13. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 10, dans lequel lesdits moyens d'affichage (201) sont adaptés de sorte que la séquence d'affichage de la condition d'enregistrement pour lesdites données enregistrées peut être changée par la spécification de l'utilisateur, de sorte qu'une condition d'enregistrement spécifique peut être déplacée d'une rangée à une autre sur ledit écran d'affichage.

14. Caméscope d'enregistrement et de lecture d'images et de sons numériques selon la revendication 12, dans lequel lesdits moyens d'affichage destinés à afficher sous forme graphique et de caractères d'écriture la condition d'enregistrement desdites données enregistrées sont adaptés pour afficher
une fonction (901) pour déplacer lesdits données enregistrées vers ladite zone de rejet temporaire,
une fonction (902) pour effacer toutes les données de ladite zone de rejet temporaire,
une fonction (905) pour changer ladite classification de recherche desdites données enregistrées,
une fonction (906) pour changer la séquence d'affichage de la condition enregistrée desdites données enregistrées,
une fonction (904) pour changer un attribut d'effacement desdites données enregistrées,
une fonction (903) pour afficher un volume restant du volume mémorisé desdites données enregistrées, et
des moyens par lesquels l'une quelconque desdites fonctions affichées peut être spécifiée.

FIG. 1

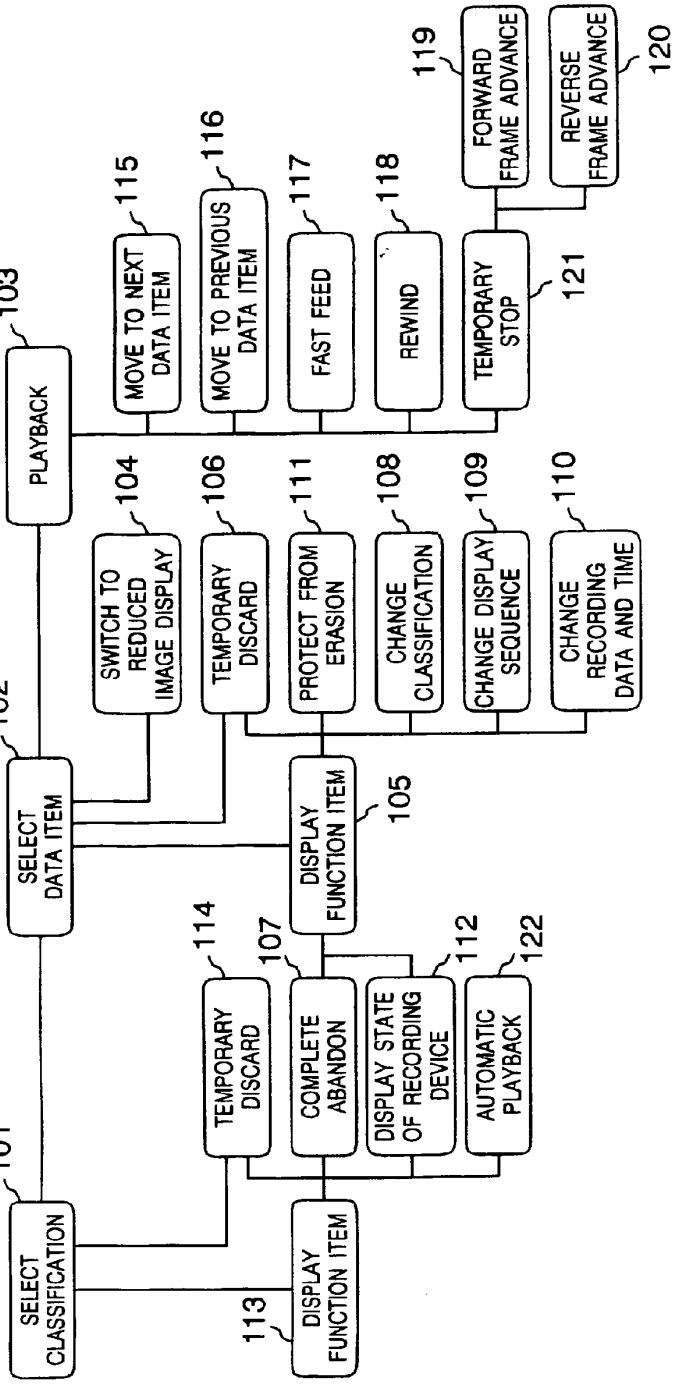

101
SELECT CLASSIFICATION
102
SELECT DATA ITEM
103
PLAYBACK
104
SWITCH TO REDUCED IMAGE DISPLAY
105
DISPLAY FUNCTION ITEM
106
TEMPORARY DISCARD
107
COMPLETE ABANDON
108
CHANGE CLASSIFICATION
109
CHANGE DISPLAY SEQUENCE
110
CHANGE RECORDING DATA AND TIME
111
PROTECT FROM ERASION
112
DISPLAY STATE OF RECORDING DEVICE
113
DISPLAY FUNCTION ITEM
114
TEMPORARY DISCARD
115
MOVE TO NEXT DATA ITEM
116
MOVE TO PREVIOUS DATA ITEM
117
FAST FEED
118
REWIND
119
FORWARD FRAME ADVANCE
120
REVERSE FRAME ADVANCE
121
TEMPORARY STOP
122
AUTOMATIC PLAYBACK

FIG. 2

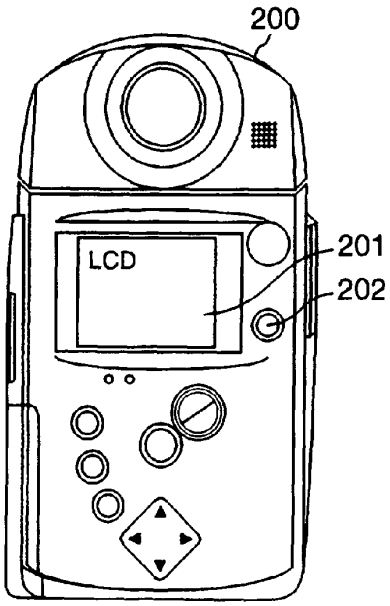

200
LCD
201
202

FIG. 3

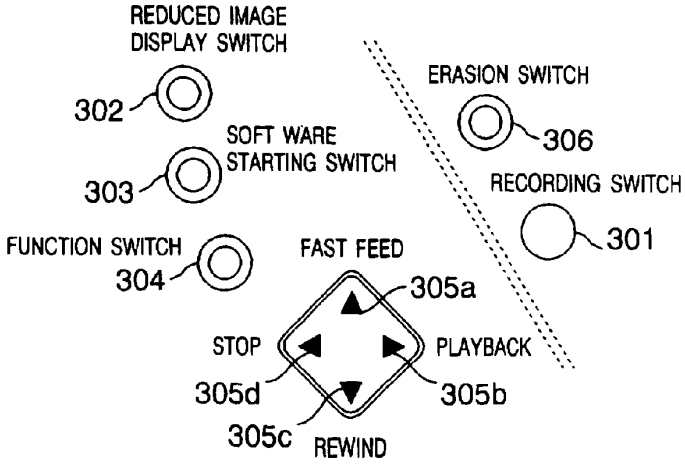

REDUCED IMAGE DISPLAY SWITCH
302
SOFT WARE STARTING SWITCH
303
FUNCTION SWITCH
304
ERASION SWITCH
306
RECORDING SWITCH
301
FAST FEED
305a
STOP
PLAYBACK
305d
305b
305c
REWIND

FIG. 4

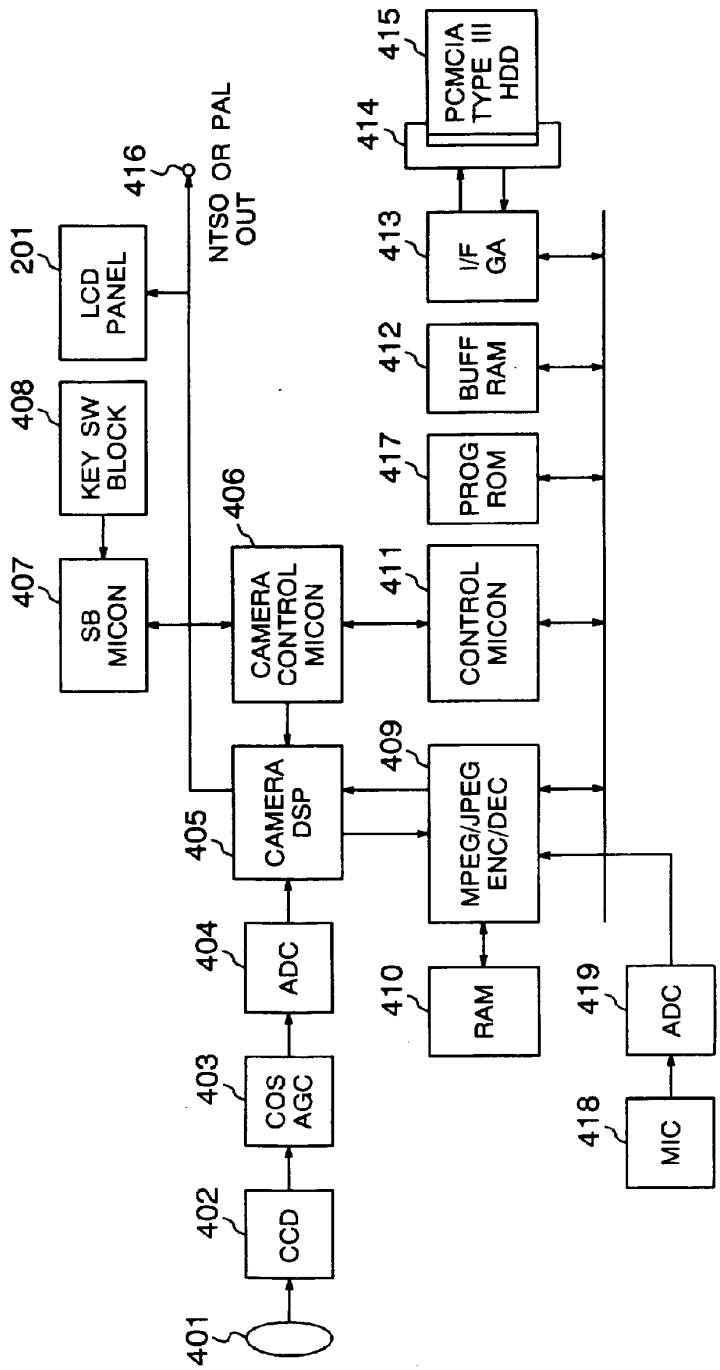

401
CCD
402
COS AGC
403
ADC
404
CAMERA DSP
405
CAMERA CONTROL MICON
406
SB MICON
407
KEY SW BLOCK
408
LCD PANEL
201
NTSO OR PAL OUT
416
MPEG/JPEG ENC/DEC
409
CONTROL MICON
411
PROG ROM
417
BUFF RAM
412
I/F GA
413
PCMCIA TYPE III HDD
415
414
RAM
410
ADC
419
MIC
418

FIG. 5

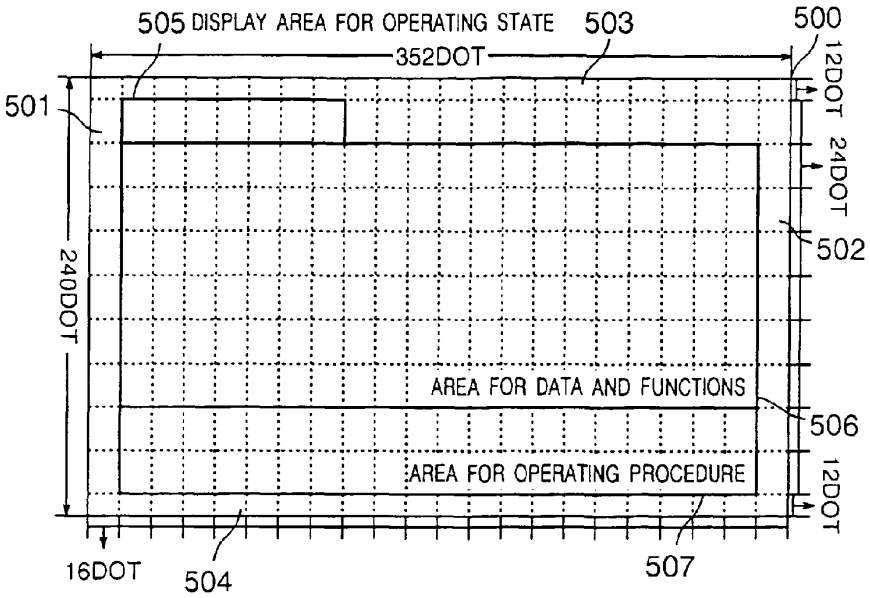

505 DISPLAY AREA FOR OPERATING STATE
503
500
352DOT
12DOT
24DOT
501
240DOT
502
AREA FOR DATA AND FUNCTIONS
506
AREA FOR OPERATING PROCEDURE
12DOT
16DOT
504
507

FIG. 6

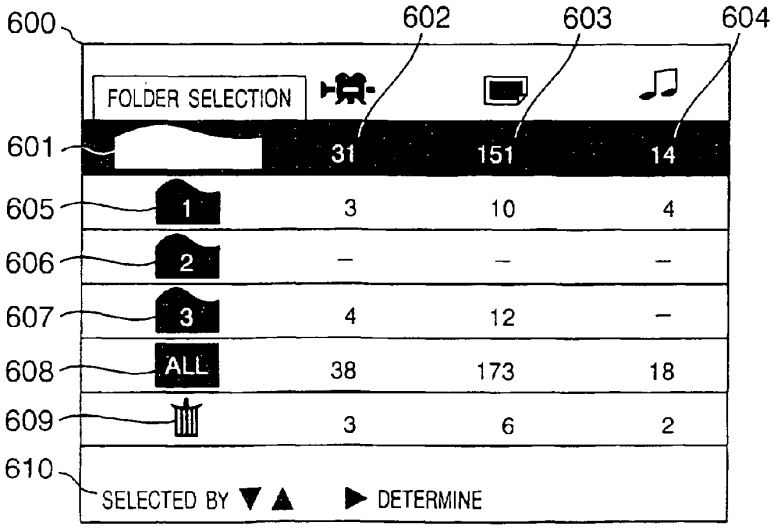

600
602
603
604
FOLDER SELECTION
601
31
151
14
605
1
3
10
4
606
2
–
–
–
607
3
4
12
–
608
ALL
38
173
18
609
3
6
2
610
SELECTED BY ▼ ▲
▶ DETERMINE

FIG. 7

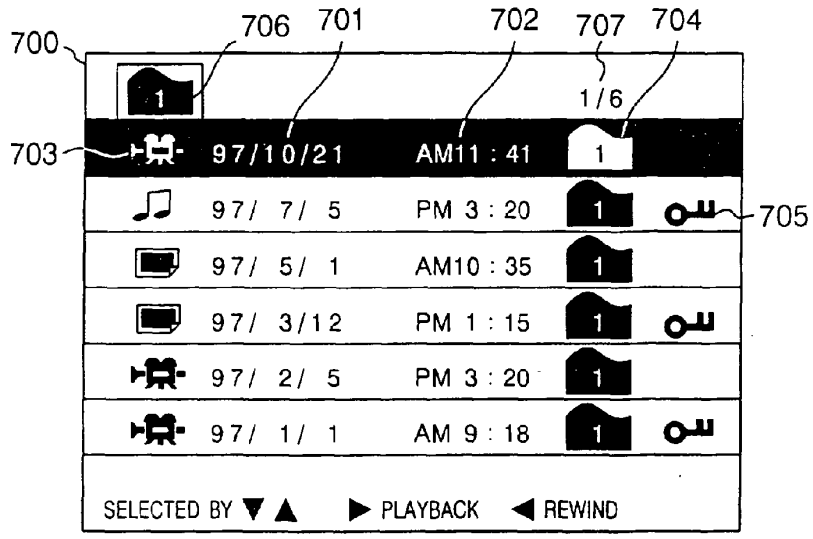

700
706
701
702
707
704
1/6
703
97/10/21
AM11 : 41
97/ 7/ 5
PM 3 : 20
705
97/ 5/ 1
AM10 : 35
97/ 3/12
PM 1 : 15
97/ 2/ 5
PM 3 : 20
97/ 1/ 1
AM 9 : 18
SELECTED BY ▼ ▲
▶ PLAYBACK
◀ REWIND

FIG. 8

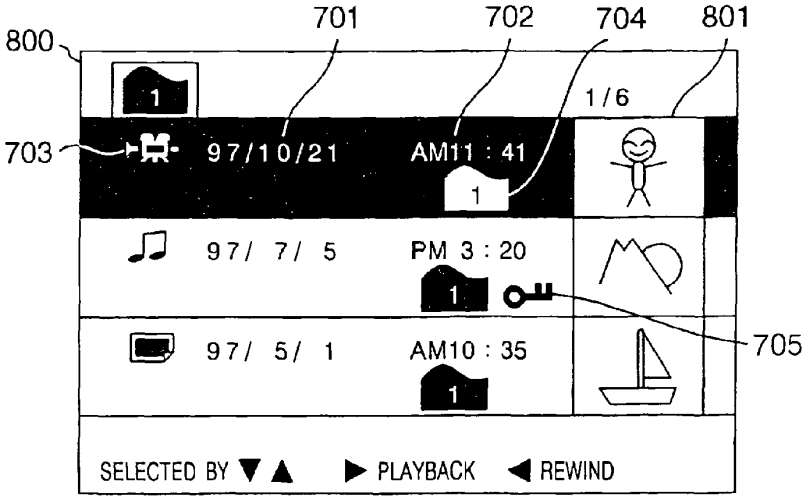

800
701
702
704
801
1/6
703
97/10/21
AM11 : 41
97/ 7/ 5
PM 3 : 20
705
97/ 5/ 1
AM10 : 35
SELECTED BY ▼ ▲
▶ PLAYBACK
◀ REWIND

FIG. 9

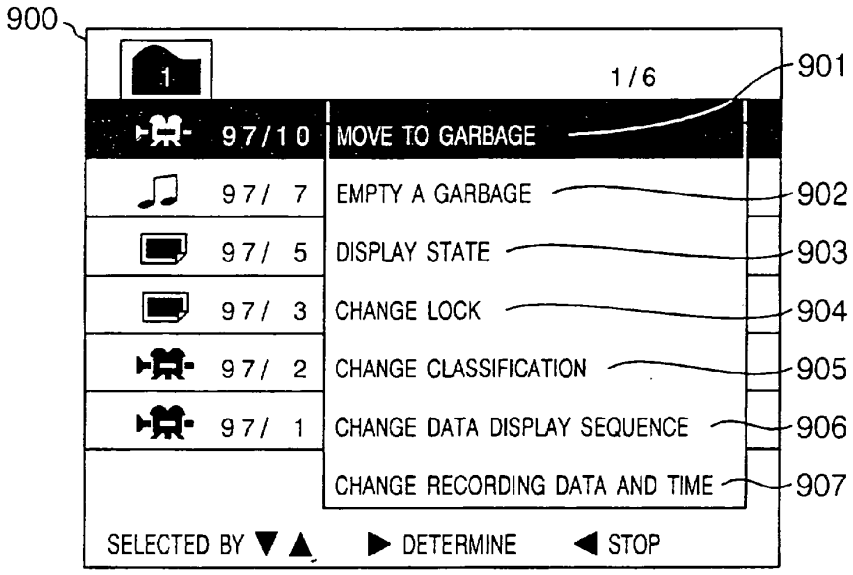

900
1
1/6
901
97/10
MOVE TO GARBAGE
97/ 7
EMPTY A GARBAGE
902
97/ 5
DISPLAY STATE
903
97/ 3
CHANGE LOCK
904
97/ 2
CHANGE CLASSIFICATION
905
97/ 1
CHANGE DATA DISPLAY SEQUENCE
906
CHANGE RECORDING DATA AND TIME
907
SELECTED BY ▼ ▲
▶ DETERMINE
◀ STOP

FIG. 10

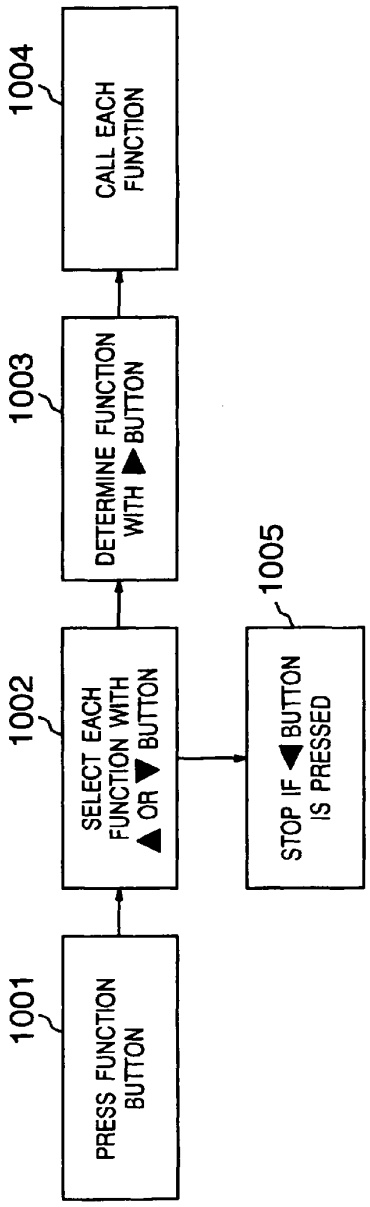

1001
PRESS FUNCTION BUTTON
1002
SELECT EACH FUNCTION WITH ▲ OR ▼ BUTTON
1003
DETERMINE FUNCTION WITH ▶ BUTTON
1004
CALL EACH FUNCTION
1005
STOP IF ◀ BUTTON IS PRESSED

FIG. 11

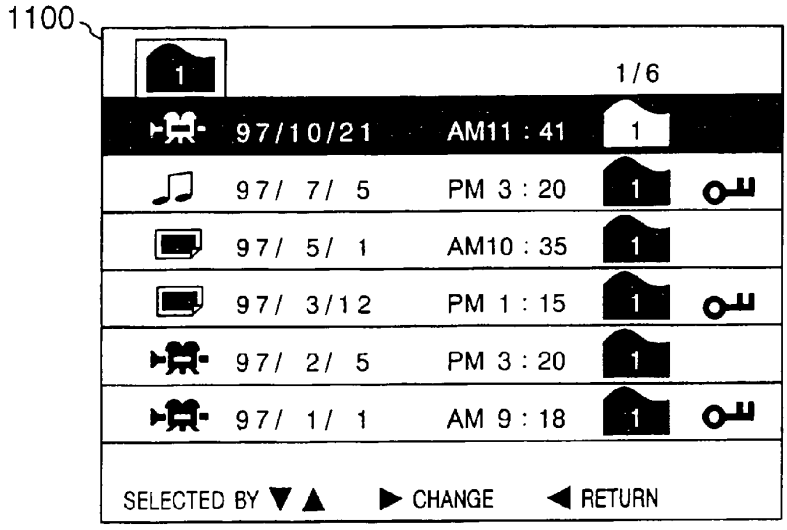

1100
1
1/6
97/10/21 AM11 : 41 1
97/ 7/ 5 PM 3 : 20 1
97/ 5/ 1 AM10 : 35 1
97/ 3/12 PM 1 : 15 1
97/ 2/ 5 PM 3 : 20 1
97/ 1/ 1 AM 9 : 18 1
SELECTED BY ▼ ▲ ▶ CHANGE ◀ RETURN

FIG. 12

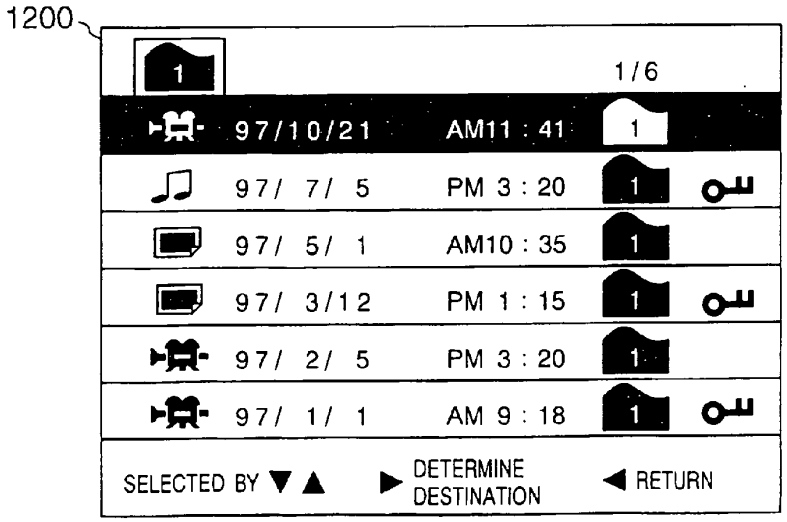

1200
1
1/6
97/10/21 AM11 : 41 1
97/ 7/ 5 PM 3 : 20 1
97/ 5/ 1 AM10 : 35 1
97/ 3/12 PM 1 : 15 1
97/ 2/ 5 PM 3 : 20 1
97/ 1/ 1 AM 9 : 18 1
SELECTED BY ▼ ▲ ▶ DETERMINE DESTINATION ◀ RETURN

FIG. 13

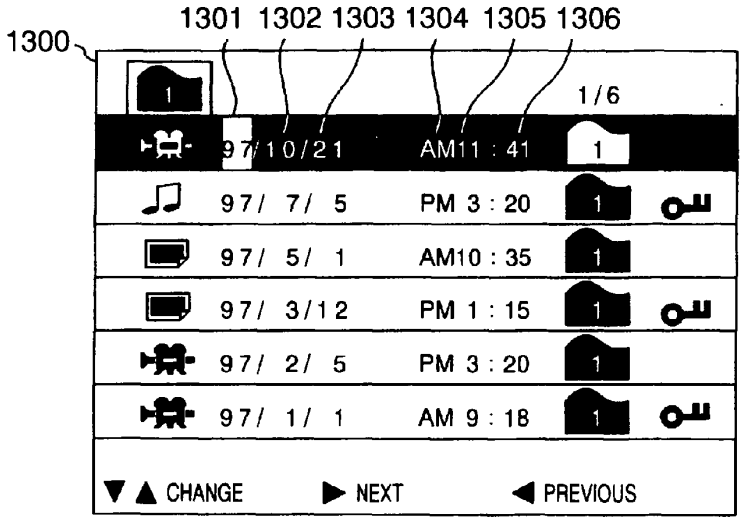

1300
1301 1302 1303 1304 1305 1306
1/6
97/10/21 AM11 : 41
97/ 7/ 5 PM 3 : 20
97/ 5/ 1 AM10 : 35
97/ 3/12 PM 1 : 15
97/ 2/ 5 PM 3 : 20
97/ 1/ 1 AM 9 : 18
CHANGE
NEXT
PREVIOUS

FIG. 14

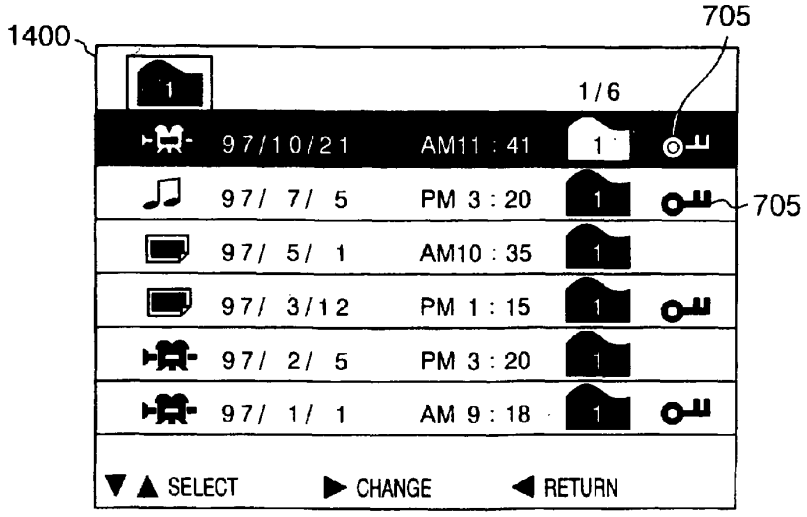

1400
705
1/6
97/10/21 AM11 : 41
97/ 7/ 5 PM 3 : 20
705
97/ 5/ 1 AM10 : 35
97/ 3/12 PM 1 : 15
97/ 2/ 5 PM 3 : 20
97/ 1/ 1 AM 9 : 18
SELECT
CHANGE
RETURN

FIG. 15

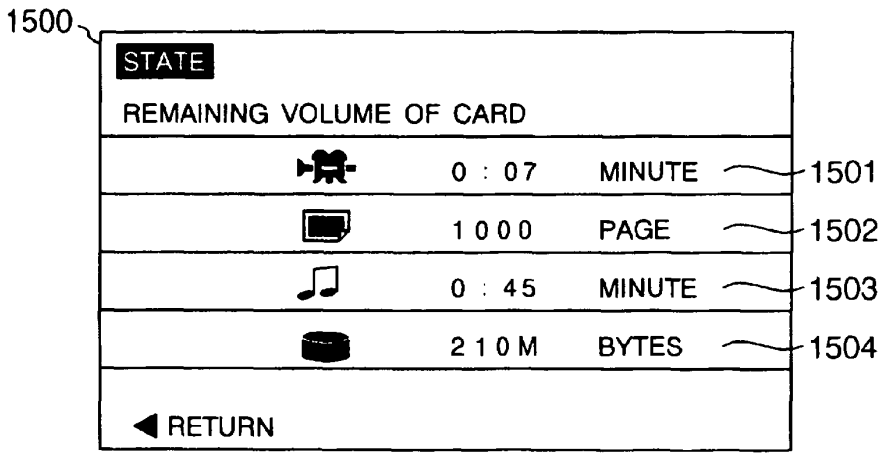

1500
STATE
REMAINING VOLUME OF CARD
0 : 07 MINUTE
1501
1000 PAGE
1502
0 : 45 MINUTE
1503
210M BYTES
1504
RETURN

FIG. 16

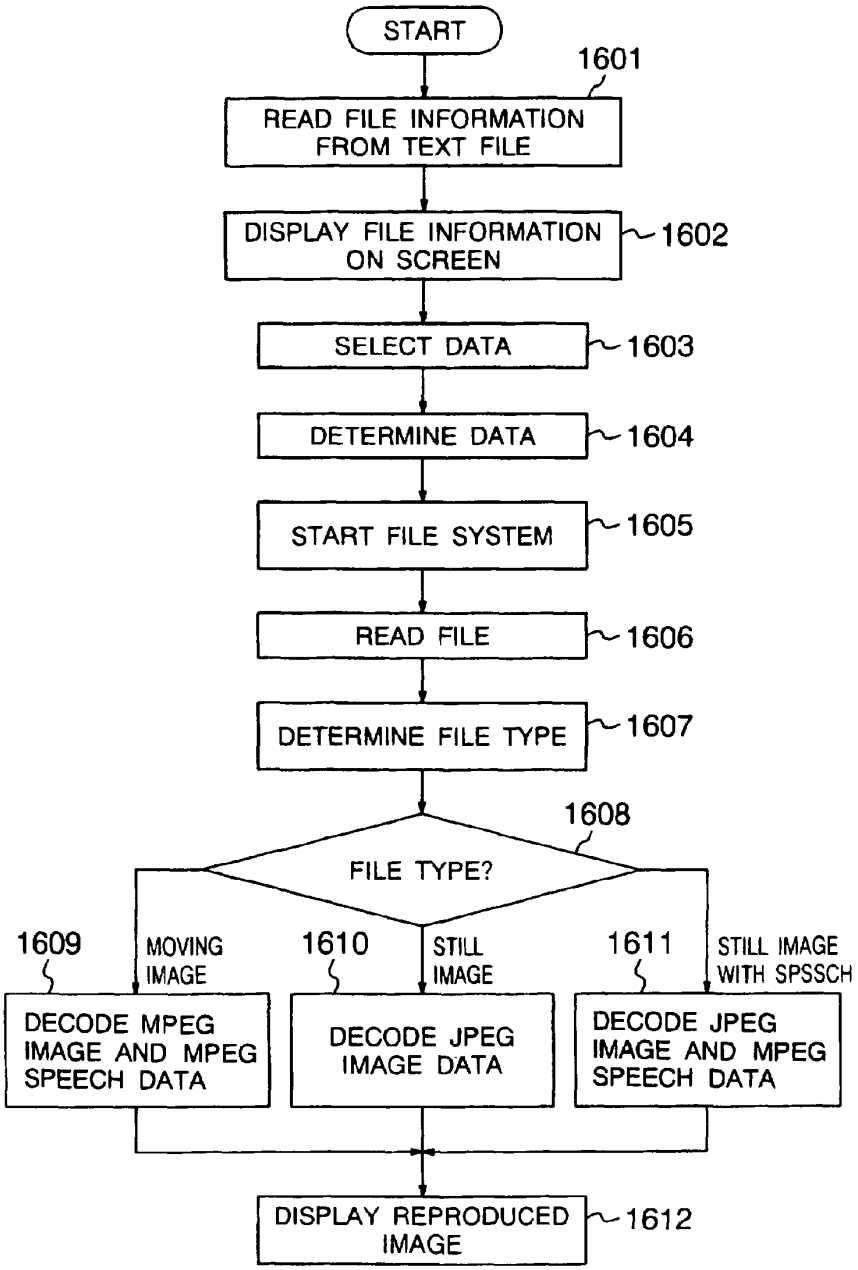

START
1601
READ FILE INFORMATION FROM TEXT FILE
DISPLAY FILE INFORMATION ON SCREEN
1602
SELECT DATA
1603
DETERMINE DATA
1604
START FILE SYSTEM
1605
READ FILE
1606
DETERMINE FILE TYPE
1607
1608
FILE TYPE?
1609
MOVING IMAGE
1610
STILL IMAGE
1611
STILL IMAGE WITH SPSSCH
DECODE MPEG IMAGE AND MPEG SPEECH DATA
DECODE JPEG IMAGE DATA
DECODE JPEG IMAGE AND MPEG SPEECH DATA
DISPLAY REPRODUCED IMAGE
1612

FIG. 17

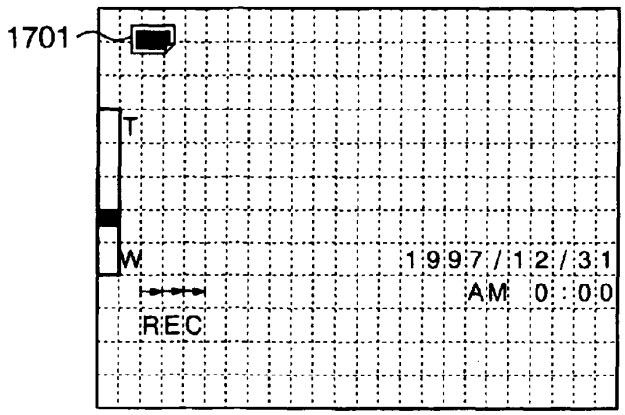


FIG. 18

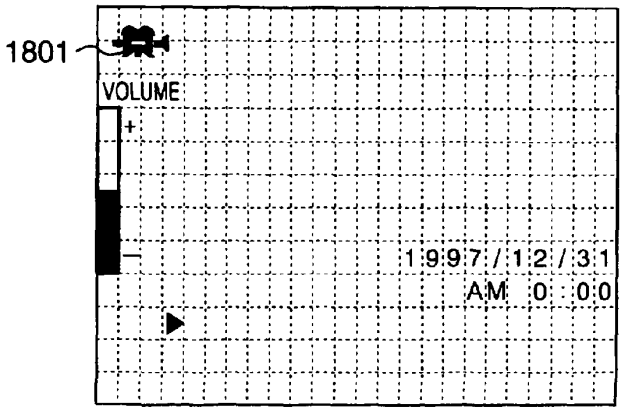


FIG. 19

RECORDING MODE	MODE SYMBOL
MOVING IMAGE	
STILL IMAGE	
SERIAL STILL IMAGE	
STILL IMAGE WITH SPEECH	

EXHIBIT 1025

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
TEXARKANA DIVISION

MAXELL, LTD.,

Plaintiff,

v.

APPLE INC.,

Defendant.

Civil Action No. _____

COMPLAINT AND DEMAND FOR JURY TRIAL

COMPLAINT FOR PATENT INFRINGEMENT

Plaintiff Maxell, Ltd. ("Maxell"), by and through its undersigned counsel, files this complaint under 35 U.S.C. § 271 for Patent Infringement against Defendant Apple Inc. ("Apple") and further alleges as follows, upon actual knowledge with respect to itself and its own acts, and upon information and belief as to all other matters.

OVERVIEW

1. This is an action for patent infringement by Maxell. Founded in 1961 as Maxell Electric Industrial Co., Ltd., Maxell is a leading global manufacturer of information storage media products, including magnetic tapes, optical discs, and battery products such as lithium ion rechargeable micro batteries and alkaline dry batteries, and the company has over 50 years of experience producing industry-leading recordable media and energy products for both the consumer and the professional markets. Maxell is also a leading manufacturer of projectors and lenses and additionally sells various other devices, such as Bluetooth headsets, wireless charging solutions, etc.

2. Maxell has built up an international reputation for excellence and reliability, for pioneering the power supplies and digital recording for today's mobile and multi-media devices, and leading the electronics industry in the fields of storage media and batteries.

3. Since being one of the first companies to develop alkaline batteries and Blu Ray camcorder discs, Maxell has always assured its customers of industry leading product innovation and is one of the world's foremost suppliers of memory, power, audio, and visual goods.

4. As more fully described below, in 2009 Hitachi, Ltd. assigned much of its intellectual property to Hitachi Consumer Electronics Co., Ltd., along with a significant portion of its Consumer Business Group, including manufacturing and research and development capabilities. Then, in 2013, Hitachi Consumer Electronics Co., Ltd. assigned the intellectual property, including many of the patents in this case, along with the related manufacturing and research and development capabilities, to Hitachi Maxell, Ltd., which later assigned the assets to Maxell as a result of a reorganization and name change. This was an effort to align the intellectual property with the licensing, business development, research and development, and manufacturing efforts of Maxell, including in the mobile and mobile-media device market. Maxell continues to sell products in the mobile device market including wireless charging solutions, wireless flash drives, multimedia players, storage devices, and headphones. Maxell also maintains intellectual property related to televisions, computer products, tablets, digital cameras, and mobile phones. As a mobile technology developer and industry leader, and due to its historical and continuous investment in research and development, including in this District, Maxell owns a portfolio of patents related to such technologies and actively enforces its patents through licensing and/or litigation. Maxell is forced to bring this action against Apple as a result of Apple's knowing and ongoing infringement of Maxell's patents as further described herein.

5. Since at least June 2013, Apple has been aware of Maxell's patents and has had numerous meetings and interactions regarding its infringement of these patents. These meetings included Apple's representatives being provided with detailed information regarding Maxell's patents, the developed technology, and Apple's ongoing use of this patented technology. Through this process, Apple's representatives requested and received detailed explanations regarding Maxell's patents and allegations. Maxell believed that the parties could reach a mutually beneficial solution and to that end considered a potential business transaction and continued to answer multiple inquiries from Apple over the course of several years, including communicating with Apple as recently as late 2018. Apple elected, however, not to enter into an agreement and did not license Maxell's patents. Instead, Apple continued, and continues today, to make, use, sell and offer for sale Maxell's patented technology without license.

6. Since 2014, Maxell has had regular and continuous business in the Eastern District of Texas. As a result of such business dealings and hopes to expand those and other business dealings, a Maxell affiliate, Maxell Research and Development America, LLC ("MRDA"), was founded in Marshall, Texas. Maxell and MRDA have and continue to regularly meet and work to expand the research and development activities, business, and investments being made by Maxell, MRDA, and their business partners in this District to further the goals of these companies.

PARTIES

7. Plaintiff Maxell, Ltd. is a Japanese corporation with a registered place of business at 1 Koizumi, Oyamazaki, Oyamazaki-cho, Otokuni-gun, Kyoto, Japan.

8. On information and belief, Defendant Apple Inc. is a California corporation having a principal place of business located at One Apple Park Way Cupertino, California 95014

and regular and established places of business at 2601 Preston Road, Frisco, Texas, and 6121 West Park Boulevard, Plano, Texas, as well as other locations in Texas. Apple offers and sells its products and/or services, including those accused herein of infringement, to customers and potential customers located in Texas, including in the judicial Eastern District of Texas. Apple may be served with process through its registered agent for service in Texas: CT Corporation System, 1999 Bryant Street, Suite 900, Dallas, Texas 75201.

NATURE OF THE ACTION, JURISDICTION, AND VENUE

9. Maxell brings this action for patent infringement under the patent laws of the United States, 35 U.S.C. § 271 *et seq*.

10. This Court has subject matter jurisdiction over the subject matter of this action pursuant to 28 U.S.C. §§ 1331 and 1338(a) because the action arises under the patent laws of the United States.

11. This Court has personal jurisdiction over Apple. Apple conducts business and has committed acts of direct and indirect patent infringement in this District, the State of Texas, and elsewhere in the United States. Moreover, Apple is registered to do business in the State of Texas, has offices and facilities in the State of Texas and this District, and actively directs its activities to customers located in the State of Texas and this District.

12. Venue is proper in this District pursuant to 28 U.S.C. § 1400(b). Apple has regular and established places of business in this District, including Apple Stores located at 2601 Preston Road, Frisco, Texas and 6121 West Park Boulevard, Plano, Texas, is deemed to reside in this District, has committed acts of infringement described herein in this District, and has purposely transacted business involving the accused devices in this District.

13. Six of the patents accused of infringement herein, including U.S. Patent Nos. 6,748,317; 8,339,493; 7,116,438; 6,408,193; 6,928,306; and 6,329,794, were previously asserted in this District against Huawei Device Co., Ltd., Huawei Device USA, Inc., ZTE (USA), Inc., ZTE Corporation, and/or ASUSTeK Computer Inc. Further, U.S. Patent Nos. 6,580,999 and 6,430,498 are the parents of the previously asserted U.S. Patent No. 6,748,317 and include similar subject matter as the one the Court is familiar with. During the course of these lawsuits, this Court heard from the parties and their experts regarding the technology at issue in these patents, construed numerous claim terms, and even conducted a jury trial, during which all patents were found to be valid and willfully infringed. Accordingly, this Court has substantial knowledge of and concerning the majority of the patents asserted in this lawsuit. Judicial economy further supports venue in this District.

COUNT 1 - INFRINGEMENT OF U.S. PATENT NO. 6,748,317

14. Maxell incorporates paragraphs 1-13 above by reference.

15. U.S. Patent No. 6,748,317 (the "'317 Patent," attached hereto at Exhibit 1) duly issued on June 8, 2004 and is entitled *Portable terminal with the function of walking navigation*.

16. Maxell is the owner by assignment of the '317 Patent and possesses all rights under the '317 Patent, including the exclusive right to recover for past and future infringement.

17. Eight years before Apple released its first GPS-enabled iPhone and five years before Google launched its first Maps product, the inventors of the '317 Patent were experimenting with ways to deliver navigation services to the small sized screens of cellular phones that were available in 1999. At the time of the priority date of the '317 Patent, even the Internet hosted map applications were geared to stationary desktop computers, not to mobile phones. The inventors of the '317 Patent recognized the benefits of delivering mapping services

to mobile phones and of supplementing those services with real-time location information from the phones themselves. '317 Patent, 1:10-30. The inventors were interested in specifically improving mapping services on small screen phones within the narrow field of walking navigation. *Id.* at 1:31-43. The inventors recognized that simply providing a map on the phone was not enough because the small, text-based displays of the phones were ill-equipped to display full maps or to enable meaningful user interactions. *Id.* at 2:17-36. The inventors also recognized that there was a need to provide a solution that did not require the enormous amount of cost required to download maps in real-time from a server linked to a computer network and to process this map information in a format that is readable on the small screens of the phones. *Id.* at 1:53-2:4. The inventors also recognized that a car navigation system from that time frame also did not provide a useful solution because it could not be used by a pedestrian to guide his/her walk due to the size and the lack of preciseness required to provide accurate route information to a pedestrian. *Id.* at 1:31-43.

18. It is against this backdrop that the inventors of the '317 Patent set about to solve the problem arising specifically in the realm of computer networks that—at that time—lacked the ability to provide accurate and precise route guidance information to pedestrians in a device that would be portable and that would not require the cost of constantly downloading maps and processing this data over a computer network in real-time. *Id.* at 2:51-61.

19. In order to solve this problem of computer, the inventors disclose a portable device with a particular combination of hardware components tailored for delivering mobile mapping services. The device includes a "[c]ellular antenna and … an infrared ray sensor" such as a "GSP [*sic*], PHS, or the like," with which it can obtain "location information." *Id.* at 5:66-6:2. The specification discloses that "location information" is "a latitude/longitude or coordinates

and an altitude." *Id.* at 5:62-64. Moreover, the device includes "a compass, a gyro, and such a sensor as a clinometer," with which it can obtain "direction information." *Id.* at 6:2-12. The specification discloses that "direction information" is "the direction of the tip of the [device] or the orientation of the display screen." *Id.* The '317 Patent thus discloses a portable device with a specific combination of hardware that has a particular set of capabilities and in order to ensure that they did not preempt the concept of simply including a map on a computer, the inventors claimed a combination of "devices" within a "portable terminal with the function of walking navigation." *See e.g., id.* at 10:42-57 (claim 1). Further, each of the claimed "devices" recites a specific function that as a whole solve the problem of the prior art devices that could not provide accurate and precise navigation information to pedestrians. *Id.*

20. For example, claim 1 recites at least "a device for getting location information," "a device for getting direction information denoting an orientation," "an input device for inputting a destination," and "a display" wherein the display specifically provides the claimed functionality of displaying positions of a "destination and a present place, and a relation of said direction and a direction from said present place to said destination." *Id.* Further, the display also specifically provides the claimed functionality of changing the display "according to a change of said direction of said portable terminal orientation for walking navigation," thus ensuring that the portable terminal can guide the pedestrian accurately in real-time in response to, for example, the pedestrian changing the direction he/she is walking. Independent claims 6 and 10 also recite similar combinations of hardware and also recite additional narrowing features (*e.g.*, "a device connected to a server"). *Id.* at 11:6-21 and 11:34-51. Similarly, at least dependent claims 2, 3, 5, 7, and 11 also provide additional narrowing features limiting the claims

to specific improvements in the field providing navigation information on portable terminals. *See id.* at 10:58-64, 11:3-5, 11:21-22, and 12:1-4.

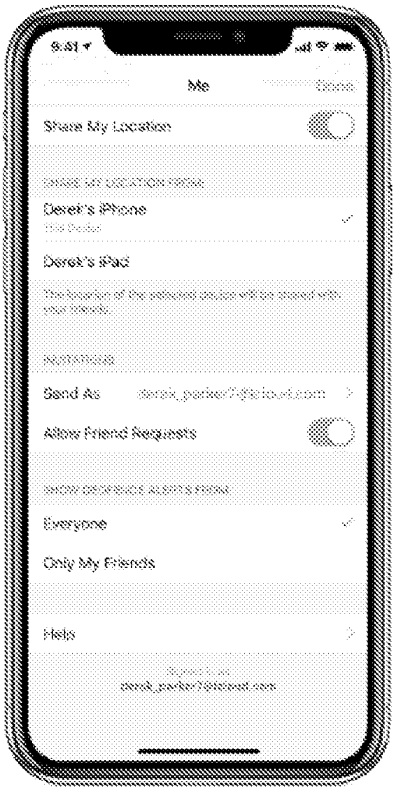
21. When considered as a whole the combination of hardware recited in the claims of the '317 Patent is directed to a specific novel and non-obvious portable terminal that includes specific functionality of providing guidance for walking navigation. Indeed, a jury in this jurisdiction made a determination that when considered as a whole, at least claims 1-3 of the '317 Patent are directed to a novel device and are not invalid over prior art.

22. Further, the patentability of the '317 Patent was challenged in IPR2018-00235, wherein the Patent Trial and Appeal Board was asked to consider the teachings of prior art (*e.g.*, U.S. Patent Nos. 5,781,150, 5,173,709, and 5,592,382, and Japanese Patent Application Publication No. H10-232992) in a challenge to the validity of claims 1-3, 6-8, 10, 15-17, and 20. In response, the Patent Trial and Appeal Board denied the petition, finding that the information presented does not "demonstrate a reasonable likelihood that Petitioner would prevail in showing that at least one of the challenged claims of the '317 Patent is unpatentable."

23. Apple has directly infringed one or more claims of the '317 Patent in this District and elsewhere in Texas, including at least claims 1-3, 5-7, and 10-11 literally and/or under the doctrine of equivalents, by or through making, using, importing, offering for sale and/or selling its telecommunications technology, including by way of example a product known as the iPhone XS.

24. The iPhone XS includes a screen for displaying information, at least a GPS chipset/cellular chipset/Wi-Fi chipset/iBeacon/compass/gyroscope for providing location and/or orientation information, "Maps" and "Find My Friends" software that allows users to access location information including the present location of the device and orientation of the device

and use such information to provide walking navigation information and/or share location. The iPhone XS further uses location servers to provide walking navigation information, route information, and/or to provide its position to additional devices in order to allow users to walk to a particular shared location. For example, the following excerpts from Apple's websites provide non-limiting examples of the iPhone XS infringing at least claims 1-3, 5-7, and 10-11 of the '317 Patent:



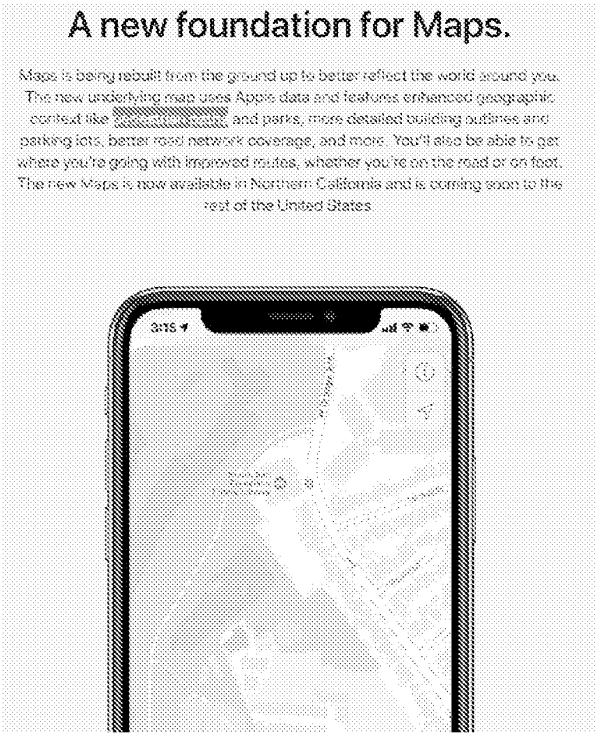
Use Find My Friends on multiple devices

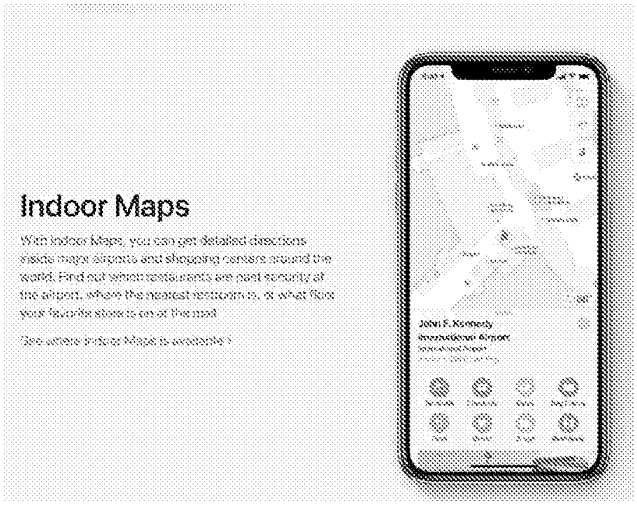
You can use Find My Friends on any iPhone, iPad, iPod touch, or Apple Watch that you own. However, only one iOS device can send your location to your followers. You can choose which one to use in Find My Friends:

- On your iPhone or iPod touch, tap Me, then tap a device under Share My Location From.
- On your iPad, tap List > Me > Info, then tap a device under Share My Location From.

This choice only appears when you're currently signed in to Find My Friends on multiple devices.

See https://support.apple.com/en-us/HT201493





See https://www.apple.com/ios/maps/

25. The foregoing features and capabilities of the iPhone XS, and Apple's description and/or demonstration thereof, including in user manuals and advertising, reflect Apple's direct

infringement by satisfying every element of at least claims 1-3, 5-7, and 10-11 of the '317 Patent, under 35 U.S.C. § 271(a).

26. On information and belief, Apple further infringes the '317 Patent through additional products utilizing the same or reasonably similar functionalities as described above with respect to the iPhone XS (collectively, "the '317 Accused Products"). The '317 Accused Products include all iOS devices including "Maps" and/or "Find My Friends" applications, for example, Apple iPhones (*e.g.*, iPhone XS (model no. A1920), iPhone XS Max (model no. A1921), iPhone XR (model no. A1984), iPhone X (model nos. A1865 and A1901), iPhone 8 Plus (model nos. A1864 and A1897), iPhone 8 (model nos. A1863 and A1905), iPhone 7 Plus (model nos. A1661 and A1784), iPhone 7 (model nos. A1660 and A1778), iPhone 6s Plus (model nos. A1634 andA1687), iPhone 6s (model nos. A1633 and A1688), iPhone 6 Plus (model nos. A1522 and A1524), iPhone 6 (model nos. A1549 and A1586), iPhone SE (model nos. A1723 and A1662), iPhone 5s (model nos. A1453 and A1533), and iPhone 5c (model nos. A1456 and A1532)) and Apple iPads with cellular functionality and/or Apple iPads with Wi-Fi and Indoor Maps (*e.g.*, iPad Air (model nos. A1474 and A1475), iPad mini 2 (model nos. A1489 and A1490), iPad Air 2 (model nos. A1566 and A1567), iPad mini 3 (model nos. A1599 and A1600), iPad mini 4 (model nos. A1538 and A1550), iPad Pro (10.5") (model nos. A1701 and A1709), iPad Pro (12.9") (model nos. A1584 and A1652), iPad Pro (9.7") (model nos. A1673, A1674, and A1675), iPad Pro (11") (model nos. A1980 and A2013), iPad (5th generation) (model nos. A1822 and A1823), iPad (6th generation) (model nos. A1893 and A1954), iPad Pro (12.9" 2nd generation) (model nos. A1670 and A1671), and iPad Pro (12.9" 3rd generation) (model nos. A1876, A2014, and A1895)). For example, each of these products also include a "Maps" application, a "Find My Friends" application, and/or "Location" services as advertised on

Apple's website. Maxell reserves the right to discover and pursue any additional infringing devices that incorporate infringing functionalities. For the avoidance of doubt, the '317 Accused Products are identified to describe Apple's infringement and in no way limit the discovery and infringement allegations against Apple concerning other devices that incorporate the same or reasonably similar functionalities.

27. Apple has indirectly infringed at least claims 1-3, 5-7, and 10-11 of the '317 Patent in this District and elsewhere in the United States by, among other things, actively inducing the use, offering for sale, selling, or importation of at least the '317 Accused Products. Apple's customers who purchase devices and components thereof and operate such devices and components in accordance with Apple's instructions directly infringe one or more claims of the '317 Patent in violation of 35 U.S.C. § 271. Apple instructs its customers through at least user guides or websites, such as those located at: https://support.apple.com/en_US/manuals or https://www.apple.com/ios/maps/. Apple is thereby liable for infringement of the '317 Patent pursuant to 35 U.S.C. § 271(b).

28. Apple has indirectly infringed at least claims 1-3, 5-7, and 10-11 of the '317 Patent, by, among other things, contributing to the direct infringement of others, including customers of the '317 Accused Products by making, offering to sell, or selling, in the United States, or importing a component of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process, constituting a material part of the invention, knowing the same to be especially made or especially adapted for use in infringement of the '317 Patent, and not a staple article or commodity of commerce suitable for substantial non-infringing use.

29. For example, the '317 Accused Products include hardware (*e.g.*, GPS chip, cellular chip, Wi-Fi chip, gyroscope, compass, A12 processor) and/or software (*e.g.*, "Maps" or "Find My Friends"). These are components of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process. Furthermore, such components are a material part of the invention and upon information and belief are not a staple article or commodity of commerce suitable for substantial non-infringing use. Thus, Apple is liable for infringement of the '317 Patent pursuant to 35 U.S.C. § 271(c).

30. Apple has been on notice of the '317 Patent since, at least, June 25, 2013. By the time of trial, Apple will thus have known and intended (since receiving such notice), that its continued actions would actively induce and contribute to actual infringement of at least claims 1-3, 5-7, and 10-11 of the '317 Patent.

31. Apple undertook and continued its infringing actions despite an objectively high likelihood that such activities infringed the '317 Patent, which has been duly issued by the USPTO, and is presumed valid. For example, since, at least June 25, 2013, Apple has been aware of an objectively high likelihood that its actions constituted and continue to constitute infringement of the '317 Patent, and that the '317 Patent is valid. On information and belief, Apple could not reasonably, subjectively believe that its actions do not constitute infringement of the '317 Patent, nor could it reasonably, subjectively believe that the patent is invalid. Despite that knowledge and subjective belief, and the objectively high likelihood that its actions constitute infringement, Apple has continued its infringing activities. As such, Apple willfully infringes the '317 Patent.

32. Maxell has been damaged by Apple's infringement of the '317 Patent.

COUNT 2 - INFRINGEMENT OF U.S. PATENT NO. 6,580,999

33. Maxell incorporates paragraphs 1-32 above by reference.

34. U.S. Patent No. 6,580,999 (the "'999 Patent," attached hereto at Exhibit 2) duly issued on June 17, 2003 and is entitled *Portable terminal with the function of walking navigation*.

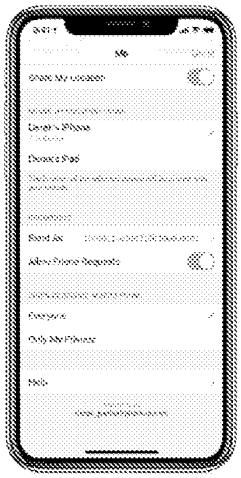
35. Maxell is the owner by assignment of the '999 Patent and possesses all rights under the '999 Patent, including the exclusive right to recover for past and future infringement.

36. The '999 Patent is the parent of the '317 Patent, and like claims of the '317 Patent, claims of the '999 Patent are also directed to a specific novel and non-obvious portable terminal that includes specific functionality of providing guidance for walking navigation. Further, claims 1-2 and 6 of the '999 Patent even include a "device for getting the location information of another portable terminal" ('999 Patent, 10:44-45), thus specifically claiming a portable terminal that can receive a location from another portable terminal and providing in real-time route guidance information to a pedestrian so that the pedestrian can walk to the location of the other portable terminal after receiving the location.

37. Apple has directly infringed one or more claims of the '999 Patent in this District and elsewhere in Texas, including at least claims 1-2 and 6 literally and/or under the doctrine of equivalents, by or through making, using, importing, offering for sale and/or selling its telecommunications technology, including by way of example a product known as the iPhone XS.

38. The iPhone XS includes a screen for displaying information, at least a GPS chipset/cellular chipset/Wi-Fi chipset/iBeacon/compass/gyroscope for providing location and/or orientation information, "Maps" and "Find My Friends" software that allows users to access location information including the present location of the device and orientation of the device

and use such information to provide walking navigation information and/or share location. The iPhone XS further uses location servers to provide walking navigation information, route information, and/or to provide its position to additional devices in order to allow users to walk to a particular shared location. For example, the following excerpts from Apple's websites provide non-limiting examples of the iPhone XS infringing at least claims 1-2 and 6 of the '999 Patent:



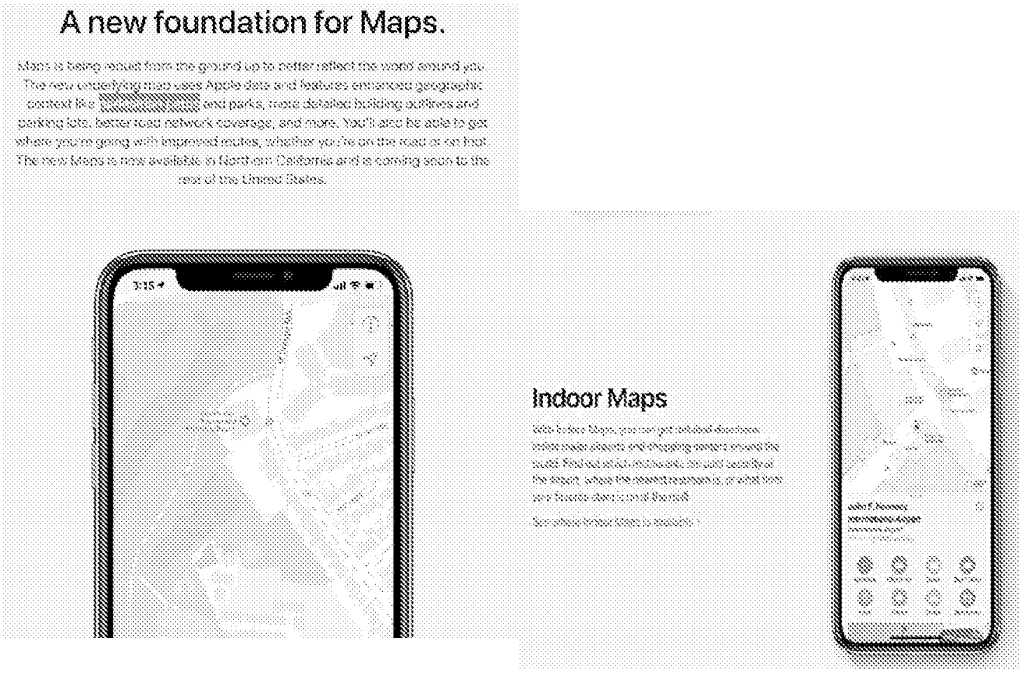
Use Find My Friends on multiple devices

You can use Find My Friends on any iPhone, iPad, iPod touch, or Apple Watch that you own. However, only one iOS device can send your location to your followers. You can choose which one to use in Find My Friends:

- On your iPhone or iPod touch, tap Me, then tap a device under Share My Location From.
- On your iPad, tap List > Me > Info, then tap a device under Share My Location From.

This choice only appears when you're currently signed in to Find My Friends on multiple devices.

See https://support.apple.com/en-us/HT201493



See https://www.apple.com/ios/maps/

39. The foregoing features and capabilities of the iPhone XS, and Apple's description and/or demonstration thereof, including in user manuals and advertising, reflect Apple's direct infringement by satisfying every element of at least claims 1-2 and 6 of the '999 Patent, under 35 U.S.C. § 271(a).

40. On information and belief, Apple further infringes the '999 Patent through additional products utilizing the same or reasonably similar functionalities as described above with respect to the iPhone XS (collectively, "the '999 Accused Products"). The '999 Accused Products include all iOS devices including "Maps" and/or "Find My Friends" applications, for example, Apple iPhones (*e.g.*, iPhone XS (model no. A1920), iPhone XS Max (model no. A1921), iPhone XR (model no. A1984), iPhone X (model nos. A1865 and A1901), iPhone 8 Plus (model nos. A1864 and A1897), iPhone 8 (model nos. A1863 and A1905), iPhone 7 Plus

(model nos. A1661 and A1784), iPhone 7 (model nos. A1660 and A1778), iPhone 6s Plus (model nos. A1634 andA1687), iPhone 6s (model nos. A1633 and A1688), iPhone 6 Plus (model nos. A1522 and A1524), iPhone 6 (model nos. A1549 and A1586), iPhone SE (model nos. A1723 and A1662), iPhone 5s (model nos. A1453 and A1533), and iPhone 5c (model nos. A1456 and A1532)) and Apple iPads with cellular functionality and/or Apple iPads with Wi-Fi and Indoor Maps (*e.g.*, iPad Air (model nos. A1474 and A1475), iPad mini 2 (model nos. A1489 and A1490), iPad Air 2 (model nos. A1566 and A1567), iPad mini 3 (model nos. A1599 and A1600), iPad mini 4 (model nos. A1538 and A1550), iPad Pro (10.5") (model nos. A1701 and A1709), iPad Pro (12.9") (model nos. A1584 and A1652), iPad Pro (9.7") (model nos. A1673, A1674, and A1675), iPad Pro (11") (model nos. A1980 and A2013), iPad (5th generation) (model nos. A1822 and A1823), iPad (6th generation) (model nos. A1893 and A1954), iPad Pro (12.9" 2nd generation) (model nos. A1670 and A1671), and iPad Pro (12.9" 3rd generation) (model nos. A1876, A2014, and A1895)). For example, each of these products also include a "Maps" application, a "Find My Friends" application, and/or "Location" services as advertised on Apple's website. Maxell reserves the right to discover and pursue any additional infringing devices that incorporate infringing functionalities. For the avoidance of doubt, the '999 Accused Products are identified to describe Apple's infringement and in no way limit the discovery and infringement allegations against Apple concerning other devices that incorporate the same or reasonably similar functionalities.

41. Apple has indirectly infringed at least claims 1-2 and 6 of the '999 Patent in this District and elsewhere in the United States by, among other things, actively inducing the use, offering for sale, selling, or importation of at least the '999 Accused Products. Apple's customers who purchase devices and components thereof and operate such devices and components in

accordance with Apple's instructions directly infringe one or more claims of the '999 Patent in violation of 35 U.S.C. § 271. Apple instructs its customers through at least user guides or websites, such as those located at: https://support.apple.com/en_US/manuals or https://www.apple.com/ios/maps/. Apple is thereby liable for infringement of the '999 Patent pursuant to 35 U.S.C. § 271(b).

42. Apple has indirectly infringed at least claims 1-2 and 6 of the '999 Patent, by, among other things, contributing to the direct infringement of others, including customers of the '999 Accused Products by making, offering to sell, or selling, in the United States, or importing a component of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process, constituting a material part of the invention, knowing the same to be especially made or especially adapted for use in infringement of the '999 Patent, and not a staple article or commodity of commerce suitable for substantial non-infringing use.

43. For example, the '999 Accused Products include hardware (*e.g.*, GPS chip, cellular chip, Wi-Fi chip, gyroscope, compass, A12 processor) and/or software (*e.g.*, "Maps" or "Find My Friends"). These are components of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process. Furthermore, such components are a material part of the invention and upon information and belief are not a staple article or commodity of commerce suitable for substantial non-infringing use. Thus, Apple is liable for infringement of the '999 Patent pursuant to 35 U.S.C. § 271(c).

44. Apple has been on notice of the '999 Patent since, at least, June 25, 2013. By the time of trial, Apple will thus have known and intended (since receiving such notice), that its continued actions would actively induce and contribute to actual infringement of at least claims 1-2 and 6 of the '999 Patent.

45. Apple undertook and continued its infringing actions despite an objectively high likelihood that such activities infringed the '999 Patent, which has been duly issued by the USPTO, and is presumed valid. For example, since, at least June 25, 2013, Apple has been aware of an objectively high likelihood that its actions constituted and continue to constitute infringement of the '999 Patent, and that the '999 Patent is valid. On information and belief, Apple could not reasonably, subjectively believe that its actions do not constitute infringement of the '999 Patent, nor could it reasonably, subjectively believe that the patent is invalid. Despite that knowledge and subjective belief, and the objectively high likelihood that its actions constitute infringement, Apple has continued its infringing activities. As such, Apple willfully infringes the '999 Patent.

46. Maxell has been damaged by Apple's infringement of the '999 Patent.

COUNT 3 - INFRINGEMENT OF U.S. PATENT NO. 8,339,493

47. Maxell incorporates paragraphs 1-46 above by reference.

48. U.S. Patent No. 8,339,493 (the "'493 Patent," attached hereto at Exhibit 3) duly issued on December 25, 2012 and is entitled *Electric Camera*.

49. Maxell is the owner by assignment of the '493 Patent and possesses all rights under the '493 Patent, including the exclusive right to recover for past and future infringement.

50. The patentability of the '493 Patent was challenged in IPR2018-00236, wherein the Patent Trial and Appeal Board was asked to consider the teachings of prior art (*e.g.*, U.S. Patent Nos. 5,493,335, 5,440,343, 5,497,192, 5,828,406, and 6,512,541) in a challenge to the validity of claims 5-6. In response, the Patent Trial and Appeal Board denied the petition, finding that the information presented does not "demonstrate a reasonable likelihood that Petitioner

would prevail in showing that at least one of the challenged claims of the '493 Patent is unpatentable."

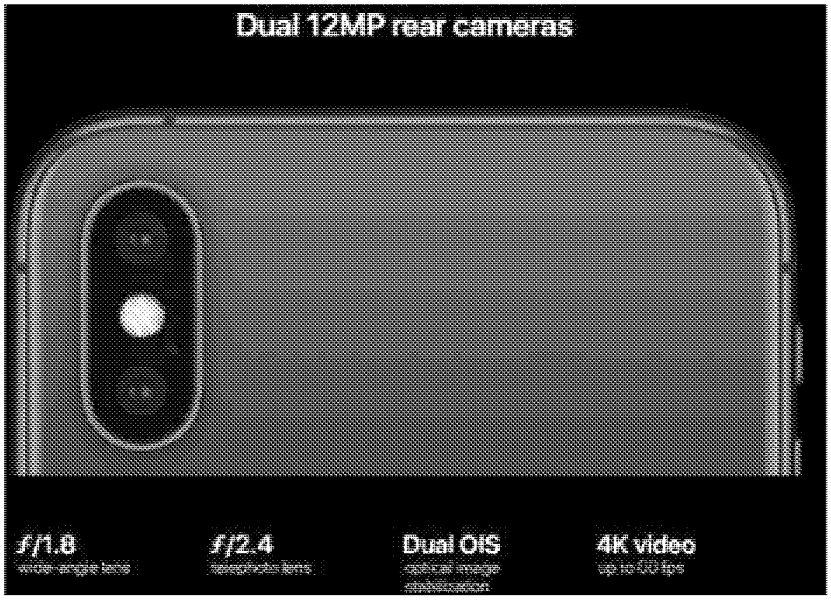
51. Apple has directly infringed one or more claims of the '493 Patent in this District and elsewhere in Texas, including at least claims 5-6 literally and/or under the doctrine of equivalents, by or through making, using, importing, offering for sale and/or selling its telecommunications technology, including by way of example a product known as the iPhone XS.

52. The iPhone XS includes front and rear-facing cameras, each of which incorporates a light-receiving sensor or imaging sensor (*e.g.*, CMOS sensor) with an array of pixels arranged vertically and horizontally in a grid pattern. The iPhone XS can record an image in a static mode, for example recording photographs and snapshots in photo camera modes, and in a moving video mode, for example recording a video clip in video camera mode.

53. The iPhone XS further includes a processor (*e.g.*, A12 chip and/or ISP) that processes signals from one or more cameras and sensors to generate image signals for displaying on the iPhone XS's display, where the generated image can be manipulated in accordance with a select pixel arrangement and/or image stabilization correction factor using a portion of the pixel lines available. For example, the following excerpts from Apple's websites provide non-limiting examples of the iPhone XS infringing at least claims 5-6 of the '493 Patent by way of implementing a dual-camera system, CMOS sensors, and an image signal processor that arranges an array of pixels in a grid pattern and processes the pixels for each of a static image mode (*e.g.*, still pictures), monitoring mode (*e.g.*, preview of pictures/videos), and moving video mode (*e.g.*, videos):



Sensors, processors, algorithms, and you. An innovative dual-camera system integrates the ISP, the Neural Engine, and advanced algorithms to unlock new creative possibilities and help you capture incredible photos.



See https://www.apple.com/iphone-xs/cameras/

54. The foregoing features and capabilities of the iPhone XS and Apple's description and/or demonstration thereof, including in user manuals and advertising, reflect Apple's direct infringement by satisfying every element of at least claims 5-6 of the '493 Patent, under 35 U.S.C. § 271(a).

55. On information and belief, Apple further infringes the '493 Patent through additional products utilizing the same or reasonably similar functionalities as described above with respect to the iPhone XS (collectively, "the '493 Accused Products"). The '493 Accused Products include, for example, Apple iPhones (*e.g.*, iPhone XS (model no. A1920), iPhone XS Max (model no. A1921), iPhone XR (model no. A1984), iPhone X (model nos. A1865 and A1901), iPhone 8 Plus (model nos. A1864 and A1897), iPhone 8 (model nos. A1863 and A1905), iPhone 7 Plus (model nos. A1661 and A1784), iPhone 7 (model nos. A1660 and A1778), iPhone 6s Plus (model nos. A1634 and A1687), iPhone 6s (model nos. A1633 andA1688), iPhone 6 Plus (model nos. A1522 and A1524), iPhone 6 (model nos. A1549 and A1586), iPhone SE (model nos. A1723 and A1662), iPhone 5s (model nos. A1453 and A1533), and iPhone 5c (model nos. A1456 and A1532)); Apple iPads (*e.g.*, iPad Air (model nos. A1474 and A1475), iPad mini 2 (model nos. A1489 and A1490), iPad Air 2 (model nos. A1566 and A1567), iPad mini 3 (model nos. A1599 and A1600), iPad mini 4 (model nos. A1538 and A1550), iPad Pro (10.5") (model nos. A1701 and A1709), iPad Pro (12.9") (model nos. A1584 and A1652), iPad Pro (9.7") (model nos. A1673, A1674, and A1675), iPad Pro (11") (model nos. A1980 and A2013), iPad (5th generation) (model nos. A1822 and A1823), iPad (6th generation) (model nos. A1893 and A1954), iPad Pro (12.9" 2nd generation) (model nos. A1670 and A1671), and iPad Pro (12.9" 3rd generation) (model nos. A1876, A2014, and A1895)); and Apple iPod Touches (*e.g.*, iPod Touch 5th generation (model nos. A1509 and A1421) and iPod Touch

6th generation (model no. A1574)). For example, each of these products also include one or more cameras, image sensors (*e.g.*, CMOS), and/or image stabilization techniques as advertised on Apple's website. Maxell reserves the right to discover and pursue any additional infringing devices that incorporate infringing functionalities. For the avoidance of doubt, the '493 Accused Products are identified to describe Apple's infringement and in no way limit the discovery and infringement allegations against Apple concerning other devices that incorporate the same or reasonably similar functionalities.

56. Apple has indirectly infringed at least claims 5-6 of the '493 Patent in this District and elsewhere in the United States by, among other things, actively inducing the use, offering for sale, selling, or importation of at least the '493 Accused Products. Apple's customers who purchase devices and components thereof and operate such devices and components in accordance with Apple's instructions directly infringe one or more claims of the '493 Patent in violation of 35 U.S.C. § 271. Apple instructs its customers through at least user guides or websites, such as those located at: https://support.apple.com/en_US/manuals or https://www.apple.com/iphone-xs/cameras/ or https://www.apple.com/iphone/#dual-cameras or https://www.apple.com/iphone-xs/cameras. Apple is thereby liable for infringement of the '493 Patent pursuant to 35 U.S.C. § 271(b).

57. Apple has indirectly infringed at least claims 5-6 of the '493 Patent, by, among other things, contributing to the direct infringement of others, including customers of the '493 Accused Products by making, offering to sell, or selling, in the United States, or importing a component of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process, constituting a material part of the invention, knowing the same to

be especially made or especially adapted for use in infringement of the '493 Patent, and not a staple article or commodity of commerce suitable for substantial non-infringing use.

58. For example, the '493 Accused Products include sensors in front and rear-facing cameras with an array of pixels arranged vertically and horizontally in a grid pattern. These are components of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process. Furthermore, such components are a material part of the invention and upon information and belief are not a staple article or commodity of commerce suitable for substantial non-infringing use. Thus, Apple is liable for infringement of the '493 Patent pursuant to 35 U.S.C. § 271(c).

59. Apple has been on notice of the '493 Patent since, at least, June 25, 2013. By the time of trial, Apple will thus have known and intended (since receiving such notice), that its continued actions would actively induce and contribute to actual infringement of at least claims 5-6 of the '493 Patent.

60. Apple undertook and continued its infringing actions despite an objectively high likelihood that such activities infringed the '493 Patent, which has been duly issued by the USPTO, and is presumed valid. For example, since, at least June 25, 2013, Apple has been aware of an objectively high likelihood that its actions constituted and continue to constitute infringement of the '493 Patent, and that the '493 Patent is valid. On information and belief, Apple could not reasonably, subjectively believe that its actions do not constitute infringement of the '493 Patent, nor could it reasonably, subjectively believe that the patent is invalid. Despite that knowledge and subjective belief, and the objectively high likelihood that its actions constitute infringement, Apple has continued its infringing activities. As such, Apple willfully infringes the '493 Patent.

61. Maxell has been damaged by Apple's infringement of the '493 Patent.

COUNT 4 - INFRINGEMENT OF U.S. PATENT NO. 7,116,438

62. Maxell incorporates paragraphs 1-61 above by reference.

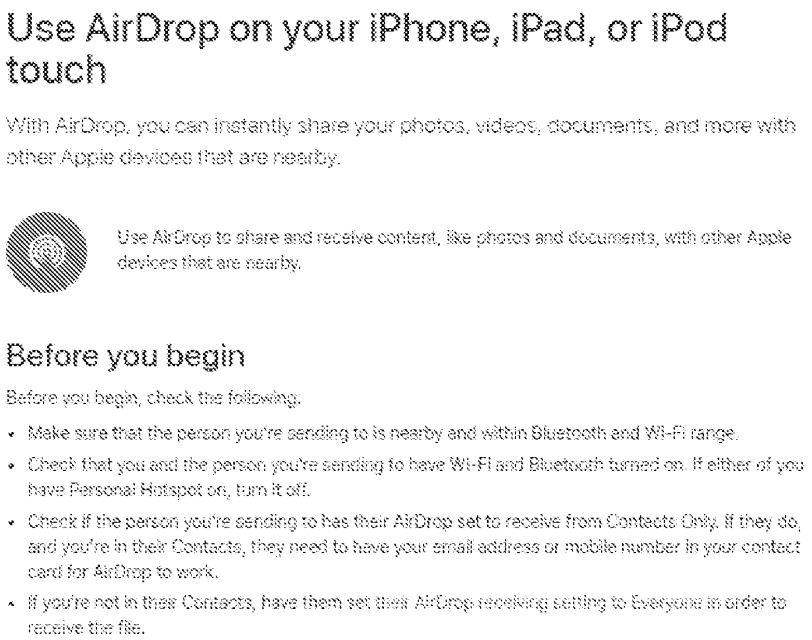
63. U.S. Patent No. 7,116,438 (the "'438 Patent," attached hereto at Exhibit 4) duly issued on October 3, 2006 and is entitled *Terminal for information processing*.

64. Maxell is the owner by assignment of the '438 Patent and possesses all rights under the '438 Patent, including the exclusive right to recover for past and future infringement.

65. Apple has directly infringed one or more claims of the '438 Patent in this District and elsewhere in Texas, including at least claims 1-3 literally and/or under the doctrine of equivalents, by or through making, using, importing, offering for sale and/or selling its telecommunications technology, including by way of example a product known as the iPhone XS.

66. The iPhone XS includes an input unit (such as the device's touch screen) for receiving input from a user in the form of hand gestures, screen touches, etc. Further, the iPhone XS includes a first short-distance communication unit (*e.g.*, Bluetooth, NFC chipset, and/or Wi-Fi) for carrying out a short-distance communication with a display apparatus. The iPhone XS also includes a second communication unit (*e.g.*, Bluetooth, Wi-Fi, and/or cellular network) for carrying out communication with a display device over a network. The iPhone XS further carries out an authentication process (*e.g.*, authentication via AirDrop) for determining whether to allow usage of the display apparatus and carries out data exchange with the display apparatus if the authentication process is confirmed. If the authentication process is not confirmed, then the iPhone XS does not exchange data with the display apparatus. For example, the following

excerpts from Apple's websites provide non-limiting examples of the iPhone XS infringing at least claims 1-3 of the '438 Patent:



Use AirDrop on your iPhone, iPad, or iPod touch

With AirDrop, you can instantly share your photos, videos, documents, and more with other Apple devices that are nearby.

Use AirDrop to share and receive content, like photos and documents, with other Apple devices that are nearby.

Before you begin

Before you begin, check the following.

- Make sure that the person you're sending to is nearby and within Bluetooth and Wi-Fi range.
- Check that you and the person you're sending to have Wi-Fi and Bluetooth turned on. If either of you have Personal Hotspot on, turn it off.
- Check if the person you're sending to has their AirDrop set to receive from Contacts Only. If they do, and you're in their Contacts, they need to have your email address or mobile number in your contact card for AirDrop to work.
- If you're not in their Contacts, have them set their AirDrop receiving setting to Everyone in order to receive the file.

See https://support.apple.com/en-us/HT204144

67. The foregoing features and capabilities of the iPhone XS, and Apple's description and/or demonstration thereof, including in user manuals and advertising, reflect Apple's direct infringement by satisfying every element of at least claims 1-3 of the '438 Patent, under 35 U.S.C. § 271(a).

68. On information and belief, Apple further infringes the '438 Patent through additional products utilizing the same or reasonably similar functionalities as described above with respect to the iPhone XS (collectively, "the '438 Accused Products"). The '438 Accused Products include at least the Apple iPhones (*e.g.*, iPhone XS (model no. A1920), iPhone XS Max (model no. A1921), iPhone XR (model no. A1984), iPhone X (model nos. A1865 and A1901), iPhone 8 Plus (model nos. A1864 and A1897), iPhone 8 (model nos. A1863 and A1905), iPhone

7 Plus (model nos. A1661 and A1784), iPhone 7 (model nos. A1660 and A1778), iPhone 6s Plus (model nos. A1634 and A1687), iPhone 6s (model nos. A1633 andA1688), iPhone 6 Plus (model nos. A1522 and A1524), iPhone 6 (model nos. A1549 and A1586), iPhone SE (model nos. A1723 and A1662), iPhone 5s (model nos. A1453 and A1533), and iPhone 5c (model nos. A1456 and A1532)); Apple iPads (*e.g.*, iPad Air (model nos. A1474 and A1475), iPad mini 2 (model nos. A1489 and A1490), iPad Air 2 (model nos. A1566 and A1567), iPad mini 3 (model nos. A1599 and A1600), iPad mini 4 (model nos. A1538 and A1550), iPad Pro (10.5") (model nos. A1701 and A1709), iPad Pro (12.9") (model nos. A1584 and A1652), iPad Pro (9.7") (model nos. A1673, A1674, and A1675), iPad Pro (11") (model nos. A1980 and A2013), iPad (5th generation) (model nos. A1822 and A1823), iPad (6th generation) (model nos. A1893 and A1954), iPad Pro (12.9" 2nd generation) (model nos. A1670 and A1671), and iPad Pro (12.9" 3rd generation) (model nos. A1876, A2014, and A1895)); Apple iPod Touches (*e.g.*, iPod Touch 5th generation (model nos. A1509 and A1421) and iPod Touch 6th generation (model no. A1574)); Apple watches (*e.g.*, Series 4 (model nos. A1975, A1976, A1977, and A1978), Series 3 (model nos. A1860, A1861, A1858, and A1859), Series 2 (model nos. A1757, A1758, A1816, and A1817), Series 1 (model nos. A1802 and A1803), and 1st Generation (model nos. A1553 and A1554)); and Mac Products implementing AirDrop sold or offered for sale on or after February 2013 (*e.g.*, MacBook Pro, MacBook Air, iMac, Mac mini, Mac Pro, and iMac Pro as identified at https://support.apple.com/en-us/HT203106). For example, each of these products also include a short distance communication unit (*e.g.*, Bluetooth, NFC chipset, and/or Wi-Fi) and a second communication unit (*e.g.*, Bluetooth, Wi-Fi, and/or cellular network) for implementing AirDrop as advertised on Apple's website. Maxell reserves the right to discover and pursue any additional infringing devices that incorporate infringing functionalities. For the avoidance of

doubt, the '438 Accused Products are identified to describe Apple's infringement and in no way limit the discovery and infringement allegations against Apple concerning other devices that incorporate the same or reasonably similar functionalities.

69. Apple has indirectly infringed at least claims 1-3 of the '438 Patent in this District and elsewhere in the United States by, among other things, actively inducing the use, offering for sale, selling, or importation of at least the '438 Accused Products. Apple's customers who purchase devices and components thereof and operate such devices and components in accordance with Apple's instructions directly infringe one or more claims of the '438 Patent in violation of 35 U.S.C. § 271. Apple instructs its customers through at least user guides or websites, such as those located at: https://support.apple.com/en_US/manuals or https://support.apple.com/en-us/HT204144 or https://support.apple.com/en-us/HT203106. Apple is thereby liable for infringement of the '438 Patent pursuant to 35 U.S.C. § 271(b).

70. Apple has indirectly infringed at least claims 1-3 of the '438 Patent, by, among other things, contributing to the direct infringement of others, including customers of the '438 Accused Products by making, offering to sell, or selling, in the United States, or importing a component of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process, constituting a material part of the invention, knowing the same to be especially made or especially adapted for use in infringement of the '438 Patent, and not a staple article or commodity of commerce suitable for substantial non-infringing use.

71. For example, the '438 Accused Products include hardware (*e.g.*, Bluetooth, NFC chipset, and/or Wi-Fi) and software components (*e.g.*, AirDrop). These are components of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process. Furthermore, such components are a material part of the invention and upon information

and belief are not a staple article or commodity of commerce suitable for substantial non-infringing use. Thus, Apple is liable for infringement of the '438 Patent pursuant to 35 U.S.C. § 271(c).

72. Apple has been on notice of the '438 Patent since, at least, May 17, 2018. By the time of trial, Apple will thus have known and intended (since receiving such notice), that its continued actions would actively induce and contribute to actual infringement of at least claims 1-3 of the '438 Patent.

73. Apple undertook and continued its infringing actions despite an objectively high likelihood that such activities infringed the '438 Patent, which has been duly issued by the USPTO, and is presumed valid. For example, since, at least May 17, 2018, Apple has been aware of an objectively high likelihood that its actions constituted and continue to constitute infringement of the '438 Patent, and that the '438 Patent is valid. On information and belief, Apple could not reasonably, subjectively believe that its actions do not constitute infringement of the '438 Patent, nor could it reasonably, subjectively believe that the patent is invalid. Despite that knowledge and subjective belief, and the objectively high likelihood that its actions constitute infringement, Apple has continued its infringing activities. As such, Apple willfully infringes the '438 Patent.

74. Maxell has been damaged by Apple's infringement of the '438 Patent.

COUNT 5 - INFRINGEMENT OF U.S. PATENT NO. 6,408,193

75. Maxell incorporates paragraphs 1-74 above by reference.

76. U.S. Patent No. 6,408,193 (the "'193 Patent," attached hereto at Exhibit 5) duly issued on June 18, 2002 and is entitled *Cellular telephone*.

77. Maxell is the owner by assignment of the '193 Patent and possesses all rights under the '193 Patent, including the exclusive right to recover for past and future infringement.

78. A jury in this jurisdiction has previously made a determination that when considered as a whole, at least claim 1 of the '193 Patent is directed to a novel and non-obvious device and is not invalid over prior art.

79. Further, the patentability of the '193 Patent was challenged in IPR2018-00237, wherein the Patent Trial and Appeal Board was asked to consider the teachings of prior art (*e.g.*, U.S. Patent Nos. 5,267,262, 5,710,981, 5,056,109, 5,548,616, 5,452,473, 5,420,536, and 3,486,128, IS-95 standard, Japanese Patent Laid-open Nos. Hei-9-46152, Hei-04-277909, and Hei-06-252797, and "*A Review and Comparison of Pulse Width Modulation (PWM) Methods for Analog and Digital Input Switching Power Amplifier*") in a challenge to the validity of claims 1-7. In response, the Patent Trial and Appeal Board denied the petition, finding that the information presented does not "demonstrate a reasonable likelihood that Petitioner would prevail in showing that at least one of the challenged claims of the '193 Patent is unpatentable."

80. Apple has directly infringed one or more claims of the '193 Patent in this District and elsewhere in Texas, including at least claim 1 literally and/or under the doctrine of equivalents, by or through making, using, importing, offering for sale and/or selling its telecommunications technology, including by way of example a product known as the iPhone XS.

81. The iPhone XS is a mobile device capable of operation in numerous networks, including CDMA. The iPhone XS includes at least one antenna for receiving first communication signals (*e.g.*, data signals transmitted on a downlink channel) and a transmitting

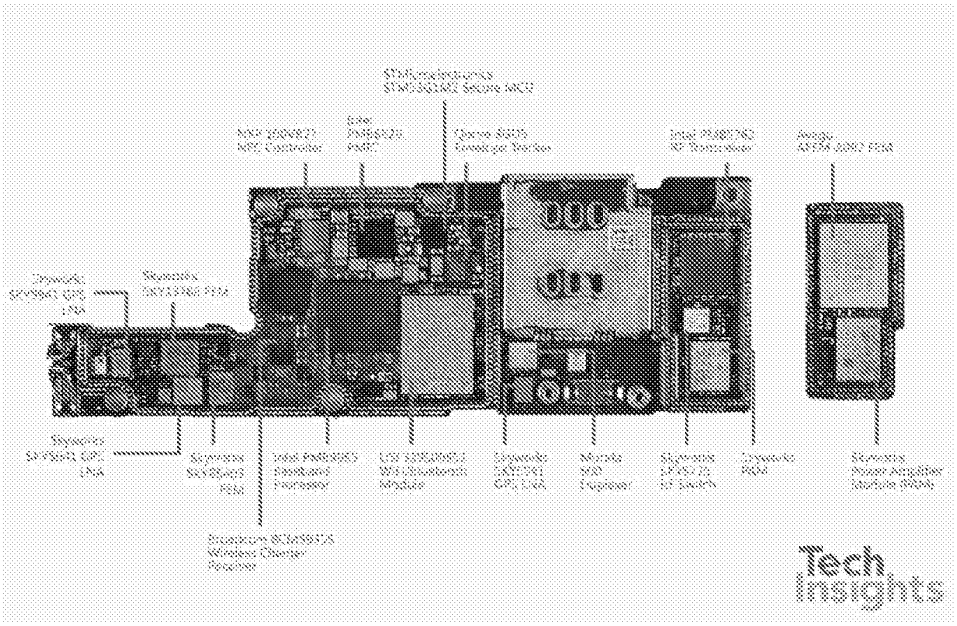
power control signal (*e.g.*, TPC transmitted on a downlink channel). It also transmits a second communication signal (*e.g.*, data on an uplink channel) to the cell-site station via the antenna.

82. The iPhone XS is observed to operate in FDD (Frequency Division Duplex), and incorporates a duplexer to allow full-duplex operation while sending and receiving at respective uplink and downlink frequencies on the same antenna or antennae and configured to convert communication signals to data, including voice signals.

83. The iPhone XS includes a receiver, *e.g.* a modem, connected to the antenna. The receiver includes an encoder/decoder and microphone and earpiece, and is configured to derive and output power control signal from the transmitting power control signal sent from the cell-site station. A controller is connected to the receiver and transmitter in the iPhone XS, which controls the amplitude of the transmission. For example, the following excerpt from Apple's websites and teardown showing the front end module components provide non-limiting examples of the iPhone XS infringing at least claim 1of the '193 Patent:

Cellular and Wireless	Model A1920*	FDD-LTE (Bands 1, 2, 3, 4, 5, 7, 8, 12, 13, 14, 17, 18, 19, 20, 25, 26, 29, 30, 32, 66, 71) TD-LTE (Bands 34, 38, 39, 40, 41, 46) CDMA EV-DO Rev. A (800, 1900 MHz) UMTS/HSPA+/DC-HSDPA (850, 900, 1700/2100, 1900, 2100 MHz) GSM/EDGE (850, 900, 1800, 1900 MHz)
	Model A1921*	FDD-LTE (Bands 1, 2, 3, 4, 5, 7, 8, 12, 13, 14, 17, 18, 19, 20, 25, 26, 29, 30, 32, 66, 71) TD-LTE (Bands 34, 38, 39, 40, 41, 46) CDMA EV-DO Rev. A (800, 1900 MHz) UMTS/HSPA+/DC-HSDPA (850, 900, 1700/2100, 1900, 2100 MHz) GSM/EDGE (850, 900, 1800, 1900 MHz)
	All models	Gigabit-class LTE with 4x4 MIMO and LAA* 802.11ac Wi-Fi with 2x2 MIMO Bluetooth 5.0 wireless technology NFC with reader mode Express Cards with power reserve

See https://www.apple.com/iphone-xs/specs/



See http://www.techinsights.com/about-techinsights/overview/blog/apple-iphone-xs-teardown/

84. The foregoing features and capabilities of the iPhone XS, and Apple's description and/or demonstration thereof, including in user manuals and advertising, reflect Apple's direct infringement by satisfying every element of at least claim 1 of the '193 Patent, under 35 U.S.C. § 271(a).

85. On information and belief, Apple further infringes the '193 Patent through additional products utilizing the same or reasonably similar functionalities as described above with respect to the iPhone XS (collectively, "the '193 Accused Products"). The '193 Accused Products include, each of the Apple iPhones (*e.g.*, iPhone XS (model no. A1920), iPhone XS Max (model no. A1921), iPhone XR (model no. A1984), iPhone X (model nos. A1865 and A1901), iPhone 8 Plus (model nos. A1864 and A1897), iPhone 8 (model nos. A1863 and A1905), iPhone 7 Plus (model nos. A1661 and A1784), iPhone 7 (model nos. A1660 and A1778), iPhone 6s Plus (model nos. A1634 and A1687), iPhone 6s (model nos. A1633

andA1688), iPhone 6 Plus (model nos. A1522 and A1524), iPhone 6 (model nos. A1549 and A1586), iPhone SE (model nos. A1723 and A1662), iPhone 5s (model nos. A1453 and A1533), and iPhone 5c (model nos. A1456 and A1532)) and Apple iPads with cellular functionality (*e.g.*, iPad Air (model no. A1475), iPad mini 2 (model no. 1490), iPad Air 2 (model no. A1567), iPad mini 3 (model no. A1600), iPad mini 4 (model no. A1550), iPad Pro (10.5") (model no. A1709), iPad Pro (12.9") (model no. A1652), iPad Pro (9.7") (model nos. A1674 and A1675), iPad Pro (11") (model no. A2013), iPad (5th generation) (model no. A1823), iPad (6th generation) (model no. A1954), iPad Pro (12.9" 2nd generation) (model no. A1671), and iPad Pro (12.9" 3rd generation) (model nos. A2014 and A1895)). For example, each of these products also include all necessary hardware and operating systems and work as described above with respect to the iPhone XS as advertised on Apple's website. Maxell reserves the right to discover and pursue any additional infringing devices that incorporate infringing functionalities. For the avoidance of doubt, the '193 Accused Products are identified to describe Apple's infringement and in no way limit the discovery and infringement allegations against Apple concerning other devices that incorporate the same or reasonably similar functionalities.

86. Apple has indirectly infringed at least claim 1 of the '193 Patent in this District and elsewhere in the United States by, among other things, actively inducing the use, offering for sale, selling, or importation of at least the '193 Accused Products. Apple's customers who purchase devices and components thereof and operate such devices and components in accordance with Apple's instructions directly infringe one or more claims of the '193 Patent in violation of 35 U.S.C. § 271. Apple instructs its customers through at least user guides or websites, such as those located at: https://support.apple.com/en_US/manuals or

https://www.apple.com/iphone-xs/specs/. Apple is thereby liable for infringement of the '193 Patent pursuant to 35 U.S.C. § 271(b).

87. Apple has indirectly infringed at least claim 1 of the '193 Patent, by, among other things, contributing to the direct infringement of others, including customers of the '193 Accused Products by making, offering to sell, or selling, in the United States, or importing a component of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process, constituting a material part of the invention, knowing the same to be especially made or especially adapted for use in infringement of the '193 Patent, and not a staple article or commodity of commerce suitable for substantial non-infringing use.

88. For example, the '193 Accused Products include a duplexer to allow full duplex operation while sending and receiving at respective uplink and downlink frequencies on the same antenna or antennae. Further, the '193 Accused Products include amplifiers and one or more processors for adjusting the transmission bias. These are components of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process. Furthermore, such components are a material part of the invention and upon information and belief are not a staple article or commodity of commerce suitable for substantial non-infringing use. Thus, Apple is liable for infringement of the '193 Patent pursuant to 35 U.S.C. § 271(c).

89. Apple has been on notice of the '193 Patent since, at least, May 17, 2018. By the time of trial, Apple will thus have known and intended (since receiving such notice), that its continued actions would actively induce and contribute to actual infringement of at least claim 1 of the '193 Patent.

90. Apple undertook and continued its infringing actions despite an objectively high likelihood that such activities infringed the '193 Patent, which has been duly issued by the

USPTO, and is presumed valid. For example, since, at least May 17, 2018, Apple has been aware of an objectively high likelihood that its actions constituted and continue to constitute infringement of the '193 Patent, and that the '193 Patent is valid. On information and belief, Apple could not reasonably, subjectively believe that its actions do not constitute infringement of the '193 Patent, nor could it reasonably, subjectively believe that the patent is invalid. Despite that knowledge and subjective belief, and the objectively high likelihood that its actions constitute infringement, Apple has continued its infringing activities. As such, Apple willfully infringes the '193 Patent.

91. Maxell has been damaged by Apple's infringement of the '193 Patent.

COUNT 6 - INFRINGEMENT OF U.S. PATENT NO. 10,084,991

92. Maxell incorporates paragraphs 1-91 above by reference.

93. U.S. Patent No. 10,084,991 (the "'991 Patent," attached hereto at Exhibit 6) duly issued on September 25, 2018 and is entitled *Communication apparatus and method for receiving an inbound videophone call notice while displaying digital information on the display*.

94. Maxell is the owner by assignment of the '991 Patent and possesses all rights under the '991 Patent, including the exclusive right to recover for past and future infringement.

95. Apple has directly infringed one or more claims of the '991 Patent in this District and elsewhere in Texas, including at least claims 1-3 and 8-10 literally and/or under the doctrine of equivalents, by or through making, using, importing, offering for sale and/or selling its telecommunications technology, including by way of example a product known as the iPhone XS.

96. The iPhone XS is a communication apparatus for transmitting and receiving digital information to and from another device. Further, the iPhone XS includes a network

interface (*e.g.*, Wi-Fi chipset or cellular chipset) to receive digital information from a server (*e.g.*, content from iCloud or iTunes) and additional information from another device. Further, the iPhone XS includes a camera to generate video information and a display to display the video information and the information received from the server and the other device. Further, the iPhone XS includes a processor (*e.g.*, A12 processor chipset or cellular chipset) that receives an inbound videophone call notice (*e.g.*, FaceTime call) while displaying the digital information on the display, the processor pauses the displaying of the first digital information and renders the camera operative. Further, the iPhone XS stops display of information being received from the server to display video from the other communication device generated based on the videophone call. For example, the following excerpts from Apple's websites provide non-limiting examples of the iPhone XS infringing at least claims 1-3 and 8-10 of the '991 Patent:

Use FaceTime with your iPhone, iPad, or iPod touch

Learn how to use FaceTime to make video and audio calls from your iPhone, iPad, or iPod touch.



You can use FaceTime over Wi-Fi or over cellular on supported iOS devices[3]. FaceTime isn't available or might not appear on devices purchased or used in Saudi Arabia, United Arab Emirates, and Pakistan. However, with iOS 11.3 and later, FaceTime is available on iPhone, iPad, and iPod touch in Saudi Arabia.

https://support.apple.com/en-us/HT204380

Download or stream movies and TV shows from the iTunes Store

You can buy or rent videos from the iTunes Store, then watch them on your iPhone, iPad, iPod touch, Mac, PC, or Apple TV.

Stream movies or TV shows

After you buy a movie or TV show from the iTunes Store, you can stream it on the device that you bought it on or on any of your other devices, as long as you're signed in with the same Apple ID.

Videos stream and download at the highest-quality version available based on the device that you're using, your device's settings, and your Internet speed. Learn more about how to find and watch movies with 4K, HDR, Dolby Vision, or Dolby Atmos.

If you don't see a play button for a movie or TV show, tap or click to download it. Some content can't be streamed over cellular data.

Switch to SD video

If you want to buy a lower-quality SD version instead, tap or click "Also available in SD" on the video's product page. Or on your Apple TV, go to Settings > Apps > iTunes Movies and TV Shows and turn on Limit Purchases and Rentals to SD, then purchase the video. The SD version won't have iTunes Extras, 4K, HDR, Dolby Vision, or Dolby Atmos formats, even if you play it later on a device that supports those features and formats.

See https://support.apple.com/en-us/HT203375#stream

97. The foregoing features and capabilities of the iPhone XS, and Apple's description and/or demonstration thereof, including in user manuals and advertising, reflect Apple's direct infringement by satisfying every element of at least claims 1-3 and 8-10 of the '991 Patent, under 35 U.S.C. § 271(a).

98. On information and belief, Apple further infringes the '991 Patent through additional products utilizing the same or reasonably similar functionalities as described above with respect to the iPhone XS (collectively, "the '991 Accused Products"). The '991 Accused Products include, each of the Apple iPhones (*e.g.*, iPhone XS (model no. A1920), iPhone XS Max (model no. A1921), iPhone XR (model no. A1984), iPhone X (model nos. A1865 and

A1901), iPhone 8 Plus (model nos. A1864 and A1897), iPhone 8 (model nos. A1863 and A1905), iPhone 7 Plus (model nos. A1661 and A1784), iPhone 7 (model nos. A1660 and A1778), iPhone 6s Plus (model nos. A1634 and A1687), iPhone 6s (model nos. A1633 andA1688), iPhone 6 Plus (model nos. A1522 and A1524), iPhone 6 (model nos. A1549 and A1586), iPhone SE (model nos. A1723 and A1662), iPhone 5s (model nos. A1453 and A1533), and iPhone 5c (model nos. A1456 and A1532)); Apple iPads (*e.g.*, iPad Air (model nos. A1474 and A1475), iPad mini 2 (model nos. A1489 and A1490), iPad Air 2 (model nos. A1566 and A1567), iPad mini 3 (model nos. A1599 and A1600), iPad mini 4 (model nos. A1538 and A1550), iPad Pro (10.5") (model nos. A1701 and A1709), iPad Pro (12.9") (model nos. A1584 and A1652), iPad Pro (9.7") (model nos. A1673, A1674, and A1675), iPad Pro (11") (model nos. A1980 and A2013), iPad (5th generation) (model nos. A1822 and A1823), iPad (6th generation) (model nos. A1893 and A1954), iPad Pro (12.9" 2nd generation) (model nos. A1670 and A1671), and iPad Pro (12.9" 3rd generation) (model nos. A1876, A2014, and A1895)); Apple iPod Touches (*e.g.*, iPod Touch 5th generation (model nos. A1509 and A1421) and iPod Touch 6th generation (model no. A1574); and MacBook products with FaceTime functionality (*e.g.*, MacBook (model nos. 8,1; 9,1; and 10,1), MacBook Air (model nos. 6,1; 6,2; 7,1; 7,2; and 8,1), and MacBook Pro (model nos. 10,1; 10,2; 11,1; 11,2; 11,3; 11,4; 11,5; 12,1; 13,1; 13,2; 13,3; 14,1; 14,2; 15,1; and 15,3)). For example, each of these products also include hardware (Wi-Fi chipset, cellular chipset, A12 processor, camera) and software (FaceTime application) as advertised on Apple's website. Maxell reserves the right to discover and pursue any additional infringing devices that incorporate infringing functionalities. For the avoidance of doubt, the '991 Accused Products are identified to describe Apple's infringement and in no way limit the

discovery and infringement allegations against Apple concerning other devices that incorporate the same or reasonably similar functionalities.

99. Apple has indirectly infringed at least claims 1-3 and 8-10 of the '991 Patent in this District and elsewhere in the United States by, among other things, actively inducing the use, offering for sale, selling, or importation of at least the '991 Accused Products. Apple's customers who purchase devices and components thereof and operate such devices and components in accordance with Apple's instructions directly infringe one or more claims of the '991 Patent in violation of 35 U.S.C. § 271. Apple instructs its customers through at least user guides or websites, such as those located at: https://support.apple.com/en_US/manuals or https://support.apple.com/en-us/HT204380 or https://support.apple.com/en-us/HT203375#stream. Apple is thereby liable for infringement of the '991 Patent pursuant to 35 U.S.C. § 271(b).

100. Apple has indirectly infringed at least claims 1-3 and 8-10 of the '991 Patent, by, among other things, contributing to the direct infringement of others, including customers of the '991 Accused Products by making, offering to sell, or selling, in the United States, or importing a component of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process, constituting a material part of the invention, knowing the same to be especially made or especially adapted for use in infringement of the '991 Patent, and not a staple article or commodity of commerce suitable for substantial non-infringing use.

101. For example, the '991 Accused Products include hardware (Wi-Fi chipset, cellular chipset, A12 processor, camera) and software (FaceTime application). These are components of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process. Furthermore, such components are a material part of the invention and upon

information and belief are not a staple article or commodity of commerce suitable for substantial non-infringing use. Thus, Apple is liable for infringement of the '991 Patent pursuant to 35 U.S.C. § 271(c).

102. Apple has been on notice of the '991 Patent since, at least, October 9, 2018. By the time of trial, Apple will thus have known and intended (since receiving such notice), that its continued actions would actively induce and contribute to actual infringement of at least claims 1-3 and 8-10 of the '991 Patent.

103. Apple undertook and continued its infringing actions despite an objectively high likelihood that such activities infringed the '991 Patent, which has been duly issued by the USPTO, and is presumed valid. For example, since, at least October 9, 2018, Apple has been aware of an objectively high likelihood that its actions constituted and continue to constitute infringement of the '991 Patent, and that the '991 Patent is valid. On information and belief, Apple could not reasonably, subjectively believe that its actions do not constitute infringement of the '991 Patent, nor could it reasonably, subjectively believe that the patent is invalid. Despite that knowledge and subjective belief, and the objectively high likelihood that its actions constitute infringement, Apple has continued its infringing activities. As such, Apple willfully infringes the '991 Patent.

104. Maxell has been damaged by Apple's infringement of the '991 Patent.

COUNT 7 - INFRINGEMENT OF U.S. PATENT NO. 6,928,306

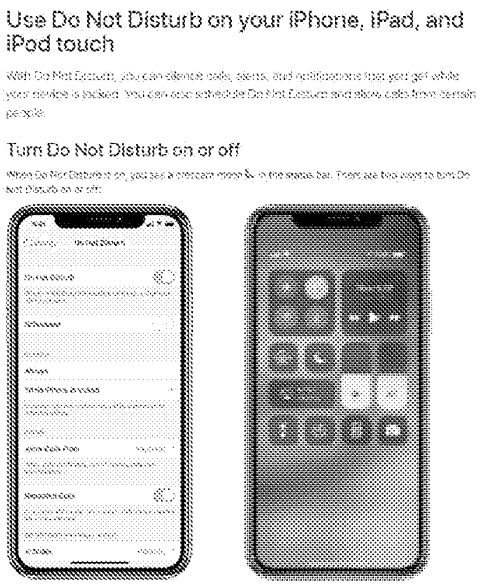
105. Maxell incorporates paragraphs 1-104 above by reference.

106. U.S. Patent No. 6,928,306 (the "'306 Patent," attached hereto at Exhibit 7) duly issued on August 9, 2005 and is entitled *Portable mobile unit*.

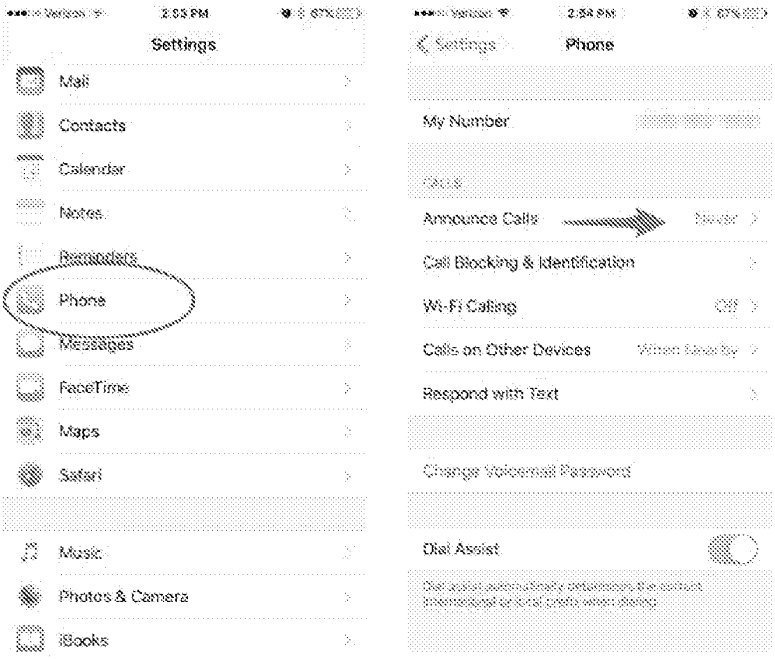
107. Maxell is the owner by assignment of the '306 Patent and possesses all rights under the '306 Patent, including the exclusive right to recover for past and future infringement.

108. Apple has directly infringed one or more claims of the '306 Patent in this District and elsewhere in Texas, including at least claims 2, 5-6, and 13-15 literally and/or under the doctrine of equivalents, by or through making, using, importing, offering for sale and/or selling its telecommunications technology, including by way of example a product known as the iPhone XS.

109. The iPhone XS is a portable mobile unit capable of alerting on incoming of a signal by a ringing sound (*e.g.*, alert for incoming call). Further, the iPhone XS includes a ringing sound generator having a plurality of sound sources (*e.g.*, a speaker and/or processor generating a ringtone and or announcing caller via Siri). Further, the iPhone XS includes a controller (*e.g.*, A12 chip) for controlling operations to generate the ringing sound using at least two of said sound sources when the signal comes in. Further, the iPhone XS includes a real time clock and/or timer to control the ringing sound based on a particular preset time (*e.g.*, "Do Not Disturb mode"). For example, the following excerpts and screenshots provide non-limiting examples of the iPhone XS infringing at least claims 2, 5-6, and 13-15 of the '306 Patent:



See https://support.apple.com/en-us/HT204321



See "Settings" in the iPhone XS

110. The foregoing features and capabilities of the iPhone XS, and Apple's description and/or demonstration thereof, including in user manuals and advertising, reflect Apple's direct infringement by satisfying every element of at least claims 2, 5-6, and 13-15 of the '306 Patent, under 35 U.S.C. § 271(a).

111. On information and belief, Apple further infringes the '306 Patent through additional products utilizing the same or reasonably similar functionalities as described above with respect to the iPhone XS (collectively, "the '306 Accused Products"). The '306 Accused Products include, for example, Apple iPhones (*e.g.*, iPhone XS (model no. A1920), iPhone XS Max (model no. A1921), iPhone XR (model no. A1984), iPhone X (model nos. A1865 and A1901), iPhone 8 Plus (model nos. A1864 and A1897), iPhone 8 (model nos. A1863 and A1905), iPhone 7 Plus (model nos. A1661 and A1784), iPhone 7 (model nos. A1660 and A1778), iPhone 6s Plus (model nos. A1634 and A1687), iPhone 6s (model nos. A1633 andA1688), iPhone 6 Plus (model nos. A1522 and A1524), iPhone 6 (model nos. A1549 and A1586), iPhone SE (model nos. A1723 and A1662), iPhone 5s (model nos. A1453 and A1533), and iPhone 5c (model nos. A1456 and A1532)); Apple iPads (*e.g.*, iPad Air (model nos. A1474 and A1475), iPad mini 2 (model nos. A1489 and A1490), iPad Air 2 (model nos. A1566 and A1567), iPad mini 3 (model nos. A1599 and A1600), iPad mini 4 (model nos. A1538 and A1550), iPad Pro (10.5") (model nos. A1701 and A1709), iPad Pro (12.9") (model nos. A1584 and A1652), iPad Pro (9.7") (model nos. A1673, A1674, and A1675), iPad Pro (11") (model nos. A1980 and A2013), iPad (5th generation) (model nos. A1822 and A1823), iPad (6th generation) (model nos. A1893 and A1954), iPad Pro (12.9" 2nd generation) (model nos. A1670 and A1671), and iPad Pro (12.9" 3rd generation) (model nos. A1876, A2014, and A1895)); and Apple iPod Touches (*e.g.*, iPod Touch 5th generation (model nos. A1509 and A1421) and iPod Touch

6th generation (model no. A1574)). For example, each of these products also include hardware and/or software to implement Siri, generate alerts, and/or implement "Do Not Disturb" mode as advertised on Apple's website. *See* https://support.apple.com/en-us/HT204321 and https://www.apple.com/siri/. Maxell reserves the right to discover and pursue any additional infringing devices that incorporate infringing functionalities. For the avoidance of doubt, the '306 Accused Products are identified to describe Apple's infringement and in no way limit the discovery and infringement allegations against Apple concerning other devices that incorporate the same or reasonably similar functionalities.

112. Apple has indirectly infringed at least claims 2, 5-6, and 13-15 of the '306 Patent in this District and elsewhere in the United States by, among other things, actively inducing the use, offering for sale, selling, or importation of at least the '306 Accused Products. Apple's customers who purchase devices and components thereof and operate such devices and components in accordance with Apple's instructions directly infringe one or more claims of the '306 Patent in violation of 35 U.S.C. § 271. Apple instructs its customers through at least user guides or websites, such as those located at: https://support.apple.com/en_US/manuals or https://support.apple.com/en-us/HT204321 or https://www.apple.com/siri/. Apple is thereby liable for infringement of the '306 Patent pursuant to 35 U.S.C. § 271(b).

113. Apple has indirectly infringed at least claims 2, 5-6, and 13-15 of the '306 Patent, by, among other things, contributing to the direct infringement of others, including customers of the '306 Accused Products by making, offering to sell, or selling, in the United States, or importing a component of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process, constituting a material part of the invention, knowing the

same to be especially made or especially adapted for use in infringement of the '306 Patent, and not a staple article or commodity of commerce suitable for substantial non-infringing use.

114. For example, the '306 Accused Products include a speaker, processor, and/or software to implement Siri announce caller and "Do Not Disturb" modes. These are components of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process. Furthermore, such components are a material part of the invention and upon information and belief are not a staple article or commodity of commerce suitable for substantial non-infringing use. Thus, Apple is liable for infringement of the '306 Patent pursuant to 35 U.S.C. § 271(c).

115. Apple has been on notice of the '306 Patent since, at least, May 17, 2018. By the time of trial, Apple will thus have known and intended (since receiving such notice), that its continued actions would actively induce and contribute to actual infringement of at least claims 2, 5-6, and 13-15 of the '306 Patent.

116. Apple undertook and continued its infringing actions despite an objectively high likelihood that such activities infringed the '306 Patent, which has been duly issued by the USPTO, and is presumed valid. For example, since, at least May 17, 2018, Apple has been aware of an objectively high likelihood that its actions constituted and continue to constitute infringement of the '306 Patent, and that the '306 Patent is valid. On information and belief, Apple could not reasonably, subjectively believe that its actions do not constitute infringement of the '306 Patent, nor could it reasonably, subjectively believe that the patent is invalid. Despite that knowledge and subjective belief, and the objectively high likelihood that its actions constitute infringement, Apple has continued its infringing activities. As such, Apple willfully infringes the '306 Patent.

117. Maxell has been damaged by Apple's infringement of the '306 Patent.

COUNT 8 - INFRINGEMENT OF U.S. PATENT NO. 6,329,794

118. Maxell incorporates paragraphs 1-117 above by reference.

119. U.S. Patent No. 6,329,794 (the "'794 Patent," attached hereto at Exhibit 8) duly issued on December 11, 2001 and is entitled *Information processing device and method for controlling power consumption thereof.*

120. Maxell is the owner by assignment of the '794 Patent and possesses all rights under the '794 Patent, including the exclusive right to recover for past and future infringement.

121. At the time of the invention of the '794 Patent, conventional devices had limited power management techniques available. '794 Patent, 1:5-45. To conserve power, they either reduced power consumption of all devices as much as possible or restricted power to function devices that were not being used. *Id.* at 1:12-22. The '794 Patent provided a new power management solution and taught assigning different priorities to independent function devices of an information processing device and controlling the supply of power to those function devices based on their priority and the remaining battery capacity. *Id.* at 1:49-67. The '794 Patent disclosed powering down lower-priority function devices (such as, in one embodiment, a videophone function) before other, higher-priority function devices (such as, in one embodiment, audio communication). *Id.* at 4:36-62. This priority-based power management provided a mechanism for users to continue using desired functions longer by reducing power to less important functions at an earlier stage of battery depletion. *Id.* at 1:55-67.

122. As a part of its solution, the '794 Patent teaches at least the use of a battery capacity detector and a controller able to send independent power consumption reduction instructions to low-priority function devices structured to receive these instructions when the

battery decreases below certain thresholds. *Id.* at 1:55-67. The '794 Patent provided a practical and desirable concrete way of prioritizing certain function devices within the information processing device by correlating their priority of usage to various thresholds of remaining battery capacity. When the battery capacity decreased past a given threshold, the function devices assigned to that priority group would receive power reduction instructions. The '794 Patent is directed to a specific improvement of the power management capabilities of an information processing device and ties this improvement to the additional inventive concept of tying specific threshold battery levels to power reduction instructions that are sent to prioritized function devices.

123. The '794 Patent is directed to power management within the computer system itself, and specifically teaches assigning different priorities to the function devices of an information processing device depending specifically on remaining battery levels. The '794 Patent teaches and claims assigning at least two priority rankings to function devices within the computer, correlating each priority ranking to a threshold remaining battery level, and sending power consumption reduction instructions to all function devices based on a priority rank when the battery level decreases below the correlated threshold. '794 Patent at claim 1. The invention of the '794 Patent allows a device to operate in a more efficient manner and improves the computer system itself, rather than using a conventional computer system as a conduit to accomplish its objectives.

124. Further, the patentability of the '794 Patent was challenged in IPR2018-00241, wherein the Patent Trial and Appeal Board was asked to consider the teachings of prior art (*e.g.*, U.S. Patent Nos. 6,031,999, 5,560,022, 6,345,180, 6,360,327, and Advanced Configuration and Power Interface Specification) in a challenge to the validity of claims 1-3 and 5-14. In response,

the Patent Trial and Appeal Board denied the petition, finding that the information presented does not "demonstrate a reasonable likelihood that Petitioner would prevail in showing that at least one of the challenged claims of the '794 Patent is unpatentable."

125. Apple has directly infringed one or more claims of the '794 Patent in this District and elsewhere in Texas, including at least claims 1-3 and 9-11 literally and/or under the doctrine of equivalents, by or through making, using, importing, offering for sale and/or selling its telecommunications technology, including by way of example a product known as the iPhone XS.

126. The iPhone XS is an information processing device that incorporates multiple component devices performing different functions, with each component having a corresponding power supplied by a battery. For example, the iPhone XS includes a display with a display power supply. The iPhone XS incorporates a processor or co-processor programmed with software, in combination with the electronic components of the iPhone XS, to monitor the battery capacity of the battery as components of the device consume the power supplied from the battery. Under an operating condition when the battery is at a first reference level, a processor or co-processor of the iPhone XS is programmed to optimize power consumption, including shutting off or reducing the power consumption of components or applications that have a lower usage priority as predefined by the software or selected by the user, where different components are shut down based on one or more defined battery capacity levels and usage priority. For example, the following excerpts provide non-limiting examples of the iPhone XS infringing at least claims 1-3 and 9-11 of the '794 Patent:

Use Low Power Mode to save battery life on your iPhone

Low Power Mode reduces the amount of power that your iPhone uses when the battery gets low.

To turn Low Power Mode on or off, go to Settings > Battery. You can also turn Low Power Mode on and off from Control Center. Go to Settings > Control Center > Customize Controls, then select Low Power Mode to add it to Control Center.

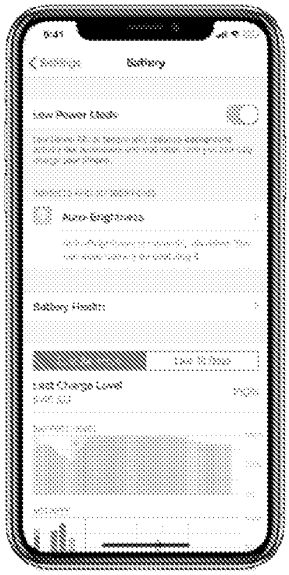
When Low Power Mode is on, your iPhone will last longer before you need to charge it, but some features might take longer to update or complete. Also, some tasks might not work until you turn off Low Power Mode, or until you charge your iPhone to 80% or higher.

Low Power Mode reduces or affects these features:

- Email fetch
- "Hey Siri"
- Background app refresh
- Automatic downloads
- Some visual effects
- Auto-Lock (defaults to 30 seconds)
- iCloud Photo Library (temporarily paused)

When Low Power Mode is on, the battery in the status bar will be yellow. You'll see [illegible] and the battery percentage. After you charge your iPhone to 80% or higher, Low Power Mode automatically turns off.

Low Power Mode is available only on iPhone.



See https://support.apple.com/en-us/HT205234

Use Low Power Mode

If you want to extend the battery life on your iPhone, turn on Low Power Mode. This reduces power consumption until you turn it off or charge your iPhone to 80%. When Low Power Mode is on, certain settings and features like app updates, downloads of new TV shows or podcast episodes, mail fetch, and some visual effects such as True Tone are reduced or disabled.

Learn more about Low Power Mode.

See https://support.apple.com/en-us/HT201264

127. The foregoing features and capabilities of the iPhone XS, and Apple's description and/or demonstration thereof, including in user manuals and advertising, reflect Apple's direct infringement by satisfying every element of at least claims 1-3 and 9-11 of the '794 Patent, under 35 U.S.C. § 271(a).

128. On information and belief, Apple further infringes the '794 Patent through additional products utilizing the same or reasonably similar functionalities as described above with respect to the iPhone XS (collectively, "the '794 Accused Products"). The '794 Accused Products include, by way of examples, the Apple iPhones (*e.g.*, iPhone XS (model no. A1920), iPhone XS Max (model no. A1921), iPhone XR (model no. A1984), iPhone X (model nos. A1865 and A1901), iPhone 8 Plus (model nos. A1864 and A1897), iPhone 8 (model nos. A1863 and A1905), iPhone 7 Plus (model nos. A1661 and A1784), iPhone 7 (model nos. A1660 and A1778), iPhone 6s Plus (model nos. A1634 andA1687), iPhone 6s (model nos. A1633 and A1688), iPhone 6 Plus (model nos. A1522 and A1524), iPhone 6 (model nos. A1549 and A1586), iPhone SE (model nos. A1723 and A1662), iPhone 5s (model nos. A1453 and A1533), and iPhone 5c (model nos. A1456 and A1532)); Apple iPads (*e.g.*, iPad Air (model nos. A1474 and A1475), iPad mini 2 (model nos. A1489 and A1490), iPad Air 2 (model nos. A1566 and A1567), iPad mini 3 (model nos. A1599 and A1600), iPad mini 4 (model nos. A1538 and A1550), iPad Pro (10.5") (model nos. A1701 and A1709), iPad Pro (12.9") (model nos. A1584 and A1652), iPad Pro (9.7") (model nos. A1673, A1674, and A1675), iPad Pro (11") (model nos. A1980 and A2013), iPad (5th generation) (model nos. A1822 and A1823), iPad (6th generation) (model nos. A1893 and A1954), iPad Pro (12.9" 2nd generation) (model nos. A1670 and A1671), and iPad Pro (12.9" 3rd generation) (model nos. A1876, A2014, and A1895)); Apple iPod Touches (*e.g.*, iPod Touch 5th generation (model nos. A1509 and A1421) and iPod Touch 6th generation (model no. A1574)); and Apple watches (*e.g.*, Series 4 (model nos. A1975, A1976, A1977, and A1978), Series 3 (model nos. A1860, A1861, A1858, and A1859), Series 2 (model nos. A1757, A1758, A1816, and A1817), Series 1 (model nos. A1802 and A1803), and 1st Generation (model nos. A1553 and A1554)). For example, each of these products also include an

Axx series chip and battery for managing/prioritizing power usage and implementing a low power mode as advertised on Apple's website. *See e.g.*, https://support.apple.com/en-us/HT205234 or https://support.apple.com/en-us/HT201264. Maxell reserves the right to discover and pursue any additional infringing devices that incorporate infringing functionalities. For the avoidance of doubt, the '794 Accused Products are identified to describe Apple's infringement and in no way limit the discovery and infringement allegations against Apple concerning other devices that incorporate the same or reasonably similar functionalities.

129. Apple has indirectly infringed at least claims 1-3 and 9-11 of the '794 Patent in this District and elsewhere in the United States by, among other things, actively inducing the use, offering for sale, selling, or importation of at least the '794 Accused Products. Apple's customers who purchase devices and components thereof and operate such devices and components in accordance with Apple's instructions directly infringe one or more claims of the '794 Patent in violation of 35 U.S.C. § 271. Apple instructs its customers through at least user guides or websites, such as those located at: https://support.apple.com/en_US/manuals or https://support.apple.com/en-us/HT205234 or https://support.apple.com/en-us/HT201264. Apple is thereby liable for infringement of the '794 Patent pursuant to 35 U.S.C. § 271(b).

130. Apple has indirectly infringed at least claims 1-3 and 9-11 of the '794 Patent, by, among other things, contributing to the direct infringement of others, including customers of the '794 Accused Products by making, offering to sell, or selling, in the United States, or importing a component of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process, constituting a material part of the invention, knowing the same to be especially made or especially adapted for use in infringement of the '794 Patent, and not a staple article or commodity of commerce suitable for substantial non-infringing use.

131. For example, the '794 Accused Products include a battery and processor for managing battery usage. These are components of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process. Furthermore, such components are a material part of the invention and upon information and belief are not a staple article or commodity of commerce suitable for substantial non-infringing use. Thus, Apple is liable for infringement of the '794 Patent pursuant to 35 U.S.C. § 271(c).

132. Apple has been on notice of the '794 Patent since, at least, May 17, 2018. By the time of trial, Apple will thus have known and intended (since receiving such notice), that its continued actions would actively induce and contribute to actual infringement of at least claims 1-3 and 9-11 of the '794 Patent.

133. Apple undertook and continued its infringing actions despite an objectively high likelihood that such activities infringed the '794 Patent, which has been duly issued by the USPTO, and is presumed valid. For example, since, at least May 17, 2018, Apple has been aware of an objectively high likelihood that its actions constituted and continue to constitute infringement of the '794 Patent, and that the '794 Patent is valid. On information and belief, Apple could not reasonably, subjectively believe that its actions do not constitute infringement of the '794 Patent, nor could it reasonably, subjectively believe that the patent is invalid. Despite that knowledge and subjective belief, and the objectively high likelihood that its actions constitute infringement, Apple has continued its infringing activities. As such, Apple willfully infringes the '794 Patent.

134. Maxell has been damaged by Apple's infringement of the '794 Patent.

COUNT 9 - INFRINGEMENT OF U.S. PATENT NO. 10,212,586

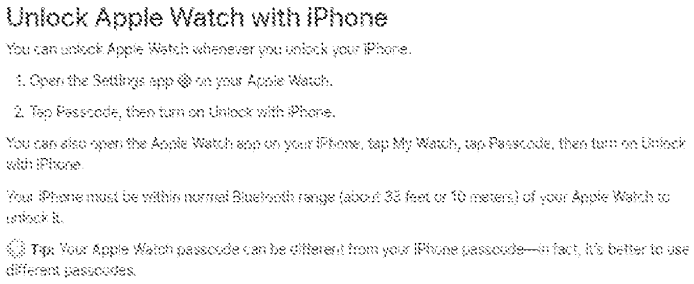
135. Maxell incorporates paragraphs 1-134 above by reference.

136. U.S. Patent No. 10,212,586 (the "'586 Patent," attached hereto at Exhibit 9) duly issued on February 19, 2019 and is entitled *Mobile terminal and control method thereof.*

137. Maxell is the owner by assignment of the '586 Patent and possesses all rights under the '586 Patent, including the exclusive right to recover for past and future infringement.

138. Apple has directly infringed one or more claims of the '586 Patent in this District and elsewhere in Texas, including at least claims 1, 7, 9, 14, 16, and 19 literally and/or under the doctrine of equivalents, by or through making, using, importing, offering for sale and/or selling its telecommunications technology, including by way of example a product known as the iPhone XS.

139. The iPhone XS is a mobile terminal configured to switch between an unlocked state and a locked state. Further, the iPhone XS includes a transceiver which performs short-range wireless communication (*e.g.*, Bluetooth, NFC, and/or Wi-Fi). The iPhone XS also includes a memory which previously stores information about another mobile terminal (*e.g.*, Apple Watch). The iPhone XS also includes a controller (*e.g.*, Axx chipset) which switches the mobile terminal between an unlocked state and a locked state based on an authentication input (*e.g.*, password) to the mobile terminal. Further, the iPhone XS transmits information to the another mobile terminal (*e.g.*, Apple Watch) for switching a state of the another mobile terminal from a locked state to an unlocked state when certain conditions are met including that the mobile terminal is in a locked state, the another mobile terminal is in a locked state, and the another mobile terminal is within communication range of the short-range wireless communications of the transceiver. For example, the following excerpts provide non-limiting examples of the iPhone XS infringing at least claims 1, 7, 9, 14, 16, and 19 of the '586 Patent:



Unlock Apple Watch with iPhone

You can unlock Apple Watch whenever you unlock your iPhone.

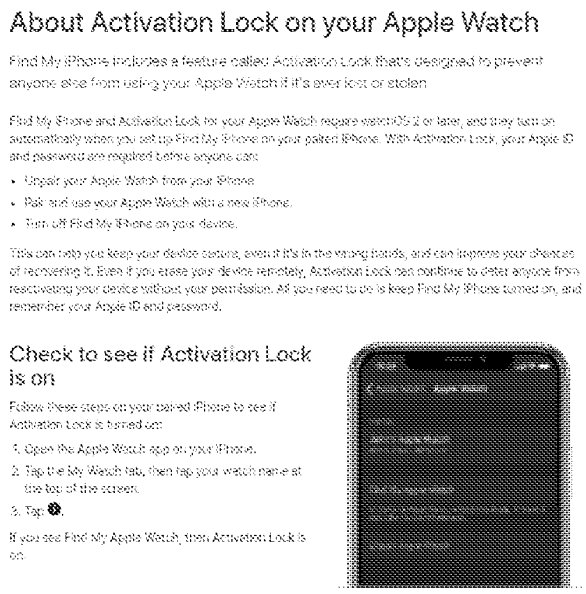
1. Open the Settings app on your Apple Watch.
2. Tap Passcode, then turn on Unlock with iPhone.

You can also open the Apple Watch app on your iPhone, tap My Watch, tap Passcode, then turn on Unlock with iPhone.

Your iPhone must be within normal Bluetooth range (about 33 feet or 10 meters) of your Apple Watch to unlock it.

Tip: Your Apple Watch passcode can be different from your iPhone passcode—in fact, it's better to use different passcodes.

See https://support.apple.com/guide/watch/unlock-apple-watch-apd0e1e73b6f/watchos



About Activation Lock on your Apple Watch

Find My iPhone includes a feature called Activation Lock that's designed to prevent anyone else from using your Apple Watch if it's ever lost or stolen.

Find My iPhone and Activation Lock for your Apple Watch require watchOS 2 or later, and they turn on automatically when you set up Find My iPhone on your paired iPhone. With Activation Lock, your Apple ID and password are required before anyone can:

- Unpair your Apple Watch from your iPhone.
- Pair and use your Apple Watch with a new iPhone.
- Turn off Find My iPhone on your device.

This can help you keep your device secure, even if it's in the wrong hands, and can improve your chances of recovering it. Even if you erase your device remotely, Activation Lock can continue to deter anyone from reactivating your device without your permission. All you need to do is keep Find My iPhone turned on, and remember your Apple ID and password.

Check to see if Activation Lock is on

Follow these steps on your paired iPhone to see if Activation Lock is turned on:

1. Open the Apple Watch app on your iPhone.
2. Tap the My Watch tab, then tap your watch name at the top of the screen.
3. Tap .

If you see Find My Apple Watch, then Activation Lock is on.

See https://support.apple.com/en-us/HT205009

140. The foregoing features and capabilities of the iPhone XS, and Apple's description and/or demonstration thereof, including in user manuals and advertising, reflect Apple's direct infringement by satisfying every element of at least claims 1, 7, 9, 14, 16, and 19 of the '586 Patent, under 35 U.S.C. § 271(a).

141. On information and belief, Apple further infringes the '586 Patent through additional products utilizing the same or reasonably similar functionalities as described above

with respect to the iPhone XS (collectively, "the '586 Accused Products"). The '586 Accused Products include each of the Apple iPhones (*e.g.*, iPhone XS (model no. A1920), iPhone XS Max (model no. A1921), iPhone XR (model no. A1984), iPhone X (model nos. A1865 and A1901), iPhone 8 Plus (model nos. A1864 and A1897), iPhone 8 (model nos. A1863 and A1905), iPhone 7 Plus (model nos. A1661 and A1784), and iPhone 7 (model nos. A1660 and A1778)). For example, each of these products also include a transceiver for short distance transmission and an Apple Watch application to pair with and unlock an Apple Watch as advertised on Apple's website. *See* https://support.apple.com/en-us/HT205009 or https://support.apple.com/guide/watch/unlock-apple-watch-apd0e1e73b6f/watchos. Maxell reserves the right to discover and pursue any additional infringing devices that incorporate infringing functionalities. For the avoidance of doubt, the '586 Accused Products are identified to describe Apple's infringement and in no way limit the discovery and infringement allegations against Apple concerning other devices that incorporate the same or reasonably similar functionalities.

142. Apple has indirectly infringed at least claims 1, 7, 9, 14, 16, and 19 of the '586 Patent in this District and elsewhere in the United States by, among other things, actively inducing the use, offering for sale, selling, or importation of at least the '586 Accused Products. Apple's customers who purchase devices and components thereof and operate such devices and components in accordance with Apple's instructions directly infringe one or more claims of the '586 Patent in violation of 35 U.S.C. § 271. Apple instructs its customers through at least user guides or websites, such as those located at: https://support.apple.com/en_US/manuals or https://support.apple.com/en-us/HT205009 or https://support.apple.com/guide/watch/unlock-

apple-watch-apd0e1e73b6f/watchos. Apple is thereby liable for infringement of the '586 Patent pursuant to 35 U.S.C. § 271 (b).

143. Apple has indirectly infringed at least claims 1, 7, 9, 14, 16, and 19 of the '586 Patent, by, among other things, contributing to the direct infringement of others, including customers of the '586 Accused Products by making, offering to sell, or selling, in the United States, or importing a component of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process, constituting a material part of the invention, knowing the same to be especially made or especially adapted for use in infringement of the '586 Patent, and not a staple article or commodity of commerce suitable for substantial non-infringing use.

144. For example, the '586 Accused Products include a transceiver and/or Apple Watch application. These are components of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process. Furthermore, such components are a material part of the invention and upon information and belief are not a staple article or commodity of commerce suitable for substantial non-infringing use. Thus, Apple is liable for infringement of the '586 Patent pursuant to 35 U.S.C. § 271(c).

145. Apple has been on notice of the '586 Patent since, at least, October 9, 2018. By the time of trial, Apple will thus have known and intended (since receiving such notice), that its continued actions would actively induce and contribute to actual infringement of at least claims 1, 7, 9, 14, 16, and 19 of the '586 Patent.

146. Apple undertook and continued its infringing actions despite an objectively high likelihood that such activities infringed the '586 Patent, which has been duly issued by the USPTO, and is presumed valid. For example, since, at least October 9, 2018, Apple has been

aware of an objectively high likelihood that its actions constituted and continue to constitute infringement of the '586 Patent, and that the '586 Patent is valid. On information and belief, Apple could not reasonably, subjectively believe that its actions do not constitute infringement of the '586 Patent, nor could it reasonably, subjectively believe that the patent is invalid. Despite that knowledge and subjective belief, and the objectively high likelihood that its actions constitute infringement, Apple has continued its infringing activities. As such, Apple willfully infringes the '586 Patent.

147. Maxell has been damaged by Apple's infringement of the '586 Patent.

COUNT 10 - INFRINGEMENT OF U.S. PATENT NO. 6,430,498

148. Maxell incorporates paragraphs 1-147 above by reference.

149. U.S. Patent No. 6,430,498 (the "'498 Patent," attached hereto at Exhibit 10) duly issued on August 6, 2002 and is entitled *Portable terminal with the function of walking navigation*.

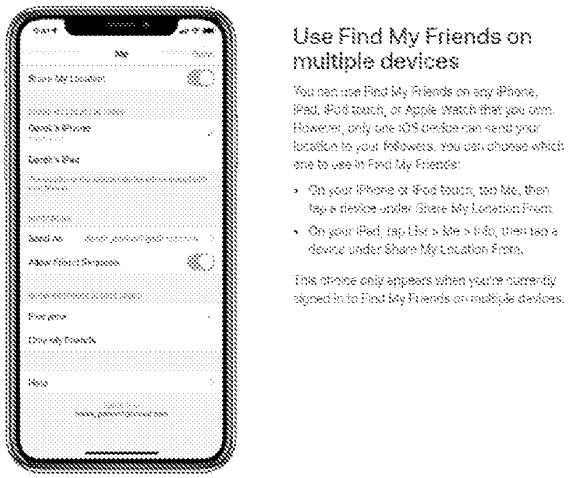
150. Maxell is the owner by assignment of the '498 Patent and possesses all rights under the '498 Patent, including the exclusive right to recover for past and future infringement.

151. The '498 Patent is the parent of the '317 Patent and the '999 Patent, and like claims of the '317 Patent and '999 Patent, claims of the '498 Patent are also directed to a specific novel and non-obvious portable terminal that includes specific functionality of providing guidance for walking navigation and further receives location information from a "partner's portable terminal" ('498 Patent, 12:6-8), thus specifically claiming a portable terminal that can receive a location from another portable terminal and providing in real-time route guidance information to a pedestrian so that the pedestrian can walk to the location of the other portable terminal after receiving the location.

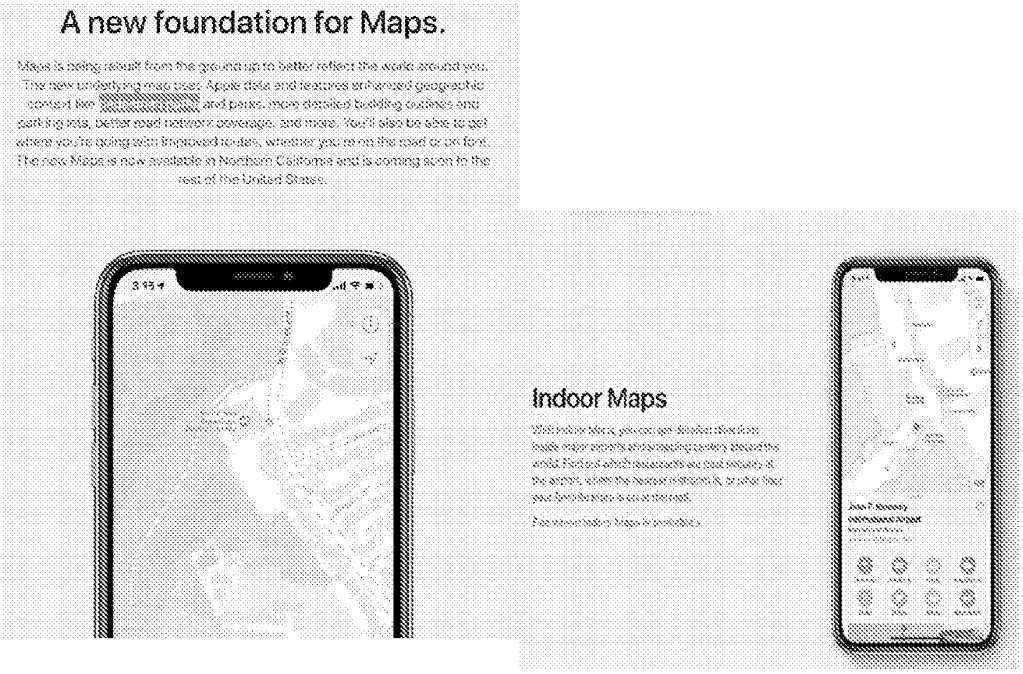
152. Further, the patentability of the '498 Patent was challenged in IPR2019-00071, wherein the Patent Trial and Appeal Board was asked to consider the teachings of prior art (*e.g.*, U.S. Patent Nos. 6,031,999, 5,560,022, 6,345,180, 6,360,327, and Advanced Configuration and Power Interface Specification) in a challenge to the validity of claims 1-13. In response, the Patent Trial and Appeal Board denied the petition, finding that "the Petitioner has not established a reasonable likelihood of prevailing against any claim challenged in the Petition."

153. Apple has directly infringed one or more claims of the '498 Patent in this District and elsewhere in Texas, including at least claims 1, 3, 4, 10, and 13 literally and/or under the doctrine of equivalents, by or through making, using, importing, offering for sale and/or selling its telecommunications technology, including by way of example a product known as the iPhone XS.

154. The iPhone XS includes a screen for displaying information, at least a GPS chipset/cellular chipset/Wi-Fi chipset/iBeacon/compass/gyroscope for providing location and/or orientation information, "Maps" and "Find My Friends" software that allows users to access location information including the present location of the device and orientation of the device and use such information to provide walking navigation information and/or share location including providing a direction and distance of a destination from a present place by using a line that is distinguished from a starting point and an ending point of the route. The iPhone XS further uses location servers to provide walking navigation information, route information, and/or to provide its position to additional devices in order to allow users to walk to a location of a partner. For example, the following excerpts from Apple's websites provide non-limiting examples of the iPhone XS infringing at least claims 1, 3, 4, 10, and 13 of the '498 Patent:



See https://support.apple.com/en-us/HT201493



See https://www.apple.com/ios/maps/

155. The foregoing features and capabilities of the iPhone XS, and Apple's description and/or demonstration thereof, including in user manuals and advertising, reflect Apple's direct

infringement by satisfying every element of at least claims 1, 3, 4, 10, and 13 of the '498 Patent, under 35 U.S.C. § 271(a).

156. On information and belief, Apple further infringes the '498 Patent through additional products utilizing the same or reasonably similar functionalities as described above with respect to the iPhone XS (collectively, "the '498 Accused Products"). The '498 Accused Products include all iOS devices including "Maps" and/or "Find My Friends" applications, for example, Apple iPhones (*e.g.*, iPhone XS (model no. A1920), iPhone XS Max (model no. A1921), iPhone XR (model no. A1984), iPhone X (model nos. A1865 and A1901), iPhone 8 Plus (model nos. A1864 and A1897), iPhone 8 (model nos. A1863 and A1905), iPhone 7 Plus (model nos. A1661 and A1784), iPhone 7 (model nos. A1660 and A1778), iPhone 6s Plus (model nos. A1634 and A1687), iPhone 6s (model nos. A1633 andA1688), iPhone 6 Plus (model nos. A1522 and A1524), iPhone 6 (model nos. A1549 and A1586), iPhone SE (model nos. A1723 and A1662), iPhone 5s (model nos. A1453 and A1533), and iPhone 5c (model nos. A1456 and A1532)) and Apple iPads with cellular functionality and/or Apple iPads with Wi-Fi and Indoor Maps (*e.g.*, iPad Air (model nos. A1474 and A1475), iPad mini 2 (model nos. A1489 and A1490), iPad Air 2 (model nos. A1566 and A1567), iPad mini 3 (model nos. A1599 and A1600), iPad mini 4 (model nos. A1538 and A1550), iPad Pro (10.5") (model nos. A1701 and A1709), iPad Pro (12.9") (model nos. A1584 and A1652), iPad Pro (9.7") (model nos. A1673, A1674, and A1675), iPad Pro (11") (model nos. A1980 and A2013), iPad (5th generation) (model nos. A1822 and A1823), iPad (6th generation) (model nos. A1893 and A1954), iPad Pro (12.9" 2nd generation) (model nos. A1670 and A1671), and iPad Pro (12.9" 3rd generation) (model nos. A1876, A2014, and A1895)). For example, each of these products also include a "Maps" application, a "Find My Friends" application, and/or "Location" services as advertised on

Apple's website. Maxell reserves the right to discover and pursue any additional infringing devices that incorporate infringing functionalities. For the avoidance of doubt, the '498 Accused Products are identified to describe Apple's infringement and in no way limit the discovery and infringement allegations against Apple concerning other devices that incorporate the same or reasonably similar functionalities.

157. Apple has indirectly infringed at least claims 1, 3, 4, 10, and 13 of the '498 Patent in this District and elsewhere in the United States by, among other things, actively inducing the use, offering for sale, selling, or importation of at least the '498 Accused Products. Apple's customers who purchase devices and components thereof and operate such devices and components in accordance with Apple's instructions directly infringe one or more claims of the '498 Patent in violation of 35 U.S.C. § 271. Apple instructs its customers through at least user guides or websites, such as those located at: https://support.apple.com/en_US/manuals or https://www.apple.com/ios/maps/ or https://support.apple.com/en-us/HT201493. Apple is thereby liable for infringement of the '498 Patent pursuant to 35 U.S.C. § 271(b).

158. Apple has indirectly infringed at least claims 1, 3, 4, 10, and 13 of the '498 Patent, by, among other things, contributing to the direct infringement of others, including customers of the '498 Accused Products by making, offering to sell, or selling, in the United States, or importing a component of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process, constituting a material part of the invention, knowing the same to be especially made or especially adapted for use in infringement of the '498 Patent, and not a staple article or commodity of commerce suitable for substantial non-infringing use.

159. For example, the '498 Accused Products include hardware (*e.g.*, GPS chip, cellular chip, Wi-Fi chip, gyroscope, compass, A12 processor) and/or software (*e.g.*, "Maps" or "Find My Friends"). These are components of a patented machine, manufacture, or combination, or an apparatus for use in practicing a patented process. Furthermore, such components are a material part of the invention and upon information and belief are not a staple article or commodity of commerce suitable for substantial non-infringing use. Thus, Apple is liable for infringement of the '498 Patent pursuant to 35 U.S.C. § 271(c).

160. Apple has been on notice of the '498 Patent since, at least, June 25, 2013. By the time of trial, Apple will thus have known and intended (since receiving such notice), that its continued actions would actively induce and contribute to actual infringement of at least claims 1, 3, 4, 10, and 13 of the '498 Patent.

161. Apple undertook and continued its infringing actions despite an objectively high likelihood that such activities infringed the '498 Patent, which has been duly issued by the USPTO, and is presumed valid. For example, since, at least June 25, 2013, Apple has been aware of an objectively high likelihood that its actions constituted and continue to constitute infringement of the '498 Patent, and that the '498 Patent is valid. On information and belief, Apple could not reasonably, subjectively believe that its actions do not constitute infringement of the '498 Patent, nor could it reasonably, subjectively believe that the patent is invalid. Despite that knowledge and subjective belief, and the objectively high likelihood that its actions constitute infringement, Apple has continued its infringing activities. As such, Apple willfully infringes the '498 Patent.

162. Maxell has been damaged by Apple's infringement of the '498 Patent.

PRAYER FOR RELIEF

WHEREFORE, Maxell prays for relief as follows:

163. A judgment declaring that Apple has infringed and is infringing one or more claims of '317, '999, '493, '438, '193, '991, '306, '794, '586, and '498 Patents;

164. A judgment awarding Maxell compensatory damages as a result of Apple's infringement of one or more claims of the '317, '999, '493, '438, '193, '991, '306, '794, '586, and '498 Patents, together with interest and costs, consistent with lost profits and in no event less than a reasonable royalty;

165. A judgment awarding Maxell treble damages and pre-judgment interest under 35 U.S.C. § 284 as a result of Apple's willful and deliberate infringement of one or more claims of the '317, '999, '493, '438, '193, '991, '306, '794, '586, and '498 Patents;

166. A judgment declaring that this case is exceptional and awarding Maxell its expenses, costs, and attorneys' fees in accordance with 35 U.S.C. §§ 284 and 285 and Rule 54(d) of the Federal Rules of Civil Procedure;

167. A grant of preliminary and permanent injunctions enjoining Defendant from further acts of infringement of one or more claims of the '317, '999, '493, '438, '193, '991, '306, '794, '586, and '498 Patents; and

168. Such other and further relief as the Court deems just and proper.

JURY TRIAL DEMANDED

Maxell hereby demands a trial by jury.

Dated: March 15, 2019

By: */s/ Geoffrey Culbertson*

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EXHIBIT 1028

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(12) **United States Patent**
Kawahara et al.

(10) **Patent No.: US 6,963,361 B1**
(45) **Date of Patent: Nov. 8, 2005**

(54) **IMAGE SENSING METHOD AND APPARATUS CAPABLE OF PERFORMING VIBRATION CORRECTION WHEN SENSING A MOVING IMAGE**

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(73) Assignee: **Canon Kabushiki Kaisha**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Feb. 22, 1999**

(30) **Foreign Application Priority Data**

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(52) **U.S. Cl.** **348/208.99**; 348/208.1; 348/208.2; 348/208.4; 348/208.5; 348/208.6; 348/208.13; 348/208.16
(58) **Field of Search** 348/208.99, 208.1, 348/208.2, 208.4, 208.5, 208.6, 208.13, 208.16

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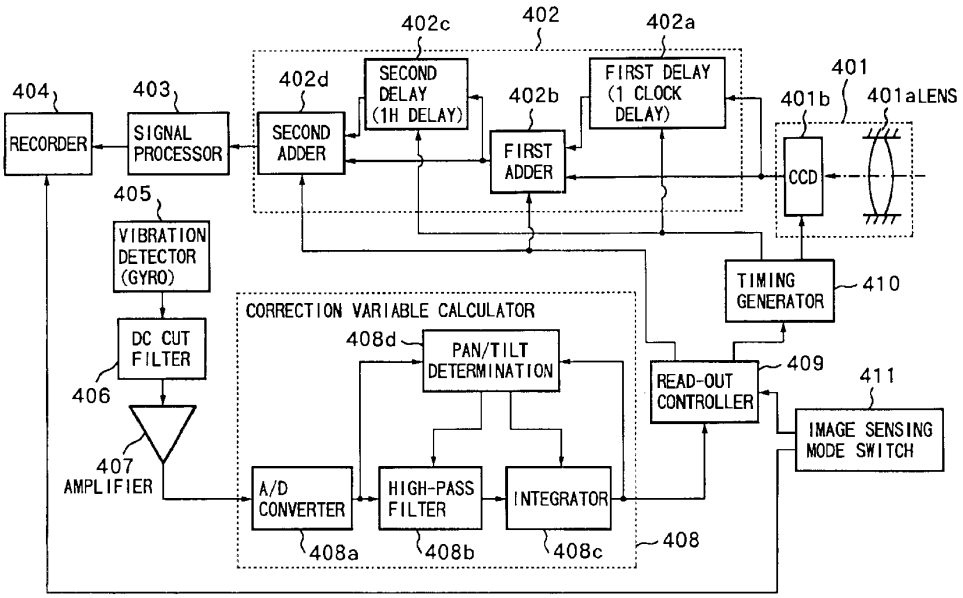
* cited by examiner

Primary Examiner—Wendy R. Garber
Assistant Examiner—James M. Hannett
(74) *Attorney, Agent, or Firm*—Morgan & Finnegan, LLP

(57) **ABSTRACT**

A correction variable is calculated based on vibration data of an image sensing apparatus. Based on the calculation result, timing of reading image signals from an image sensing device is controlled. The read image signals are delayed by predetermined time, the read image signals and the delayed image signals are added at a predetermined addition ratio based on the calculation result of the correction variable calculator. In still image sensing, the above addition operation is not performed.

8 Claims, 22 Drawing Sheets



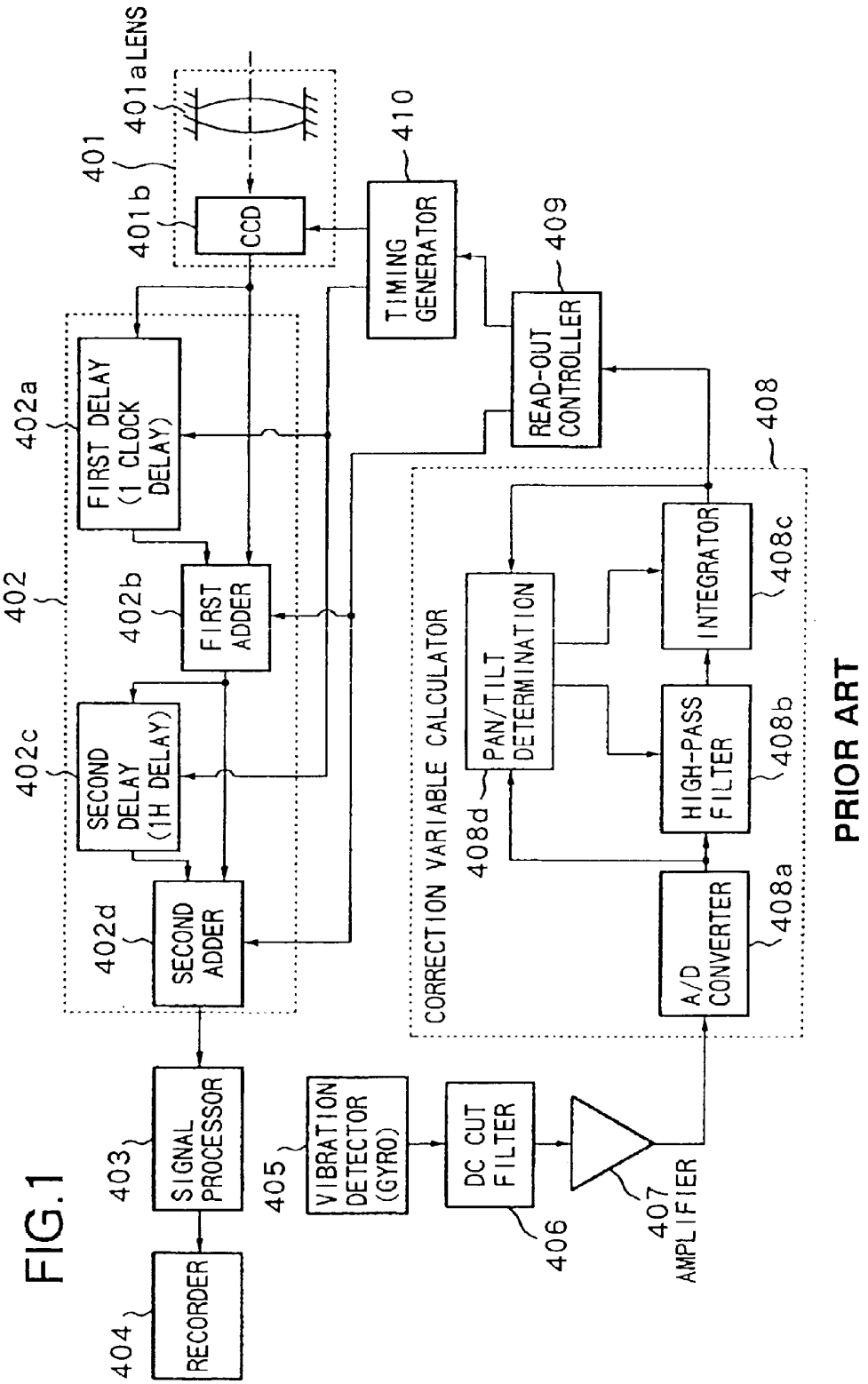
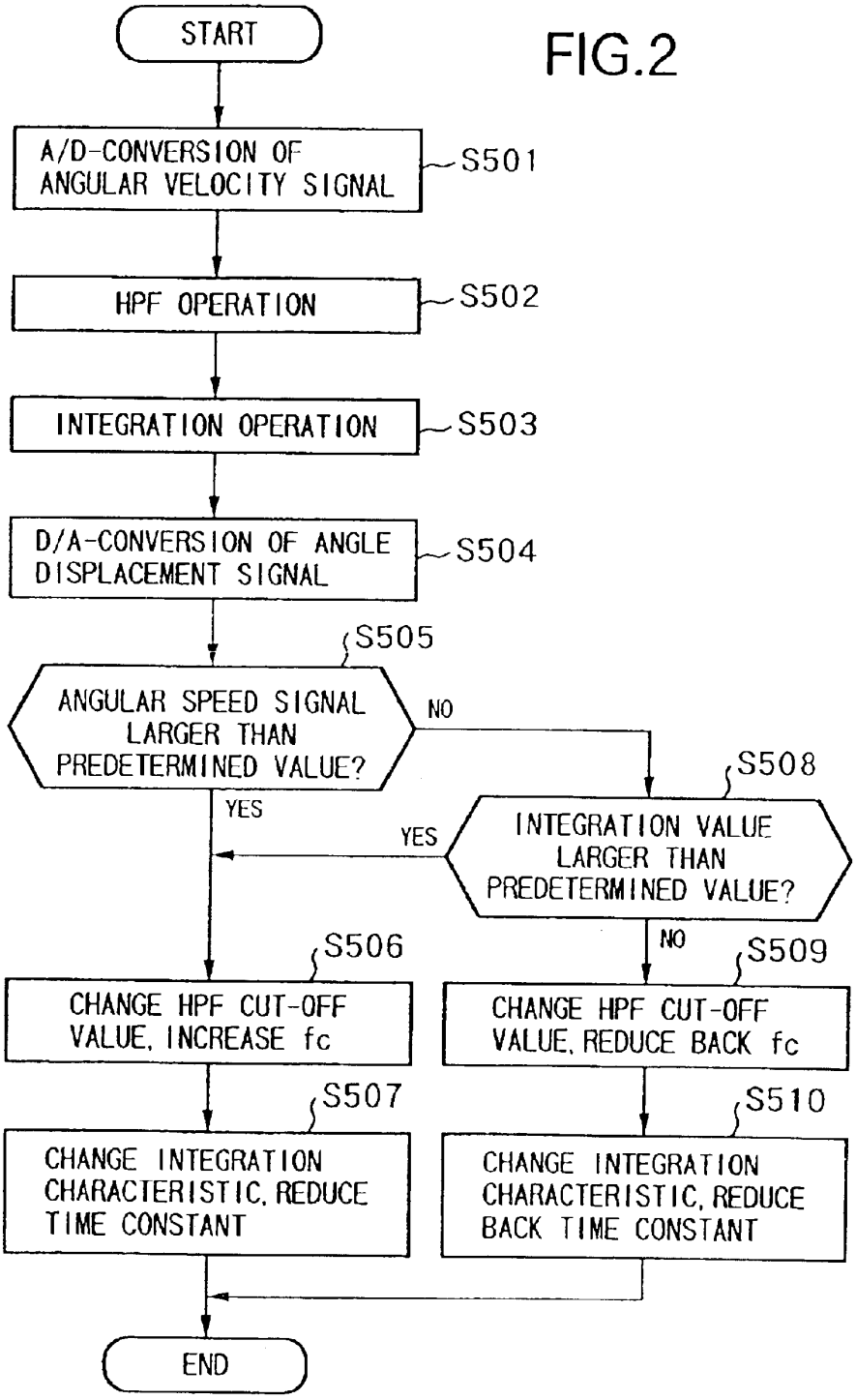


FIG. 1

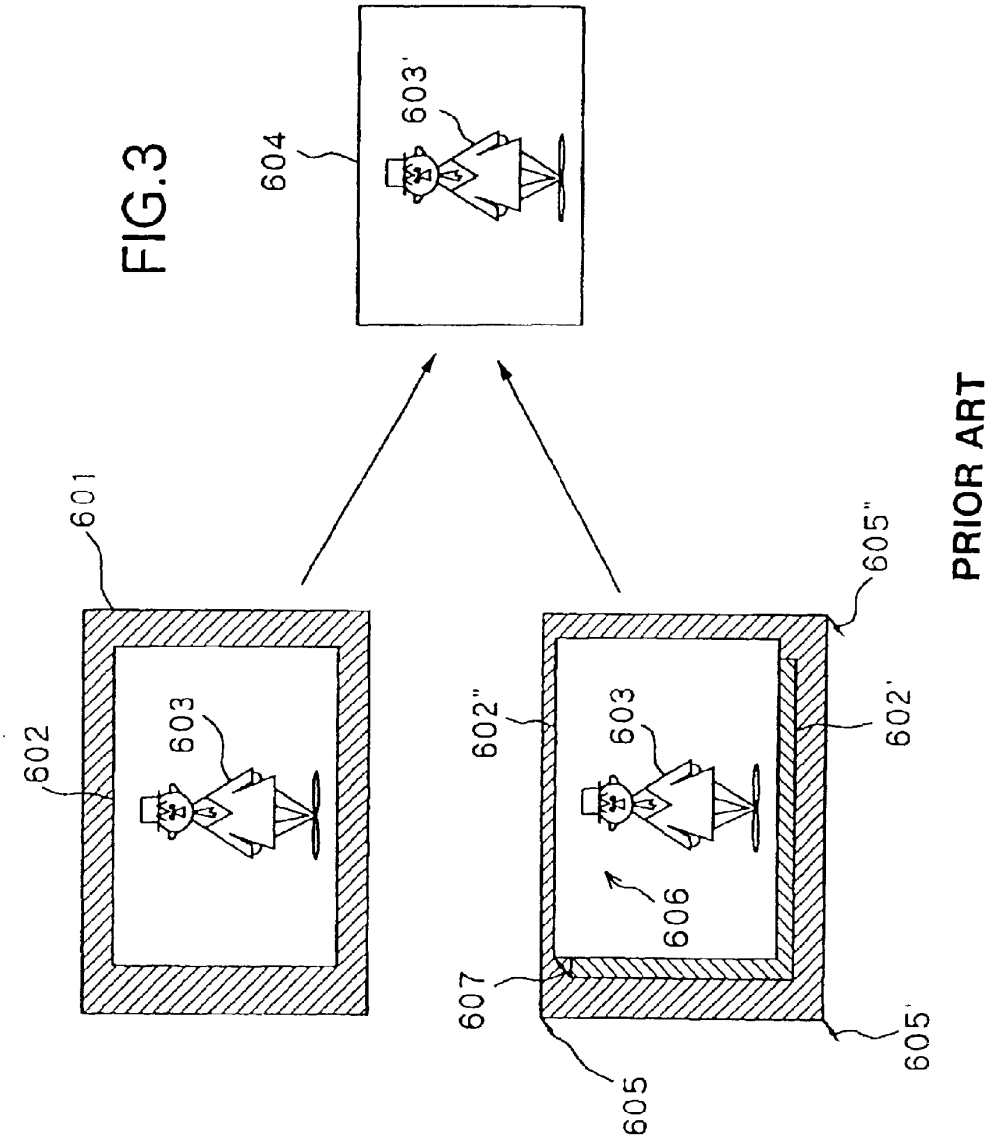
PRIOR ART

FIG.2



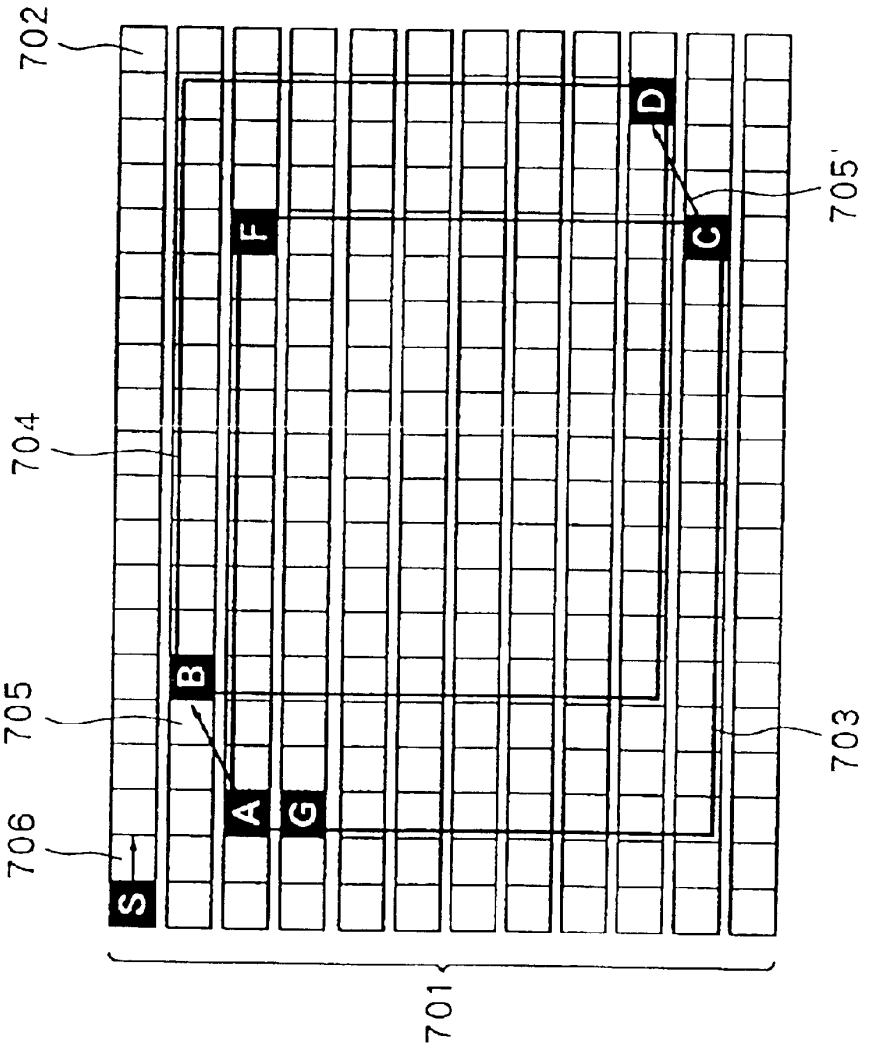
PRIOR ART

FIG.3



PRIOR ART

FIG.4



PRIOR ART

FIG.5

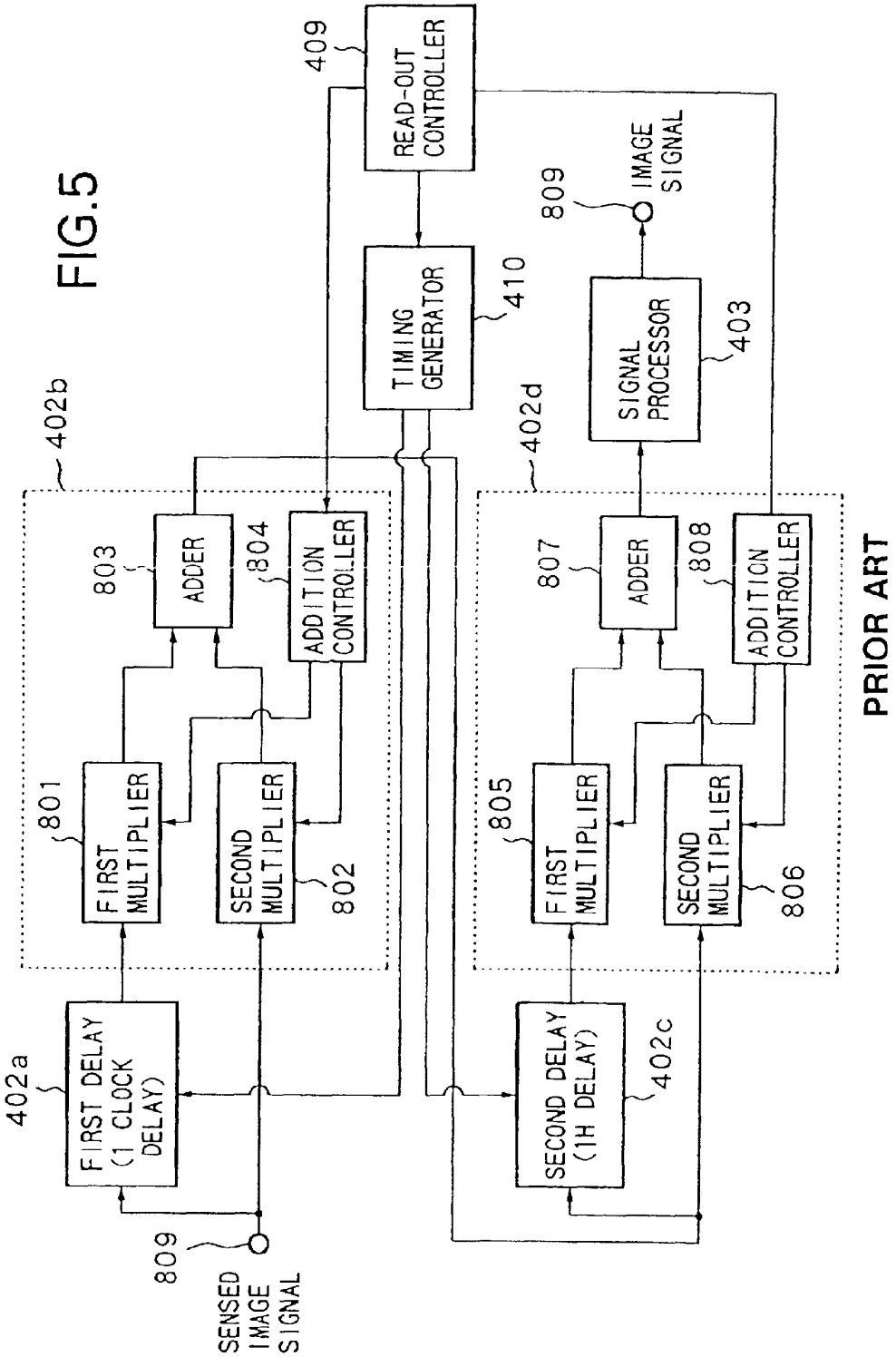
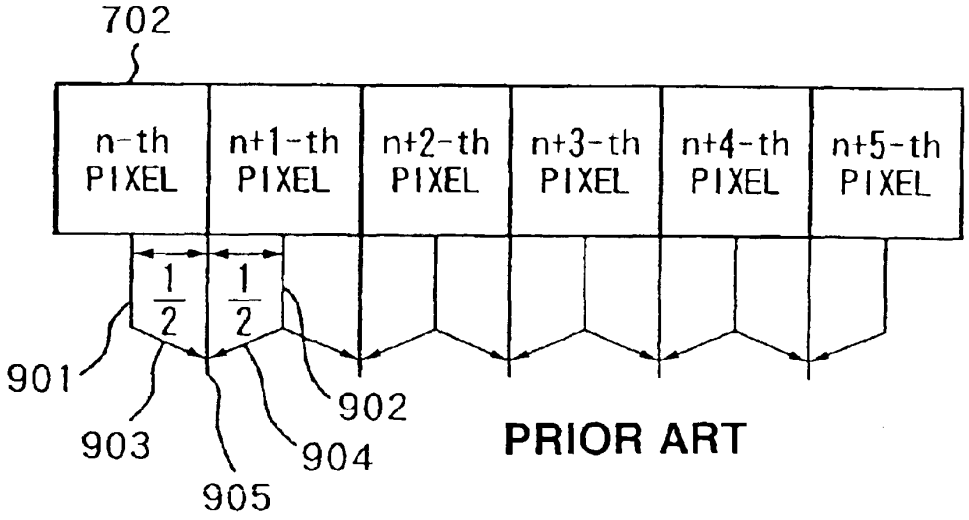
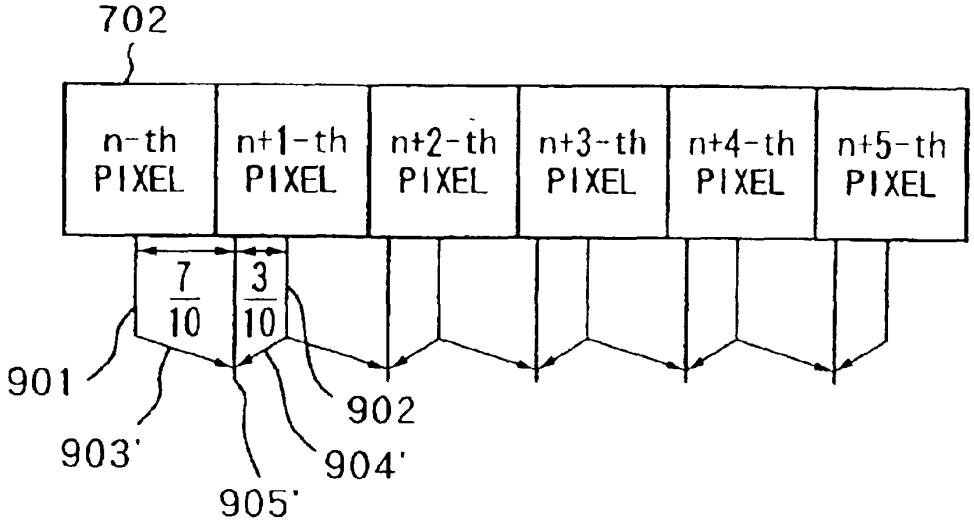

409
READ-OUT CONTROLLER
809
IMAGE SIGNAL
TIMING GENERATOR
410
SIGNAL PROCESSOR
403
402b
402d
803
ADDER
804
ADDITION CONTROLLER
807
ADDER
808
ADDITION CONTROLLER
801
FIRST MULTIPLIER
802
SECOND MULTIPLIER
805
FIRST MULTIPLIER
806
SECOND MULTIPLIER
402a
FIRST DELAY (1 CLOCK DELAY)
SECOND DELAY (1H DELAY)
402c
809
SENSED IMAGE SIGNAL
PRIOR ART

FIG.6A



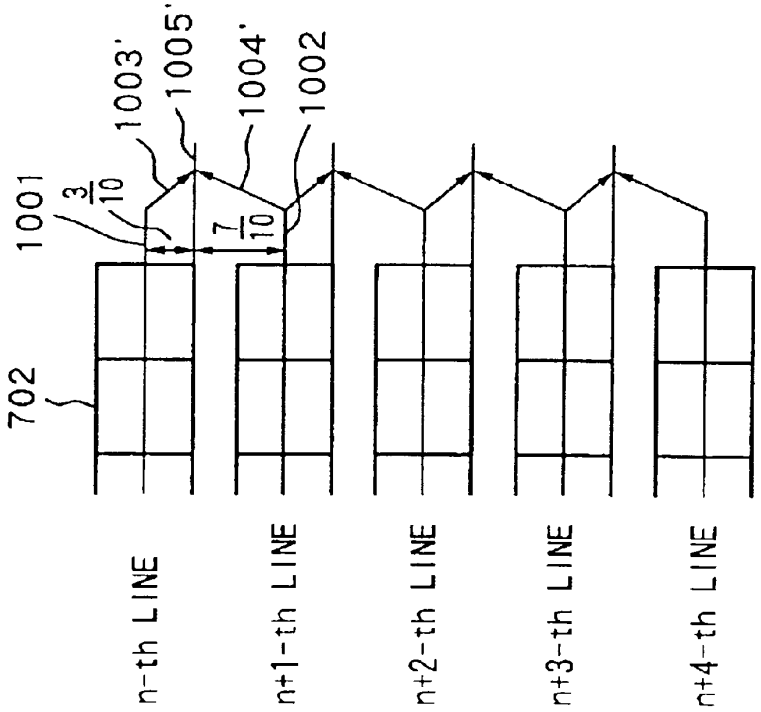
PRIOR ART

FIG.6B



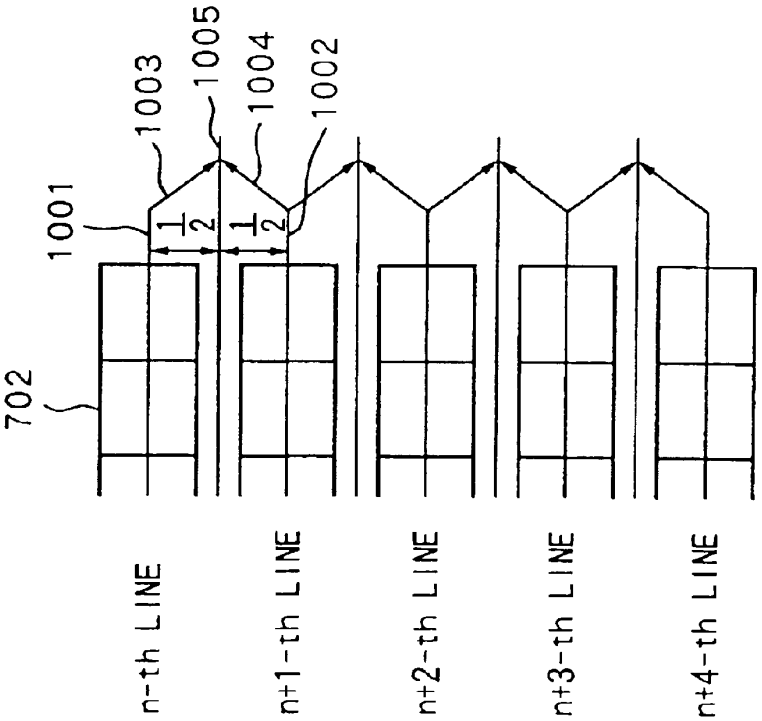
PRIOR ART

FIG.7B

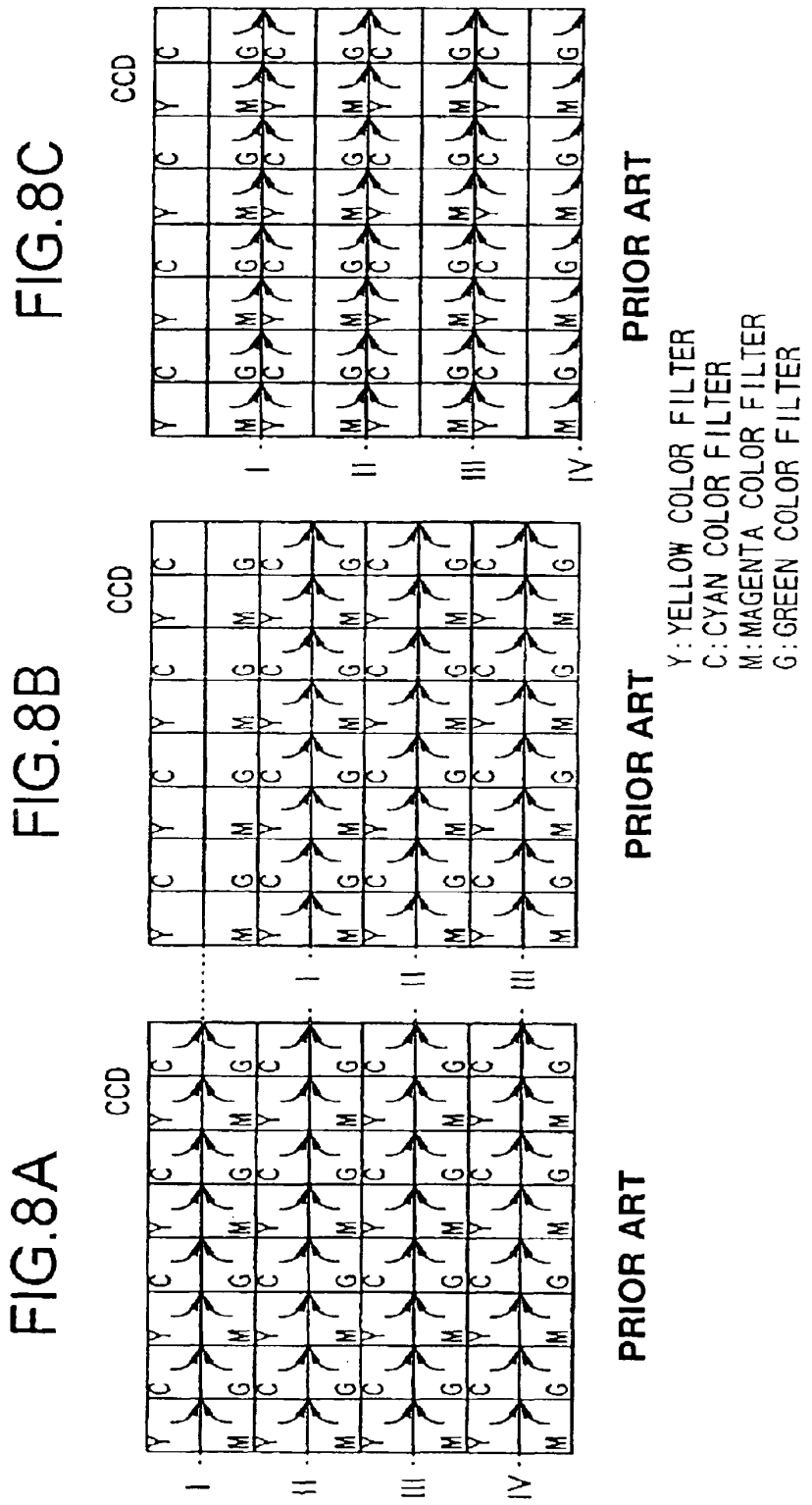


PRIOR ART

FIG.7A



PRIOR ART


FIG.8A
CCD
I
II
III
IV
PRIOR ART
FIG.8B
CCD
I
II
III
PRIOR ART
FIG.8C
CCD
I
II
III
IV
PRIOR ART
Y: YELLOW COLOR FILTER
C: CYAN COLOR FILTER
M: MAGENTA COLOR FILTER
G: GREEN COLOR FILTER

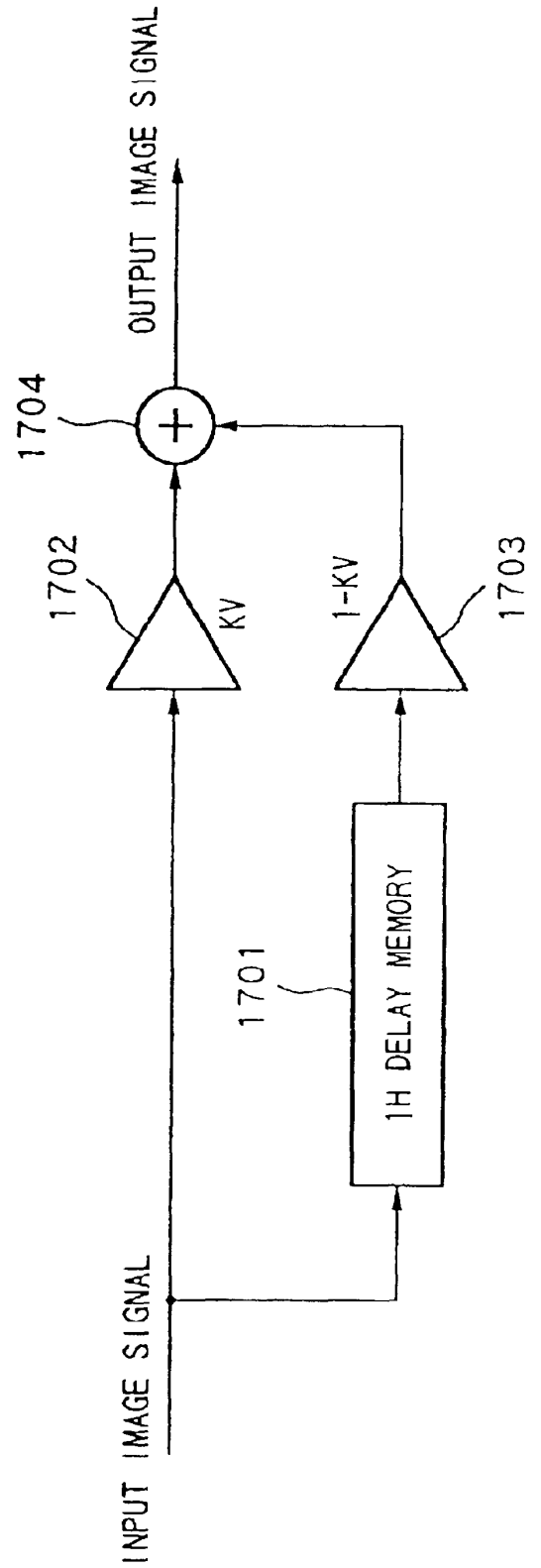
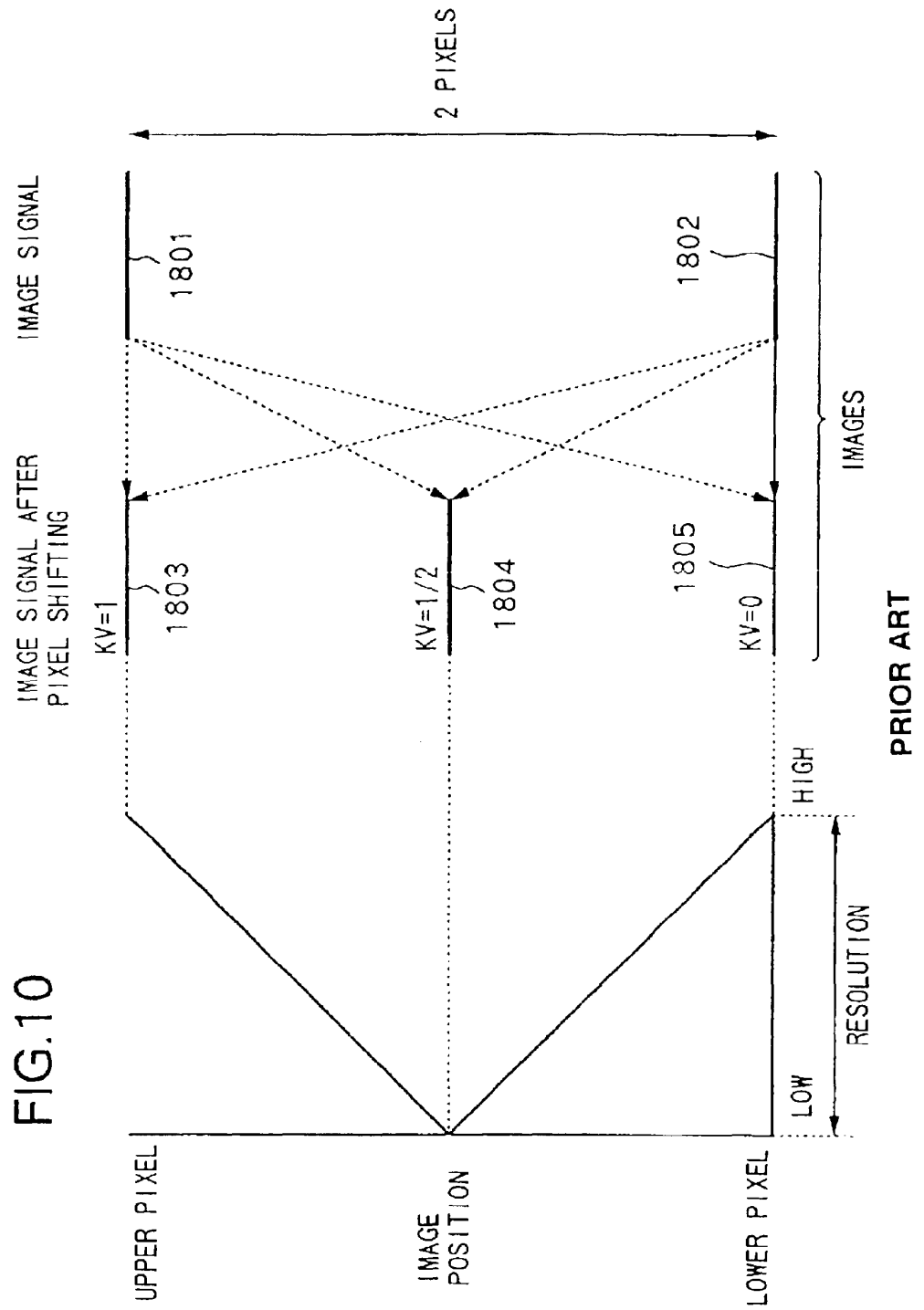


FIG.9

PRIOR ART

FIG.10


2 PIXELS
IMAGE SIGNAL
1801
1802
IMAGE SIGNAL AFTER PIXEL SHIFTING
KV=1
1803
KV=1/2
1804
1805
KV=0
IMAGES
HIGH
LOW
RESOLUTION
UPPER PIXEL
IMAGE POSITION
LOWER PIXEL
PRIOR ART

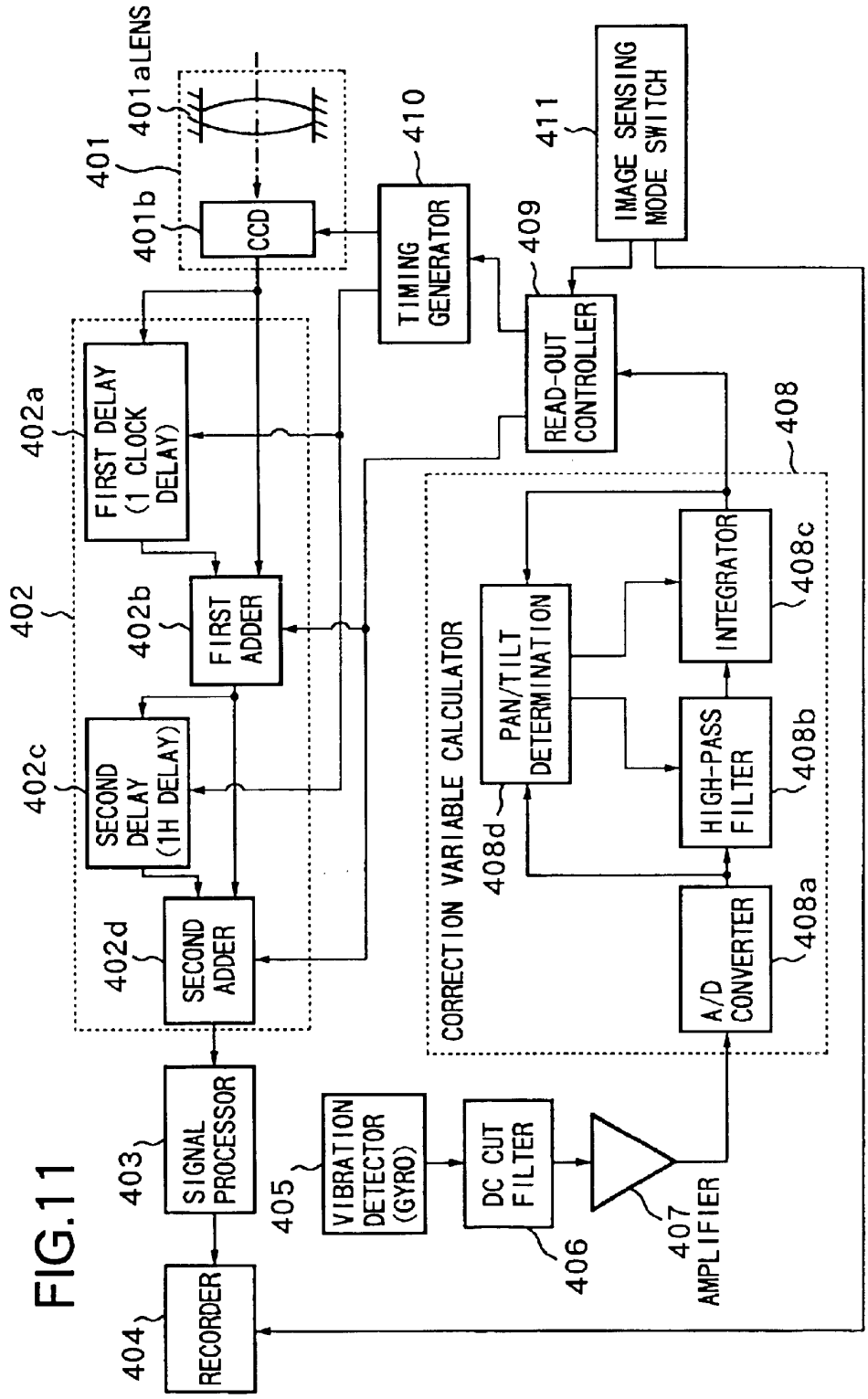
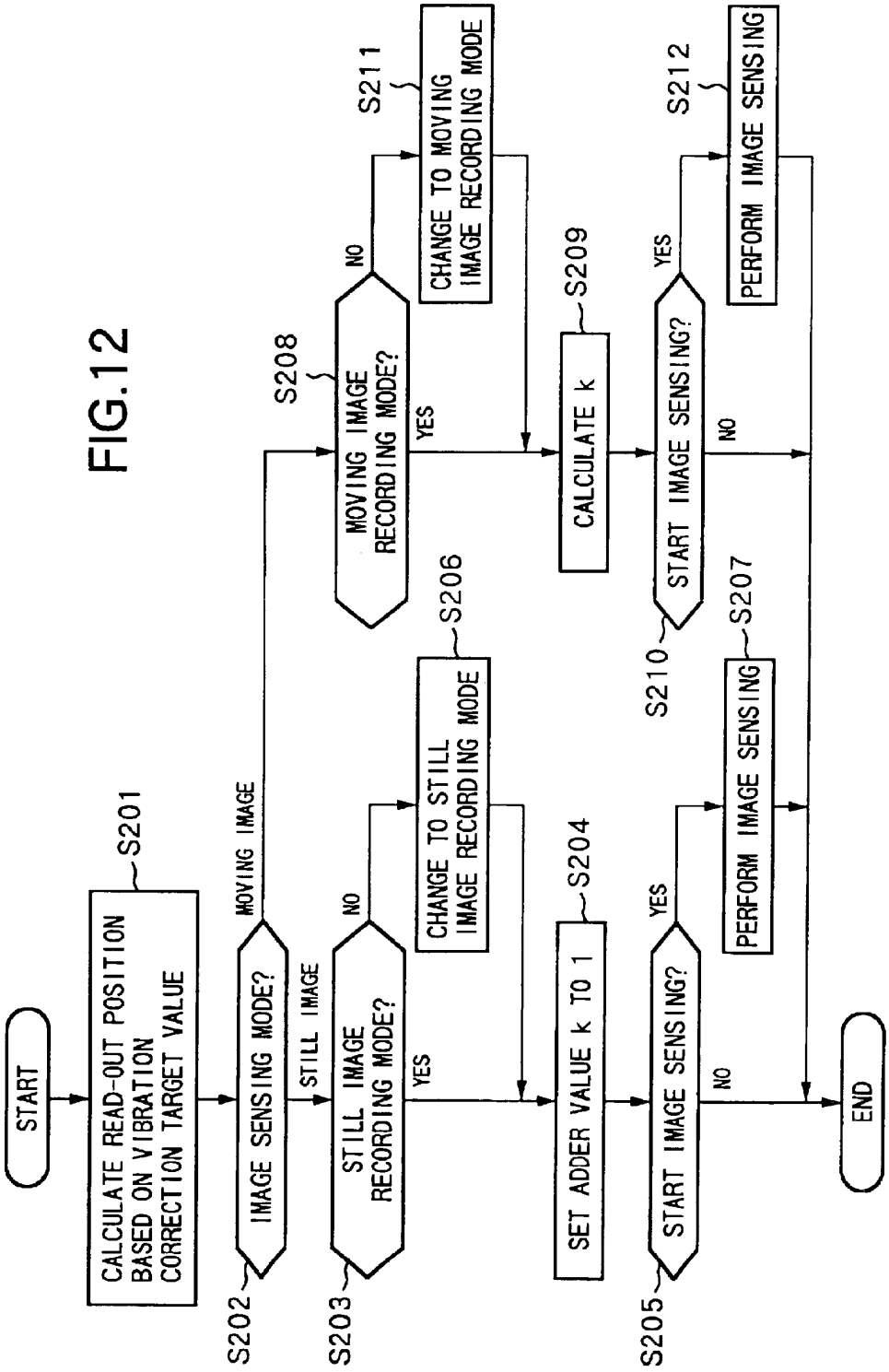

401
401a LENS
401b
CCD
410
TIMING GENERATOR
411
IMAGE SENSING MODE SWITCH
409
READ-OUT CONTROLLER
402
402a
FIRST DELAY (1 CLOCK DELAY)
402b
FIRST ADDER
402c
SECOND DELAY (1H DELAY)
402d
SECOND ADDER
408
CORRECTION VARIABLE CALCULATOR
PAN/TILT DETERMINATION
408d
INTEGRATOR
408c
HIGH-PASS FILTER
408b
A/D CONVERTER
408a
403
SIGNAL PROCESSOR
404
RECORDER
405
VIBRATION DETECTOR (GYRO)
406
DC CUT FILTER
407
AMPLIFIER

FIG.11

FIG.12


START
CALCULATE READ-OUT POSITION BASED ON VIBRATION CORRECTION TARGET VALUE
S201
IMAGE SENSING MODE?
S202
MOVING IMAGE
STILL IMAGE
STILL IMAGE RECORDING MODE?
S203
NO
YES
CHANGE TO STILL IMAGE RECORDING MODE
S206
SET ADDER VALUE k TO 1
S204
START IMAGE SENSING?
S205
YES
NO
PERFORM IMAGE SENSING
S207
END
MOVING IMAGE RECORDING MODE?
S208
NO
YES
CHANGE TO MOVING IMAGE RECORDING MODE
S211
CALCULATE k
S209
START IMAGE SENSING?
S210
YES
NO
PERFORM IMAGE SENSING
S212

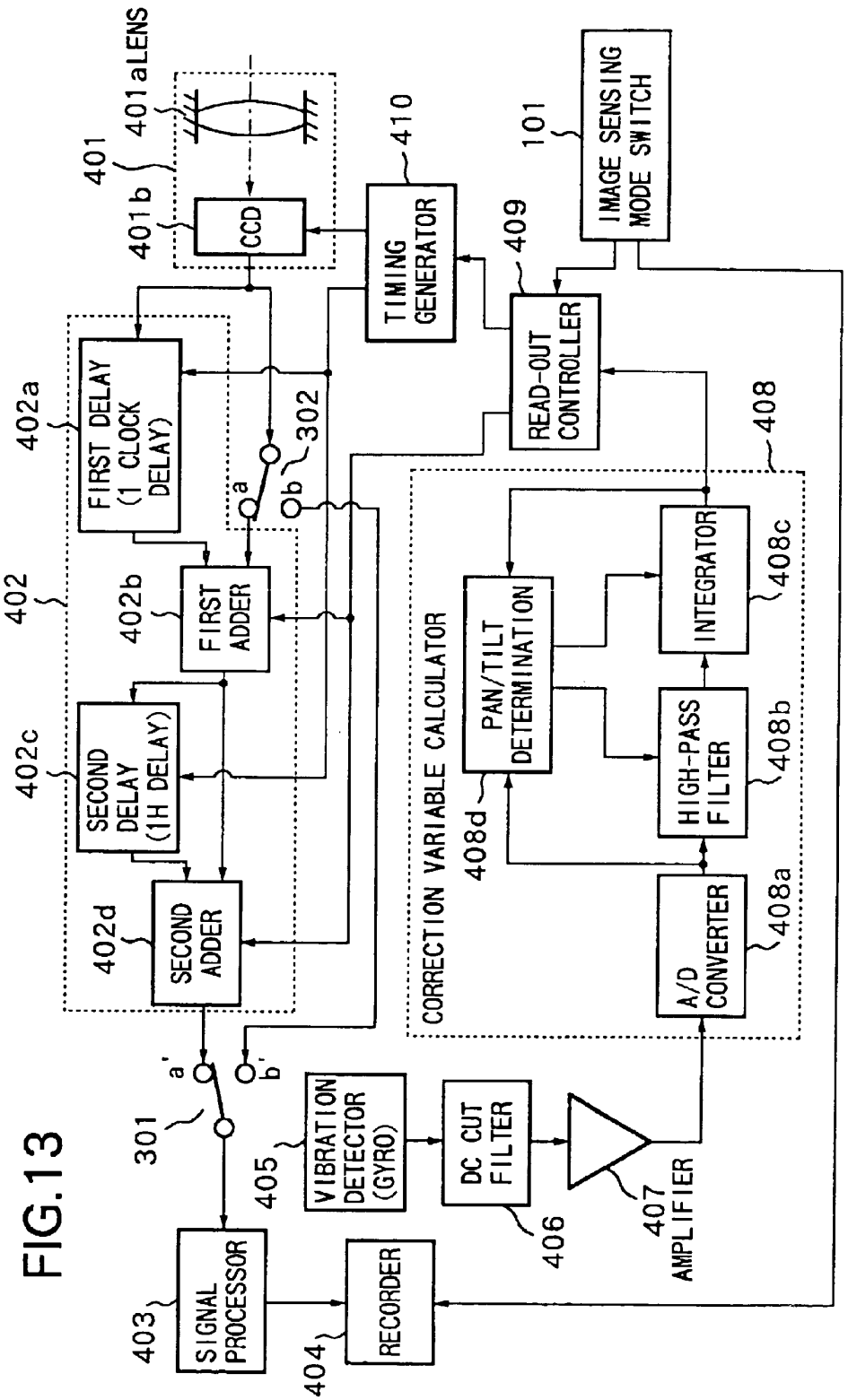
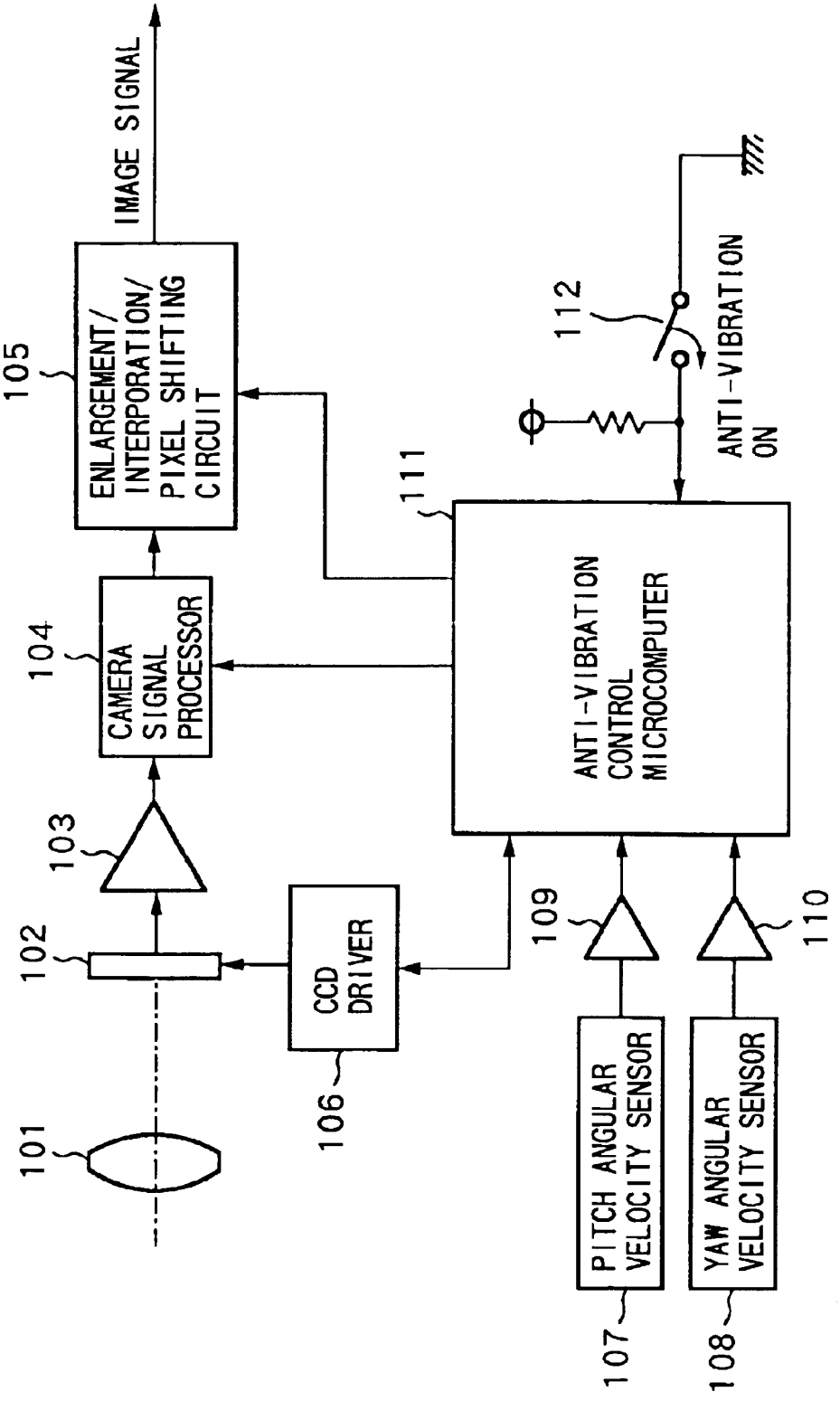

401aLENS
401
401b
CCD
410
TIMING GENERATOR
101
IMAGE SENSING MODE SWITCH
409
READ-OUT CONTROLLER
402a
FIRST DELAY (1 CLOCK DELAY)
302
a
b
402
402b
FIRST ADDER
408
CORRECTION VARIABLE CALCULATOR
408c
INTEGRATOR
PAN/TILT DETERMINATION
408d
402c
SECOND DELAY (1H DELAY)
HIGH-PASS FILTER
408b
402d
SECOND ADDER
A/D CONVERTER
408a
a'
b'
301
405
VIBRATION DETECTOR (GYRO)
DC CUT FILTER
406
407
AMPLIFIER
403
SIGNAL PROCESSOR
404
RECORDER

FIG.13

FIG.14


IMAGE SIGNAL
105
ENLARGEMENT/
INTERPORATION/
PIXEL SHIFTING
CIRCUIT
104
CAMERA
SIGNAL
PROCESSOR
103
102
101
CCD
DRIVER
106
111
ANTI-VIBRATION
CONTROL
MICROCOMPUTER
112
ANTI-VIBRATION
ON
109
110
PITCH ANGULAR
VELOCITY SENSOR
YAW ANGULAR
VELOCITY SENSOR
107
108

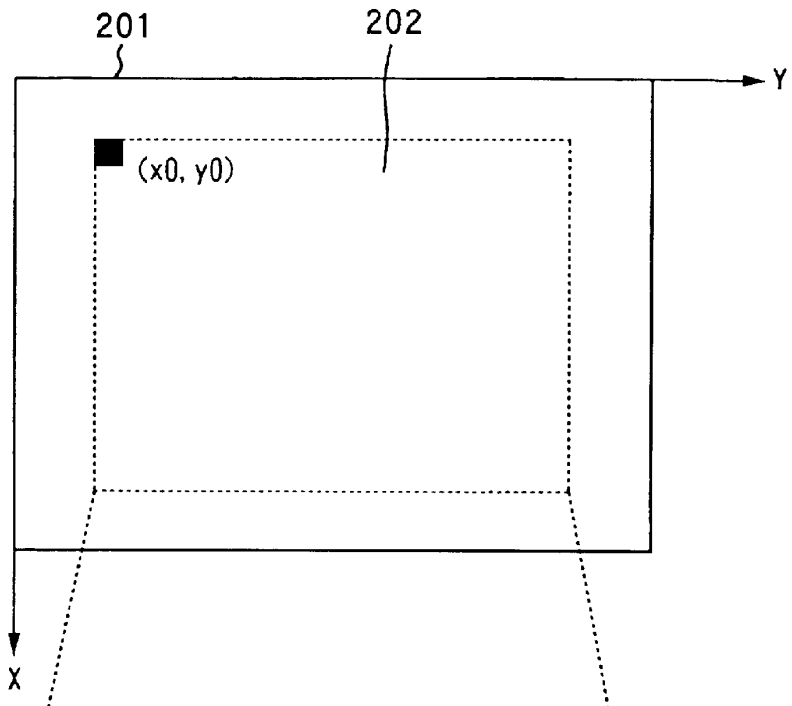


FIG.15A

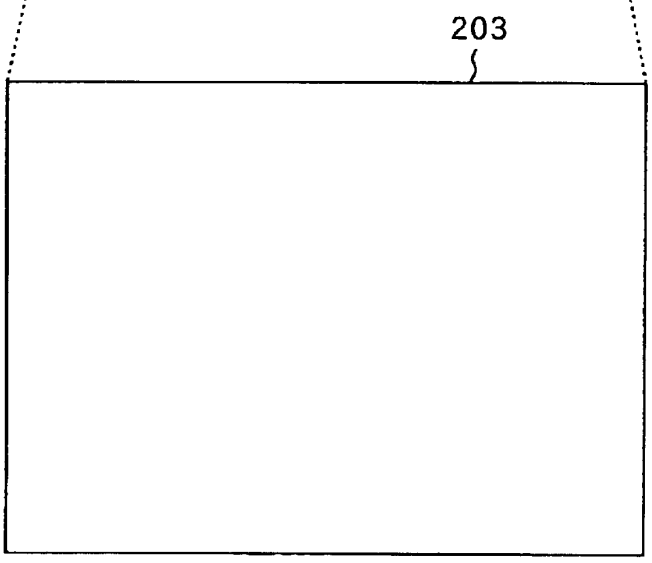


FIG.15B

FIG.16

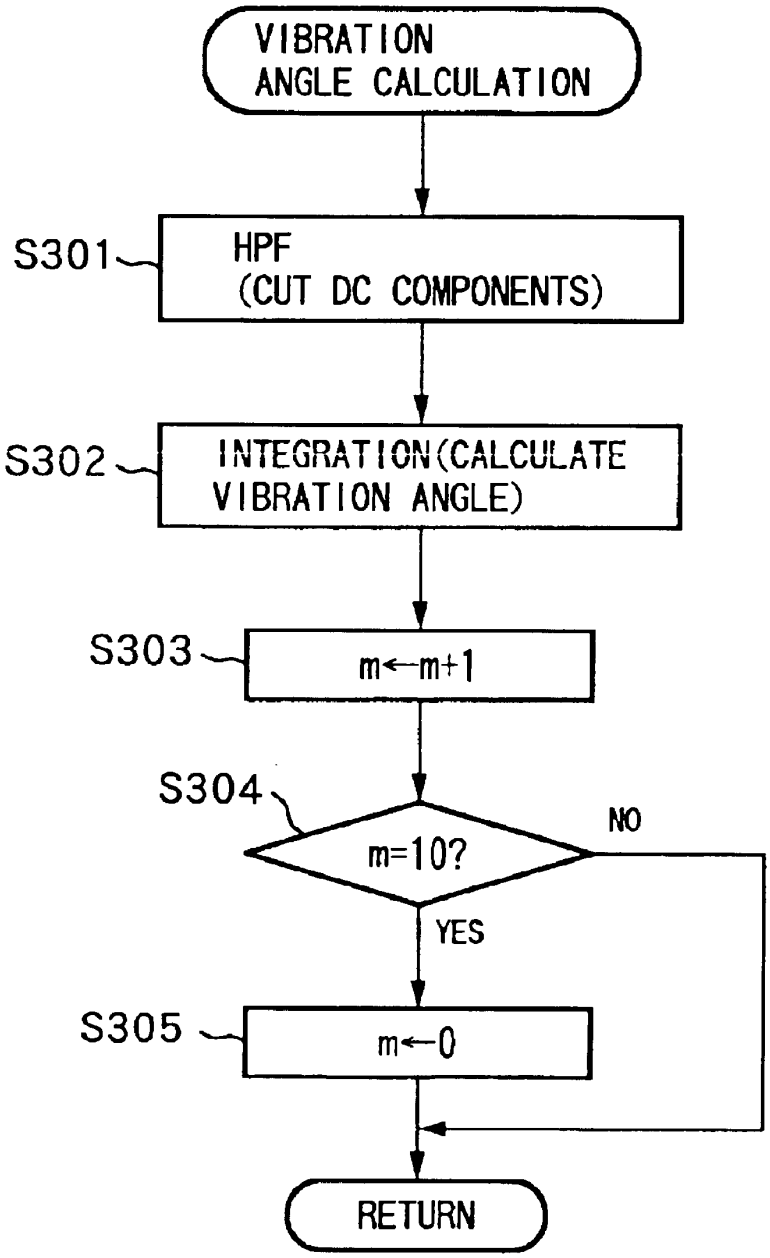

VIBRATION ANGLE CALCULATION
S301
HPF (CUT DC COMPONENTS)
S302
INTEGRATION(CALCULATE VIBRATION ANGLE)
S303
m←m+1
S304
m=10?
NO
YES
S305
m←0
RETURN

FIG.17

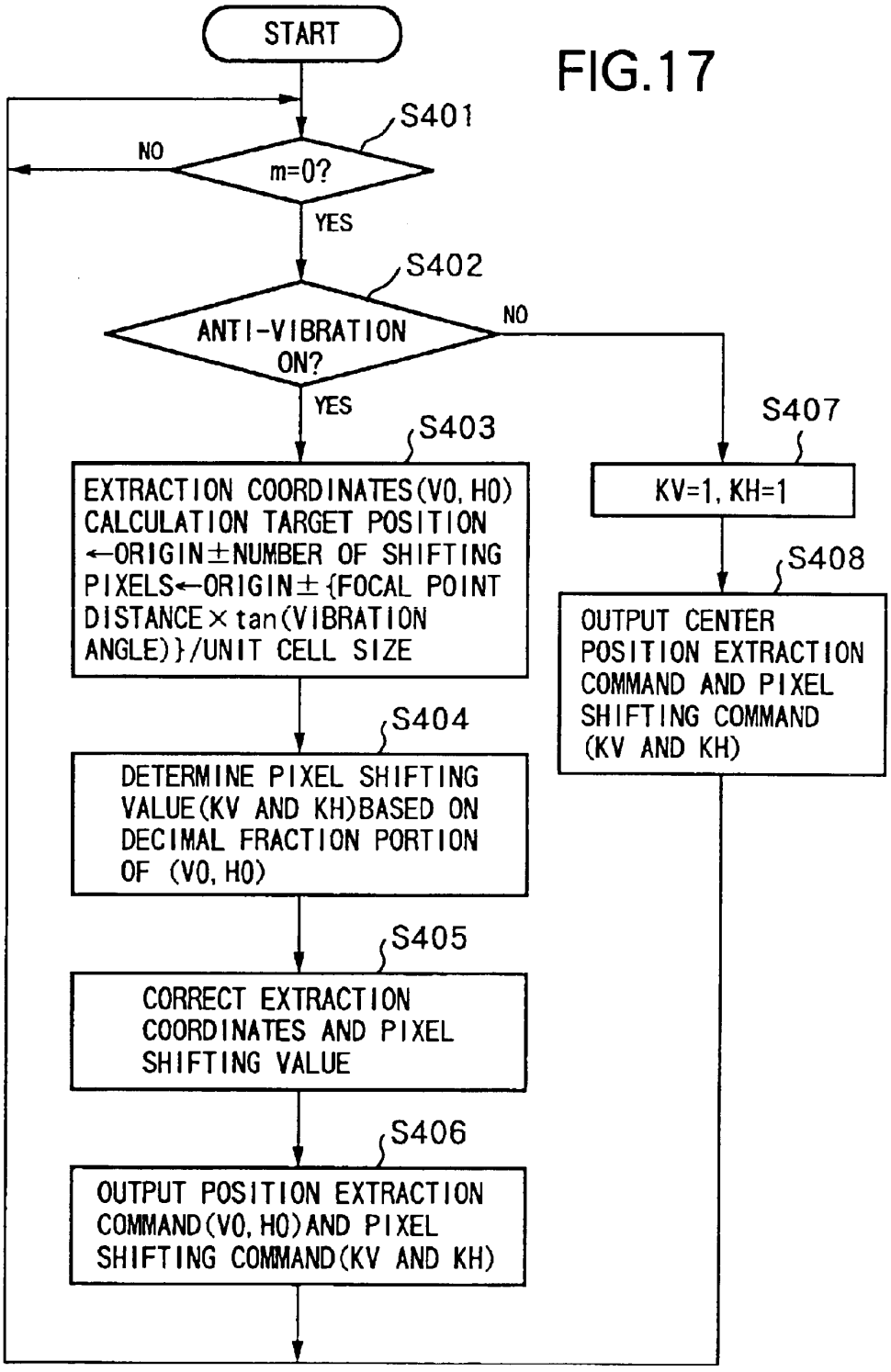

START
S401
m=0?
NO
YES
S402
ANTI-VIBRATION ON?
NO
YES
S403
EXTRACTION COORDINATES(V0, H0) CALCULATION TARGET POSITION ←ORIGIN±NUMBER OF SHIFTING PIXELS←ORIGIN±{FOCAL POINT DISTANCE×tan(VIBRATION ANGLE)}/UNIT CELL SIZE
S404
DETERMINE PIXEL SHIFTING VALUE(KV AND KH)BASED ON DECIMAL FRACTION PORTION OF (V0, H0)
S405
CORRECT EXTRACTION COORDINATES AND PIXEL SHIFTING VALUE
S406
OUTPUT POSITION EXTRACTION COMMAND(V0, H0)AND PIXEL SHIFTING COMMAND(KV AND KH)
S407
KV=1, KH=1
S408
OUTPUT CENTER POSITION EXTRACTION COMMAND AND PIXEL SHIFTING COMMAND (KV AND KH)

FIG. 18

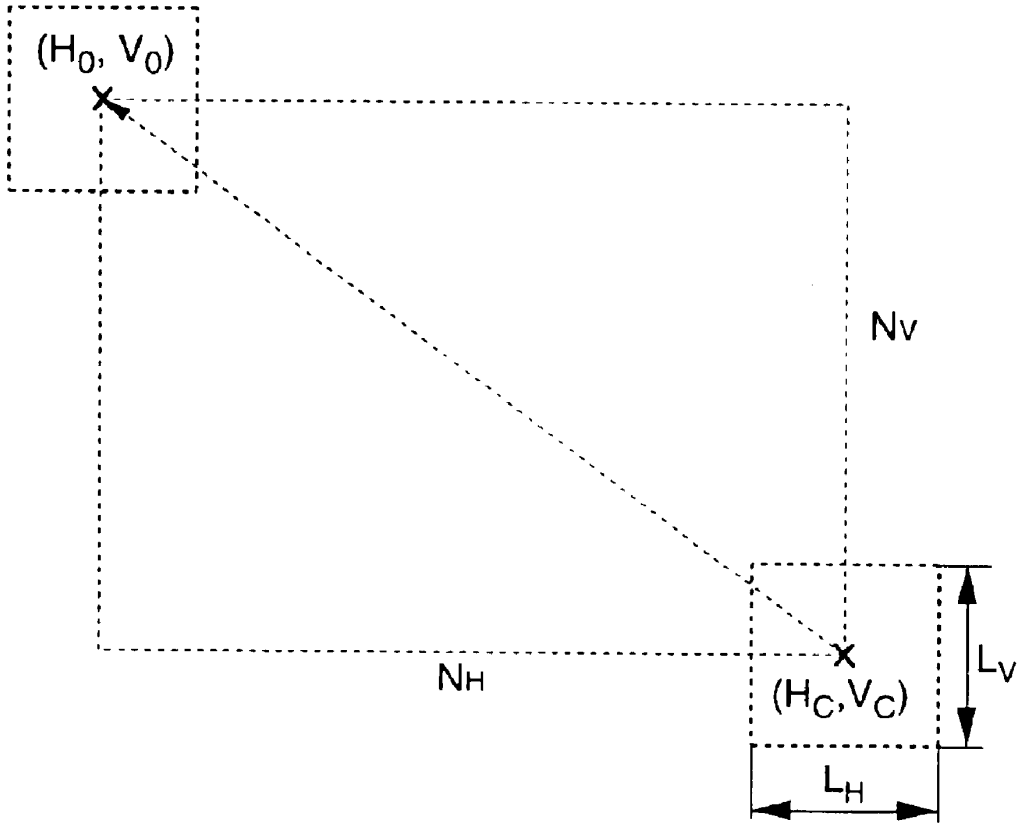


FIG. 19

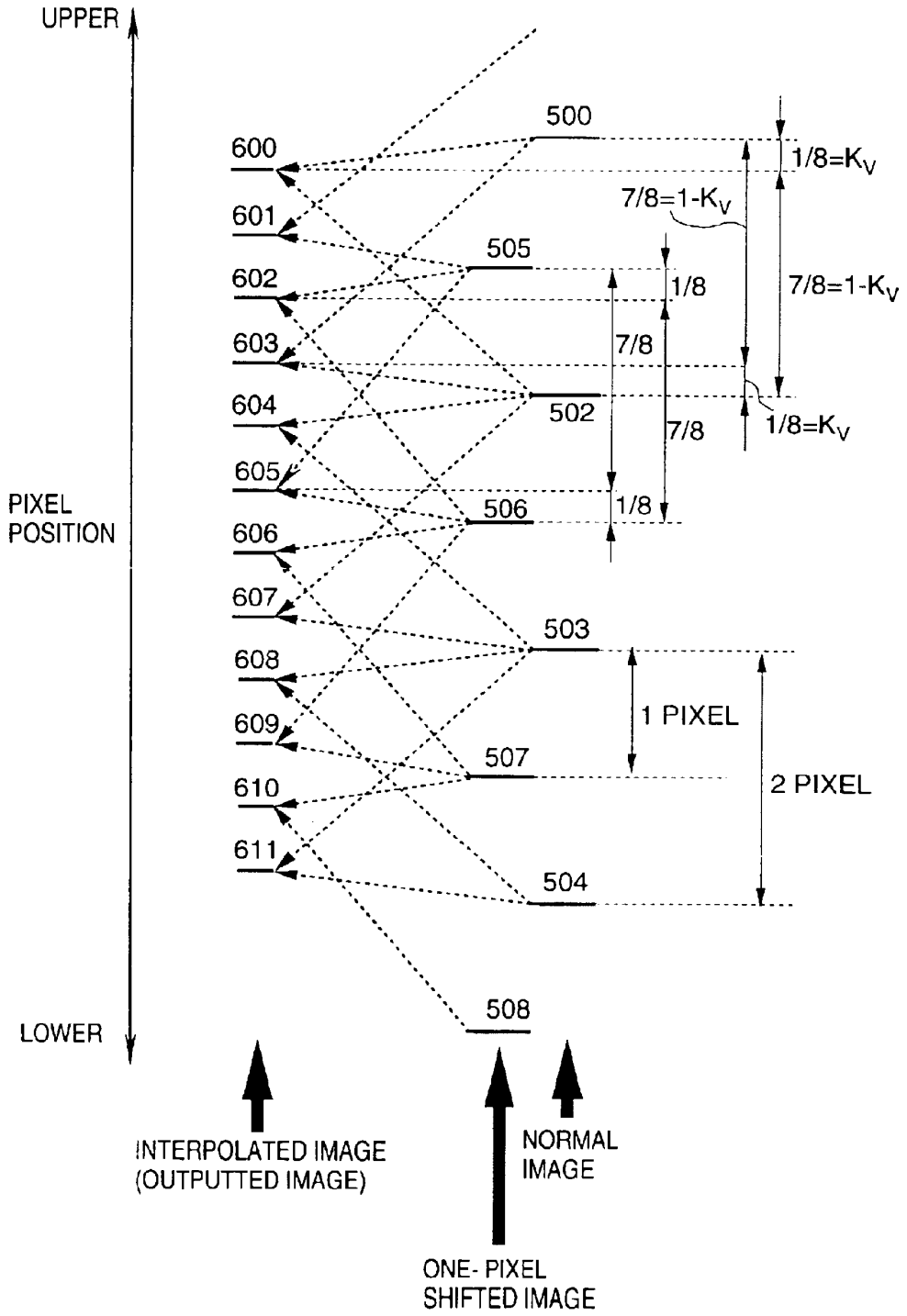

UPPER
PIXEL POSITION
LOWER
600
601
602
603
604
605
606
607
608
609
610
611
500
505
502
506
503
507
504
508
1/8=K_V
7/8=1-K_V
1/8
7/8
7/8
1/8
1/8=K_V
7/8=1-K_V
1 PIXEL
2 PIXEL
INTERPOLATED IMAGE (OUTPUTTED IMAGE)
NORMAL IMAGE
ONE- PIXEL SHIFTED IMAGE

FIG.20

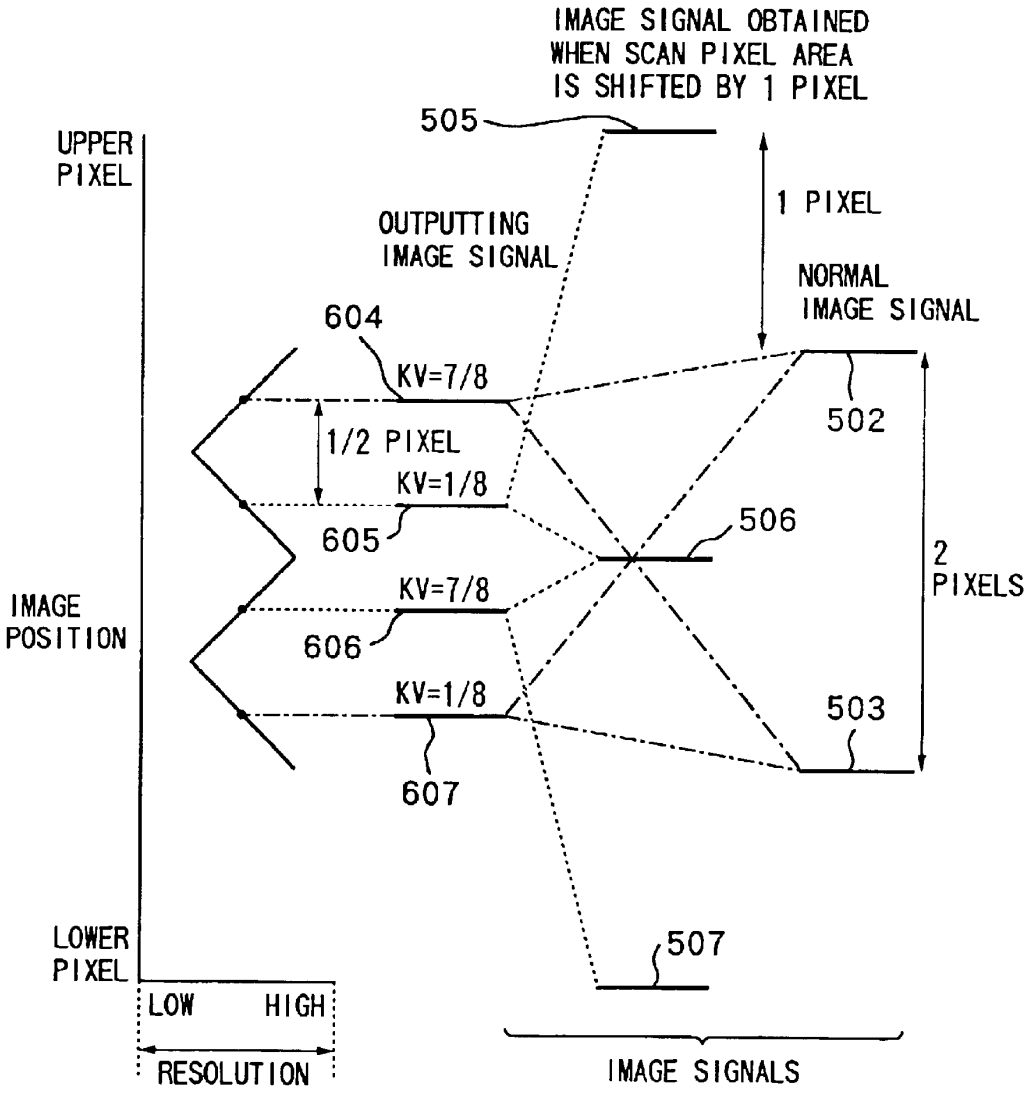

IMAGE SIGNAL OBTAINED
WHEN SCAN PIXEL AREA
IS SHIFTED BY 1 PIXEL
505
UPPER
PIXEL
1 PIXEL
OUTPUTTING
IMAGE SIGNAL
NORMAL
IMAGE SIGNAL
604
KV=7/8
502
1/2 PIXEL
KV=1/8
605
506
2
PIXELS
IMAGE
POSITION
KV=7/8
606
KV=1/8
503
607
507
LOWER
PIXEL
LOW
HIGH
RESOLUTION
IMAGE SIGNALS

FIG. 21

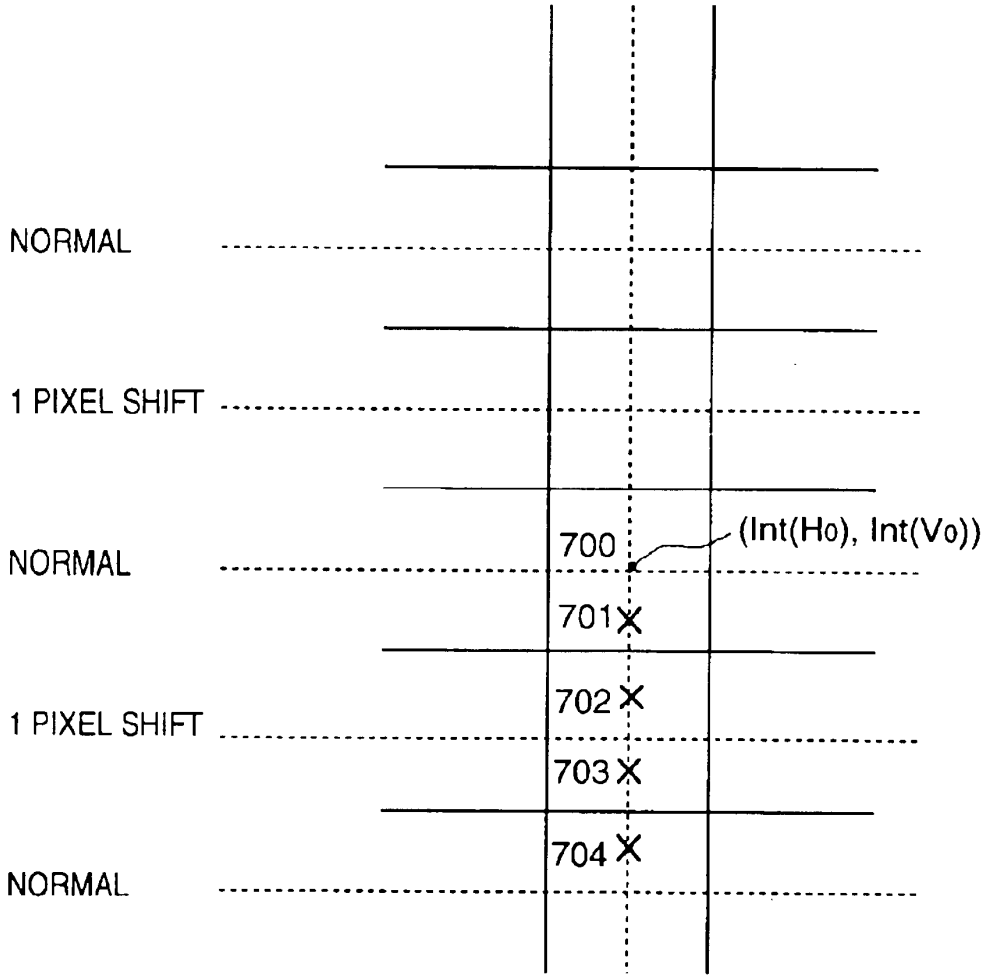

NORMAL
1 PIXEL SHIFT
NORMAL
1 PIXEL SHIFT
NORMAL
700
(Int(Ho), Int(Vo))
701
702
703
704
X : POSITION INDICATED BY Int(Vo)+Dec(V0)

FIG. 22

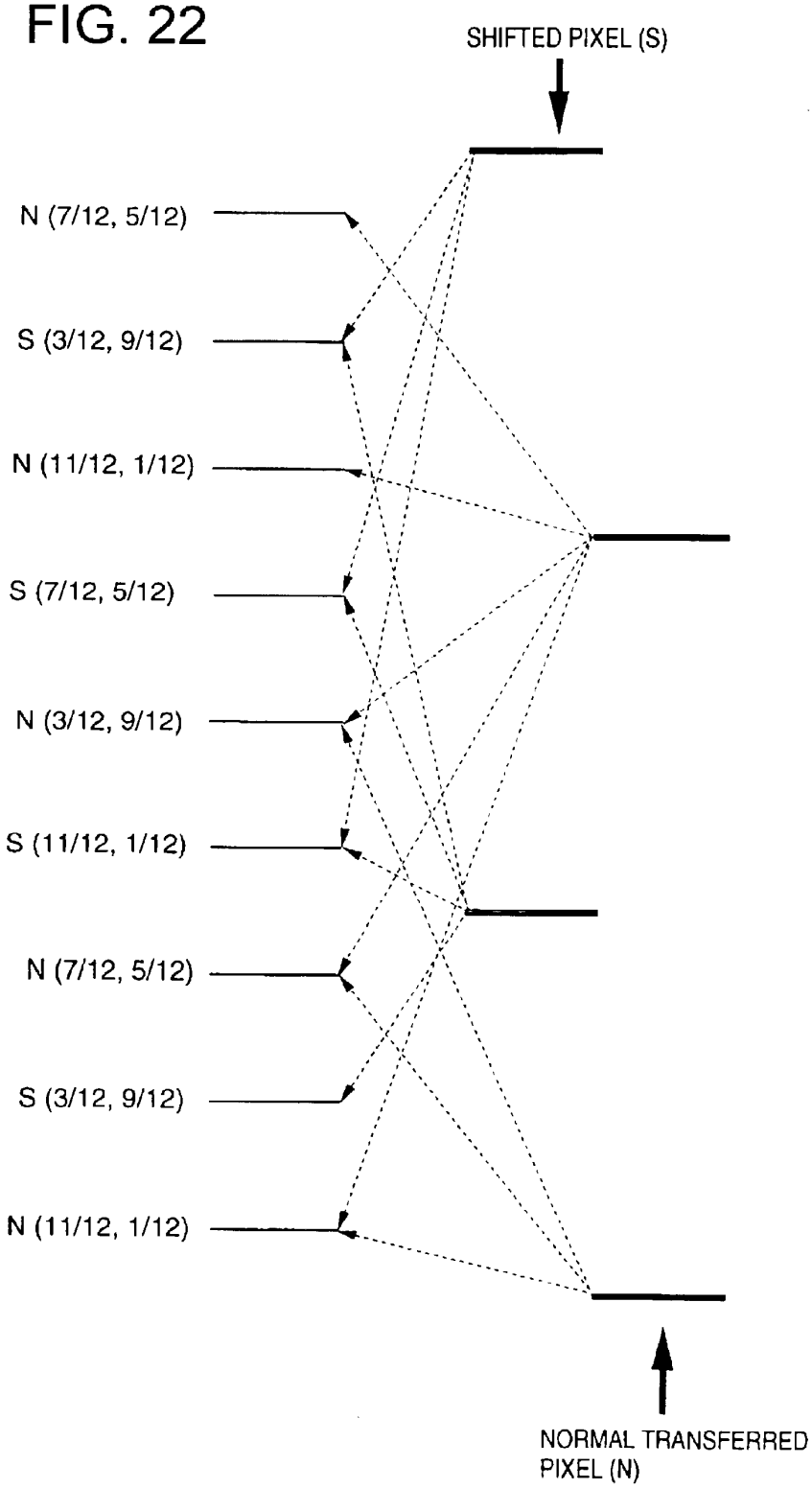

SHIFTED PIXEL (S)
N (7/12, 5/12)
S (3/12, 9/12)
N (11/12, 1/12)
S (7/12, 5/12)
N (3/12, 9/12)
S (11/12, 1/12)
N (7/12, 5/12)
S (3/12, 9/12)
N (11/12, 1/12)
NORMAL TRANSFERRED PIXEL (N)

IMAGE SENSING METHOD AND APPARATUS CAPABLE OF PERFORMING VIBRATION CORRECTION WHEN SENSING A MOVING IMAGE

BACKGROUND OF THE INVENTION

The present invention relates to an image sensing apparatus comprising an electronic anti-vibration system which performs vibration correction by electrically extracting a sensed image based on vibration data of the image sensing apparatus main body. Particularly, the present invention relates to an image sensing method and apparatus capable of sensing a moving image and a still image, and a storage medium storing control programs for controlling the image sensing apparatus.

Conventional image sensing apparatuses such as a video camera or the like have achieved automatic functions and multi-functions in various aspects, e.g., automatic exposure (AE), automatic focus (AF) and so forth. By virtue of this, high quality image sensing is possible.

Furthermore, as the sizes of image sensing apparatuses become smaller and magnifications of optical systems become higher, vibration of the image sensing apparatus causes deteriorated sensed image quality. To compensate for such influence of vibration of the image sensing apparatus, various image sensing apparatuses having a function for correcting vibration have been proposed.

FIG. **1** is a block diagram showing a construction of a conventional image sensing apparatus having a vibration correction function.

The image sensing apparatus having the vibration correction function shown in FIG. **1** comprises an image sensing unit **401**, a vibration correction section **402**, a signal processor **403**, a recording section **404**, a vibration detector **405**, a DC cut filter **406**, an amplifier **407**, a correction variable calculator **408**, a read-out controller **409**, and a tiring generator **410**.

The image sensing unit **401** comprises a lens **401***a*, and an image sensing device **401***b* such as a CCD or the like.

The vibration correction section **402** is provided to correct image signals, obtained by the image sensing device **401***b*, in order to reduce vibration components of a moving image influenced by unsteady hands or the like. The vibration correction section **402** comprises a first delay section **402***a* serving as delay means for one pixel, a first adder **402***b*, a second delay section **402***c* serving as delay means for one image line, and a second adder **402***d*.

The signal processor **403** converts electric signals, where vibration components are reduced by the vibration correction section **402**, to standard video signals such as NTSC signals or the like. The recorder **404**, comprising a video tape recorder or the like, records the standard video signals converted by the signal processor **403** as image signals.

The vibration detector **405** comprises an angular velocity sensor such as a vibration gyro sensor or the like and is installed in the image sensing apparatus main body.

The DC cut filter **406** cuts off the DC components of the angular velocity signal, outputted by the vibration detector **405**, and passes AC components only, i.e., vibration components. The DC cut filter **406** may employ a high-pass filter (hereinafter referred to as HPF) for cutting off signals of a predetermined band.

The amplifier **407** amplifies the angular velocity signal outputted by the DC cut filter **406** to an appropriate level.

The correction variable calculator **408** comprises, e.g., a microcomputer or the like, which includes an A/D converter **408***a*, high-pass filter (HPF) **408***b*, integrator **408***c*, and pan/tilt determination section **408***d*.

The A/D converter **408***a* converts the angular velocity signal outputted by the amplifier **407** to digital signal.

The high-pass filter **408***b*, having a variable cut-off frequency, cuts off low frequency components of the digital signal outputted by the A/D converter **408***a*.

The integrator **408***c* outputs an angle displacement signal by integrating the signals (angular velocity signal) outputted by the high-pass filter **408***b*, and has the function to vary characteristics in an arbitrary frequency band.

The pan/tilt determination section **408***d* determines panning or tilting based on the angular velocity signal, the angular velocity signal outputted by the integrator **408***c*, and an integrated signal, i.e., angle displacement signal, on which integration process has been performed on the angular velocity signal. The pan/tilt determination section **408***d* performs panning control, which will be described later, in accordance with the levels of the angular velocity signal and angle displacement signal.

The angle displacement signal obtained by the correction variable calculator **408** serves as a correction target value in the control described later.

The read-out controller **409** shifts a read-out start position of the image sensing device **401***b* in accordance with the vibration correction target value signal, and controls operation timing of the first delay **402***a* and the second delay **402***c* as well as an addition ratio of the first adder **402***b* and the second adder **402***d*.

The timing generator **410** generates driving pulses for the image sensing device **401***b*, the first delay **402***a*, and the second delay **402***c*, based on the control data of the read-out controller **409**. Driving pulses are generated for the image sensing device **401***b* according to the storage and read operation of the image sensing device **401***b*. For the first delay **402***a* and the second delay **402***c*, driving pulses which serve as a reference for delaying operation, and whose phases are coherent with the driving pulses of the image sensing device **401***b*, are generated.

The vibration correction comprises the vibration detector **405**, DC cut filter **406**, amplifier **407**, correction variable calculator **408**, read-out controller **409**, and timing generator **410**.

Next, operation of the pan/tilt determination section **408***d* of the correction variable calculator **408** will be described in detail.

The pan/tilt determination section **408***d* determines an angular velocity signal from the A/D converter **408***a* and an angle displacement signal from the integrator **408***c*. If the angle displacement signal, which is obtained by integrating the angular velocity signal, is larger than the predetermined threshold value, the section **408***d* determines that panning/tilting operation is being performed, regardless of whether or not the angular velocity is larger or smaller than a predetermined threshold value. In such case, the low cut-off frequency of the high-pass filter **408***b* is shifted higher to change the characteristics so that the vibration correction system does not respond to low frequencies. Further, in order to gradually shift a correction position of the image correction means to the center of the correction range, control is performed (hereinafter referred to as panning control) such that a time constant serving as an integration characteristic of the integrator **408***c* is reduced, so that an

integral value by the integrator **408***c* becomes to a reference value (a value obtained if vibration is not detected).

Note that during the above operation, the angular velocity signals and angle displacement signals continue to be detected. When the panning or tilting is completed, the low cut-off frequency is reduced to expand the vibration correction range, then the panning control ends.

The panning determination operation will be described with reference to the flowchart in FIG. **2**.

First in step **S501**, the A/D converter **408***a* converts (A/D conversion) an angular velocity signal amplified by the amplifier **407**, to a digital value which can be operable by the correction variable calculator **408**. Next in step **S502**, the high-pass filter **408***b* operates using the cut-off frequency value prepared in the previous step. Then in step **S503**, the integrator **408***c* executes an integration calculation using the time constant value prepared in the previous step. In step **S504**, the integration result obtained in step **S503**, i.e., an angle displacement signal, is converted from a digital value to an analogue value then outputted.

In step **S505**, it is determined whether or not the angular velocity signal is equal to or larger than a predetermined threshold value. If the angular velocity signal is equal to or larger than the predetermined threshold value, determination is made that a panning/tilting operation is being performed. Then in step **S506**, the cut-off frequency value f_C used for the operation of the high-pass filter **408***b* is increased from the current value so that the signal in low frequency bands is attenuated in power. Next in step **S507**, the time constant value used in the integration is reduced from the current value by a predetermined value so that the angle displacement output becomes close to the reference value. Then, the control operation ends.

Meanwhile, if the angular velocity signal is not equal to or larger than the predetermined threshold value in step **S505**, it is determined in step **S508** whether or not the integrated value is equal to or larger than a predetermined threshold value. If the integrated value is equal to or larger than the predetermined threshold value, determination is made that panning or tilting operation is being performed, and the control proceeds to step **S506**. Meanwhile, if the integrated value is not equal to or larger than the predetermined threshold value in step **S508**, determination is made that the camera is in a normal control state or panning/tilting operation has been completed. Then, the control proceeds to step **S509**.

In step **S509**, the cut-off frequency value used in operation of the high-pass filter **408***b* is reduced from the current value by a predetermined value so that the signal power in low frequency signals is more decreased. Next in step **S510**, the time constant value used in integration is increased from the current value by a predetermined value so that the integration are more effective. Then, the control operation ends.

By the above described control, the overflow of integration value exceeding a correction target value is prevented. As a result, the correction target value is kept stationary, and a stable anti-vibration control is achieved.

Next, the correction means in the above-described conventional example will be briefly described with reference to FIG. **3**.

Referring to FIG. **3**, reference numeral **601** denotes an entire image sensing area of the image sensing device **401***b*; **602**, an extraction frame set in the entire image sensing area **601**, where an image signal is actually converted to standard video signals and outputted; and **603**, an object sensed by the image sensing device.

Standard video signal in this stage is seen as an image indicated as reference numeral **604**. More specifically, reference numeral **604** denotes an image area on a monitor where the video signal is reproduced, and **603'** denotes the object reproduced in the image area **604** of the monitor. By extracting an image signal from a sensed image as will be described later, the periphery is removed from the entire image sensing area **601** and the remaining portion, that is an extracted image is outputted as standard video signals. By this, the image area **604** is reproduced on the monitor.

FIG. **3** shows a case where an operator, who performs image sensing of the object **603**, shifts the image sensing apparatus in a lower left direction indicated by arrows **605**, **605'**, and **605'**.

In this state, if an image is extracted by using an extraction frame **602'** which corresponds to the extraction frame **602**, the obtained video signal would represent the object **603**, which is shifted by the amount of vector indicated by the arrow **606**. It is possible to obtain the image **604** if the extraction position is corrected and moved from the extraction frame **602'** to the extraction frame **602"**, using an image displacement **607** obtained based on a vibration amount of the image sensing apparatus, i.e., vibration correction target value. By employing such principle, image vibration correction is realized.

Next, extraction of an image sensing area for correction will be described with reference to FIG. **4**.

In FIG. **4**, reference numeral **701** denotes the entire image sensing device; and **702**, pixels constructing the entire image sensing device **701**, each serving as a photoelectric converter. Based on electric driving pulses generated by a timing generator (not shown), charge storage and read-out controls are performed pixel by pixel. Reference numerals **703** and **704** are extraction frames similar to the extraction frame **602** shown in FIG. **3**. This will be explained for a case where video signals are extracted with, e.g., the extraction frame **703**.

First, starting from the pixel "S", photoelectrically converted charges are read in the sequence of the arrow **706**. The reading operation starts in concurrence with the synchronization period of output video signals. During the synchronization period, reading is performed at a faster transfer rate than the normal reading rate until the reading-out reaches the pixel preceding the pixel "A" by one pixel.

After the synchronization period, charges for a real image period are read starting from the pixel "A" to the pixel "F" at the normal reading rate, as a line of image data in video signals.

During the horizontal synchronization period, charges of pixels are read from the pixel "F" to the pixel before the pixel "G" at a faster transfer rate than the normal reading rate, preparing for reading the next image period. Starting from the pixel "G", reading is performed in a similar manner to the reading from the pixel "A" to the pixel "F".

By controlling the reading operation as described above, for instance, the central part of the image sensing device **401***b* can be selectively extracted from the entire image sensing area **601** of the image sensing device **401***b*, and video signals can be obtained.

Described next with reference to FIG. **4** is moving the extraction position, necessary in a case where the image sensing surface is shifted due to vibration on the image sensing apparatus as described in FIG. **3**.

In a case where the movement of the object (vibration of the image sensing apparatus), which is equivalent to the

arrow **705**, is detected on the image sensing device **401***b*, the extraction frame **703** is changed to the extraction frame **704** so that an image without any object movement is obtained.

In order to change the extraction position, the aforementioned read-out start position is changed from the pixel "A" to the pixel "B". By this change, it is possible to selectively extract a partial image from the entire image sensing area **601** of the image sensing device **401***b*, similar to the case where reading starts from the pixel "A".

More specifically, photoelectrically converted charges are read from the pixel "S" in the sequence of the arrow **706**, as similar to the case of reading the extraction frame **703**. The reading operation starts in concurrence with the synchronization period of output video signals. During the synchronization period, reading is performed at a faster transfer rate than the normal reading rate until the reading reaches the pixel one-pixel prior to the pixel "B". Then, in the real image period, reading starts from the pixel "B".

As described above, a partial image sensing area, which is the periphery of the image sensing device **401***b*, is read in advance for the amount corresponding to vibration correction data during the synchronization signal period which does not appear in the real image period, and the part of the image sensing device **401***b* is selectively read out based on the vibration data. By this, it is possible to obtain video signals from which displacement caused by vibration on the image sensing apparatus is removed.

Next, pixel shifting operation by the first delay **402***a*, second delay **402***c*, first adder **402***b*, and second adder **402***d* will be described in detail with reference to FIG. **5**.

FIG. **5** is a block diagram showing a construction of an image sensing apparatus for performing finer image correction by extracting an image from the image sensing device **401***b*. Components shown in FIG. **5**, which are identical to that of the above-described conventional example in FIG. **1**, have the same reference numerals.

Referring to FIG. **5**, the first adder **402***b* comprises a first multiplier **801**, a second multiplier **802**, an adder **803**, and addition controller **804**. The second adder **402***d* comprises a first multiplier **805**, a second multiplier **806**, an adder **807**, and addition controller **808**.

The image extraction, as described with reference to FIG. **4** can only be performed in each unit pixel **702** of the image sensing device **401***b*. Therefore, the correction could not be made for a shift less than one pixel pitch. Therefore, the first delay **402***a*, second delay **402***c*, first adder **402***b*, and second adder **402***d* perform a fine pixel shifting which accompanies a correction calculation for an amount less than one pixel unit.

Referring to FIG. **5**, reference numeral **809** denotes an input terminal for inputting a sensed image signal obtained by the image sensing device **401***b*. While the sensed image signal is inputted to the second multiplier **802** of the first adder **402***b*, the signal is inputted to the first multiplier **801** through the first delay **402***a* constructed by a CCD or the like. After the first multiplier **801** and the second multiplier **802** multiply the respective image signal by a predetermined multiplier, addition is executed by the adder **803**. As a result, a horizontal pixel-shifting correction has been performed on the sensed image signal.

The sensed image signal, on which horizontal pixel-shifting correction has been performed, is inputted to the second multiplier **806** of the second adder **402***d*, and to the first multiplier **805** through the second delay **402***c*, which is constructed by a CCD or the like. The first multiplier **805** and the second multiplier **806** multiply the signals by predetermined multipliers. The adder **807** adds the outputs of the multipliers **805** and **806**. Thus, the sensed image signal on which horizontal and vertical pixel-shifting correction has been performed is obtained. The image signals are encoded to video signals by the signal processor **403** in the next step.

The read-out controller **409** controls the timing of driving pulses generated by the timing generator **410** for performing image extraction control of the image sensing device **401***b* based on the correction target value signal which corresponds to vibration of the image sensing apparatus, which is generated by the correction variable calculator **408** shown in FIG. **1**. Meanwhile, the read-out controller **409** controls the addition controller **804** of the first adder **402***b* and the addition controller **808** of the second adder **402***d* so as to perform addition operation at an appropriate addition ratio.

This addition operation will now be described in detail with reference to FIGS. **6**A, **6**B, **7**A and **7**B.

FIGS. **6**A and **6**B are explanatory views showing the process of the first delay **402***a* and the first adder **402***b* in unit of the pixels **702** of the image sensing device **401***b*. The pixels **702** of the image sensing device **401***b* are arranged in a regular order in the vertical and horizontal directions on the surface of the image sensing device **401***b* as shown in FIG. **4**. FIGS. **6**A and **6**B only show the pixels arranged in the horizontal direction for explanatory purpose.

First, addition operation performed in pixel units shown in FIG. **6**A is described.

A horizontal center position of the n-th pixel of the pixels **702** of the image sensing device **401***b* is referred to as a horizontal pixel center **901**. Similarly, a horizontal center position of the (n+1)th pixel of the pixels **702** is referred to as a horizontal pixel center **902**. FIG. **6**A graphically shows a method of calculating an imaginary center of the n-th pixel and the (n+1)th pixel. The n-th pixel value which is multiplied by ½, denoted by numeral **903**, the (n+1)th pixel value which is multiplied by ½, denoted by **904**, are added, thereby obtaining a pixel value at the imaginary center **905** of the n-th pixel and (n+1)th pixel. Similarly, a value in which the (n+1)th pixel is multiplied by ½ is added to a value in which the (n+2)th pixel is multiplied by ½, thereby obtaining a pixel value at the imaginary center of the (n+1)th pixel and the (n+2)th pixel.

Next, another addition operation shown in FIG. **6**B will be described. FIG. **6**B adopts a different addition ratio from that of FIG. **6**A, showing a case of executing an addition with a ratio of 7/10 to 3/10.

In FIG. **6**B, as similar to FIG. **6**A, the horizontal center position of the n-th pixel of the pixels **702** of the image sensing device **401***b* is defined as a horizontal pixel center **901**, and the horizontal center position of the (n+1)th pixel of the pixels **702** of the image sensing device **401***b* is defined as a horizontal pixel center **902**. In order to obtain an image having 7/10 of the n-th pixel value and 3/10 of the (n+1)th pixel value, a pixel value **903'** in which the n-th pixel is multiplied by 7/10 is added to a value **904'** in which the (n+1)th pixel is multiplied by 3/10, thereby obtaining an image **905'** having 7/10 of the n-th pixel and 3/10 of the (n+1)th pixel. Similarly, by adding a value in which the (n+1)th pixel is multiplied by 7/10 to a value in which the (n+2)th pixel is multiplied by 3/10, it is possible to obtain an pixel having 7/10 of the (n+1)th pixel and 3/10 of the (n+2)th pixel.

As described above, by adjusting the addition ratio of adding the n-th pixel and (n+1)th pixel, it is possible to obtain pixel data for an arbitrary position of a pixel in the horizontal direction. Note that assuming that an n-th pixel

value is generally multiplied by k, the addition ratio is obtained by multiplying an (n+1)-th pixel value by (1−K) (where, $0 \leqq K \leqq 1$). Where the multiplication ratio is set to 1:0 or 0:1, addition is not performed. Then, the normal read-out operation is performed.

FIGS. **7**A and **7**B are explanatory views showing the process of the second delay **402***c* and the second adder **402***d* in the horizontal line units of the image sensing device **401***b*.

First, addition operation performed in horizontal line units shown in FIG. **7**A will be described. The horizontal line is constructed by a horizontal array of pixels of the image sensing device **401***b*. Vertical center position of the n-th line is referred to as a vertical pixel center **1001**. Similarly, the vertical center position of the (n+1)th line is referred to as a vertical pixel center **1002**.

FIG. **7**A graphically shows a method of calculating a pixel value at the center positioned between the n-th line and the (n+1)th line. A value **1003** in which the n-th line is multiplied by ½ is added to a value **1004** in which the (n+1)th line is multiplied by ½, thereby obtaining a line **1005**. Similarly, a value in which the +(n+1)th line is multiplied by ½ is added to a value in which the (n+2)th line is multiplied by ½, thereby obtaining the center image of the (n+1)th line and (n+2)th line.

Next, addition operation performed in horizontal line units shown in FIG. **7**B will be described. FIG. **7**B adopts a different addition ratio from that of FIG. **7**A, showing a case of executing addition with a ratio of 7/10 to 3/10.

In FIG. **7**B, similar to FIG. **7**A, the vertical center position of the n-th line of the pixels **702** of the image sensing device **401***b* is referred to as a vertical pixel center **1001**, and the vertical center position of the (n+1)th line is referred to as the vertical pixel center **1002**. In order to obtain an image having 7/10 of the n-th line and 3/10 of the (n+1)th line, a value **1003'** in which the n-th line is multiplied by 7/10 is added to a value **1004'** in which the (n+1)th line is multiplied by 3/10, thereby obtaining a line image **1005'** having 7/10 of the n-th line and 3/10 of the (n+1)th line. Similarly, by adding a value in which the (n+1)th line is multiplied by 7/10 to a value in which the (n+2)th line is multiplied by 3/10, it is possible to obtain an image having 7/10 of the (n+1)th line and 3/10 of the (n+2)th line.

As described above, by adjusting the addition ratio of adding the n-th line and the (n+1)th line, it is possible to obtain line data for an arbitrary position in one line in the vertical direction.

Note that assuming that the n-th line is generally multiplied by k, the addition ratio is obtained by multiplying the (n+1)th line by (1−k) ($0 \leqq K \leqq 1$). If the multiplication ratio is set to 1:0 or 0:1, addition is not performed. Thus, the normal read-out operation is performed.

As set forth above, correction operation in pixel units is achieved by reading out data by the image sensing device **401***b*. Correction operation for an amount less than one pixel unit is achieved by performing pixel shifting. By this, excellent anti-vibration can be attained.

However, recently an image sensing apparatus sensing both a moving image and a still image has been proposed. Such image sensing apparatus also employs a similar anti-vibration system to the above. However, the anti-vibration system employed by the foregoing conventional image sensing apparatus realizes anti-vibration process by pixel shifting operation. In this case, data stored between pixels are added up, resulting in deteriorated resolution in images. Particularly in a case of sensing a still image wherein a correction between frames by image extraction is not important, a problem of deteriorating resolution in images (hereinafter referred to as a first problem) rather arises.

Next, a second problem of the conventional apparatus will be described.

As a conventional method of anti-vibration, the method disclosed in Japanese Patent Application Laid-Open No. 60-143330 is known.

The conventional method includes an optically and electronically vibration correction methods. According to the optical correction method, vibration is detected from an image sensing apparatus main body by a rotational gyro sensor, and based on the detected result, the optical systems including lens and the image sensing apparatus main body are controlled. According to the electronic correction method, signal transferring of an image sensing device is divided into a high-velocity transfer mode and a normal transfer mode, and the number of pixels transferred in high-velocity transferring is controlled. The above-described conventional examples employs the electronic correction method. The electronic correction method particularly provides an advantage of apparatus size reduction.

In the electronic anti-vibration method, the number of pixels transferred is controlled. In a case of employing an image sensing device reading vertically neighboring pixels simultaneously, the pixel area where signals are normally transferred is shifted at two pixel pitch. This limits a resolving power in anti-vibration.

For a method of improving the resolving power in anti-vibration, the method disclosed in Japanese Patent Application Laid-Open No. 3-132173 is known. According to this method, vertically neighboring two pixels which are read simultaneously by an image sensing device are shifted at one pixel pitch. Since pixels are shifted at one pixel pitch within an image area where signals are normally transferred, smooth pixel movement is achieved.

For instance, in a case of reading pixels, the conventional art reads pixel data at two pixel pitch as shown in FIG. **8**A. When shifting read-out data, the conventional apparatus, instead of shifting pixels at two pixel pitch as shown in FIG. **8**B, shifts image data at one pixel pitch, as shown in FIG. **8**C. By this, a pixel area normally transferred can be shifted at one pixel pitch. In this, regard, since the pixel combinations are different, color process has to be changed later to perform color processing according to the combination of pixels.

Note that in FIGS. **8**A, **8**B and **8**C, Y denotes an yellow color filter; C, a cyan color filter; M, a magenta color filter; and G, a green color filter.

Meanwhile, there is a pixel shifting technique available today in which image signals of the vertically neighboring two pixels are added in a predetermined ratio, and an image is shifted by changing the ratio, thereby improving a resolving power in anti-vibration. Herein, pixel shifting will be described with reference to FIG. **9**.

Referring to FIG. **9**, first, an image signal for one horizontal scan period (H) is stored in 1-H delay memory **1701**. A first multiplier **1702** multiplies currently inputted image signal by K_V. A second multiplier **1703** multiplies the outputs of the 1-H delay memory **1701** by $(1-K_V)$. These multiplied values are added by an adder **1704**. By this, when K_V is 1, currently inputted image signal is outputted. When K_V is ½, an intermediate image signal between the currently inputted image signal and the signal in the 1-H delay memory **1701** is outputted. When K_V is 0, an image signal which is 1H prior to what is stored in the 1-H delay memory **1701** is outputted. By virtue of this, it is possible to shift

positions of image signals. If the addition ratio is adjusted in small increments, smaller vibration can be accommodated.

However, in the above-described conventional example in FIG. **9**, if anti-vibration operation is performed by shifting a pixel area where signals are normally transferred at one pixel pitch, the resolving power is not high enough to perform anti-vibration. As a result, very small vibration remains, or excessive vibration is caused on the contrary. Moreover, performing anti-vibration by pixel shifting causes a problem of "resolution unevenness" and flickers on a screen. Herein, the "resolution unevenness" will be described.

Since pixel shifting is performed by adding image signals of the vertically neighboring two pixels as described above, the resolution is deteriorated. Shown in FIG. **10** is a graph showing deterioration of resolution. The ordinate in FIG. **10** indicates an image position, and the abscissa indicates resolution. Reference numerals **1801** to **1805** denote image signals respectively.

As can be seen from FIG. **10**, the highest resolution is achieved when pixel shifting is not performed. The resolution falls to the lowest level when pixels are shifted to an intermediate position of two pixels. Therefore, if pixel shifting to an arbitrary position is performed in anti-vibration control, resolution changes one after another, causing flickers on a screen. This is called "resolution unevenness." The occurrence of the resolution unevenness is the second problem to be solved in the conventional art.

SUMMARY OF THE INVENTION

The present invention is made in consideration of the above situation, and a first object of the present invention is to provide an image sensing method and apparatus capable of performing vibration correction similar to the conventional example when sensing a moving image, and obtaining a sensed image with no image deterioration when sensing a still image, so as to solve the above-described first problem.

A second object of the present invention is to provide an image sensing method and an apparatus capable of eliminating the resolution unevenness while securing a resolving power necessary for anti-vibration, so as to solve the above-described second problem.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the description, serve to explain the principles of the invention.

FIG. **1** is a block diagram showing a construction of a conventional image sensing apparatus;

FIG. **2** is a flowchart showing operation steps of panning control performed by the conventional image sensing apparatus;

FIG. **3** is an explanatory view for briefly explaining vibration correction means of the conventional image sensing apparatus;

FIG. **4** is an explanatory view for explaining extraction of a stored image by vibration correction means of the conventional image sensing apparatus;

FIG. **5** is a block diagram for explaining pixel shifting in the conventional image sensing apparatus;

FIGS. **6**A and **6**B are explanatory views explaining horizontal pixel shifting in the conventional image sensing apparatus;

FIGS. **7**A and **7**B are explanatory views explaining vertical pixel shifting in the conventional image sensing apparatus;

FIGS. **8**A to **8**C are explanatory views for explaining brief operation of vibration correction means in the conventional image sensing apparatus;

FIG. **9** is a block diagram showing a construction of a section performing pixel shifting in the conventional image sensing apparatus;

FIG. **10** is a graph showing relationship between an image position upon pixel shifting and resolution, in the conventional image sensing apparatus;

FIG. **11** is a block diagram showing a construction of an image sensing apparatus according to a first embodiment of the present invention;

FIG. **12** is a flowchart showing operation steps of pixel shifting control performed by the image sensing apparatus according to the first embodiment of the present invention;

FIG. **13** is a block diagram showing a construction of an image sensing apparatus according to a modified example of the first embodiment;

FIG. **14** is a block diagram showing a construction of an image sensing apparatus according to a second embodiment of the present invention;

FIGS. **15**A and **15**B are explanatory views for explaining an image area extracted by electronic anti-vibration control in the image sensing apparatus according to the second embodiment;

FIG. **16** is a flowchart showing operation flow of the image sensing apparatus according to the second embodiment;

FIG. **17** is a flowchart showing operation flow of the image sensing apparatus according to the second embodiment;

FIG. **18** illustrates a position (H_0, V_0) where an image extraction (image shifting) is started with respect to the position (H_C, V_C) without image shifting;

FIG. **19** illustrates how interpolated pixels are generated from image signals;

FIG. **20** is a graph for explaining a process of regenerating correction variable data in the image sensing apparatus according to the second embodiment;

FIG. **21** illustrates how interpolated pixels are quantized so that they are equally spaced; and

FIG. **22** illustrates how interpolated pixels are generated where a resolving power is raised to three times.

DETAILED DESCRIPTION OF THE INVENTION

Preferred embodiments of the present invention will be described in detail in accordance with the accompanying drawings.

<First Embodiment>

First, the first embodiment is described with reference to FIGS. **11** and **12**.

FIG. **11** is a block diagram showing a construction of an image sensing apparatus according to the first embodiment. Components shown in FIG. **11**, which are identical to that of the above-described conventional example in FIG. **1**, have the same reference numerals.

FIG. **11** differs from FIG. **1** by having an image sensing mode switch **411** in addition to the construction shown in FIG. **1**. The image sensing mode switch **411** allows users to switch the record mode of the recording section **404**, between a moving image recording mode and a still image recording mode. The recording section **404** employs a record format corresponding to the selected image sensing mode, depending on a recording medium.

In the above-described conventional example, the read-out controller **409** respectively controls the timing generator **410** and the first and second adders **462***b* and **402***d* based on vibration correction target value data obtained by the correction variable calculator **408**. However, in the present embodiment, the read-out controller **409** changes operation of the timing generator **410** and the first and second adders **402***b* and **402***d* in accordance with the state of the image sensing mode switch **411**.

The operation of the image sensing mode switch **411** is now described with reference to the flowchart in FIG. **12**.

First in step S**201**, a vibration correction target value is obtained by the correction variable calculator **408** based on vibration data obtained by the vibration detector **405**. The read-out controller **409** controls read-out operation of the image sensing device **401***b* so as to perform an anti-vibration correction according to the obtained vibration correction target value. Next in step S**202**, it is determined whether the image sensing mode switch **411** is set in the moving image sensing mode or in the still image sensing mode. In a case where it is set in the still image sensing mode, it is determined in step S**203** whether or not the record mode of the recording section **404** is ready for a still image, i.e., set in the still image recording mode. If the recording section **404** is set in the still image recording mode, the process proceeds directly to step S**204**, while if the recording section **404** is set in the moving image recording mode, the record mode of the recording section **404** is changed from the moving image recording mode to the still image recording mode in step S**206**, then the control proceeds to step S**204**.

In step S**204**, addition control is performed by setting the value K of the adders **402***b* and **402***d* to **1** so as not to perform fine pixel-shifting operation, based on the above-described reason. Then, the control proceeds to step S**205** where it is determined whether or not an image sensing start switch (not shown) has been depressed. In a case where the image sensing start switch is not depressed, the process ends without further processing. In a case where the image sensing start switch is depressed, still image sensing is executed in step S**207** and the control operation ends.

Meanwhile, in a case where the image sensing mode switch **411** is set in the moving image sensing mode in step S**202**, it is determined in step S**208** whether or not the record mode of the recording section **404** is ready for a moving image, i.e., set in the moving image recording mode. If the recording section **404** is set in the moving image recording mode, the process proceeds directly to step S**209**, while if the recording section **404** is set in the still image recording mode, the record mode of the recording section **404** is changed from the still image recording mode to the moving image recording mode in step S**211**, then the control proceeds to step S**209**.

In step S**209**, as similar to the conventional example, addition control for fine pixel-shifting operation is performed by calculating an addition ratio value K for the adders **402***b* and **402***d*, in order to perform correction for an amount less than one pixel based on the correction target value data. Then, the control proceeds to step S**210** where it is determined whether or not an image sensing start switch (not shown) has been depressed. In a case where the image sensing start switch is not depressed, the process ends without further processing. In a case where the image sensing start switch is depressed, moving image sensing is executed in step S**212** and the control operation ends.

By the above operation, the fine pixel-shifting operation is performed when sensing a moving image, as conventionally performed. As a result, an image where connections between image fields are smooth is obtained. Meanwhile in a case of sensing a still image, since the fine pixel shifting is not performed, it is possible to obtain an image where resolution is not greatly deteriorated.

<Modified Example of First Embodiment>

Next, a modified example of the first embodiment will be described with reference to FIG. **13**. FIG. **13** is a block diagram showing a construction of an image sensing apparatus according to a modified example to the first embodiment which will be described later. Components shown in FIG. **13**, which are identical to that of the aforementioned conventional example in FIG. **1** and that of the first embodiment in FIG. **11**, have the same reference numerals.

FIG. **13** differs from FIG. **11** by having a first switch **301** and a second switch **302** in addition to the construction shown in FIG. **11**. The first switch **301** and the second switch **302** select a–a' or b–b' in accordance with the switching mode of the image sensing mode switch **411**, wherein a–a' is a route in which image signals flow from the image sensing device **401***b* to the first adder **402***b*, then through the second delay **402***c* and second adder **402***d* to the signal processor **403**, while b–b' is a route in which image signals flow from the image sensing device **401***b* to the signal processor **403** directly.

A switch, capable of switching the image signal flows may be employed for the first switch **301** and the second switch **302**. The switching operation is controlled such that the first switch **301** and the second switch **302** are switched simultaneously.

For sensing a moving image, the first switch **301** and the second switch **302** select the a–a' side so that not only the vibration correction operation which is executed by extracting an image from the image sensing device **401***b*, but also the above-described pixel shifting control is performed. Accordingly, smooth anti-vibration operation is performed.

For sensing a still image, the first switch **301** and the second switch **302** select the b–b' side so that vibration correction operation, executed by extracting an image from the image sensing device **401***b*, is performed without using the block including the first delay **402***a*, the second delay **402***c*, first adder **402***b*, and the second adder **402***d*. Accordingly, a still image where resolution is not deteriorated can be obtained.

<Second Embodiment>

FIG. **14** is a block diagram showing a construction of an image sensing apparatus (video camera) according to the second embodiment of the present invention. In FIG. **14**, reference numeral **101** denotes lenses; **102**, an image sensing device such as a CCD or the like; **103**, an amplifier; **104**, a camera signal processor; **105**, an enlargement/interpolation/pixel shifting circuit for performing enlargement process, interpolation process, and pixel shifting process on image data; **106**, a CCD driver; **107**, a pitch angular velocity sensor; **108**; a yaw angular velocity sensor; **109** and **110**, amplifiers; **111**, an anti-vibration control microcomputer; and **112**, a switch. Note that the pitch angle sensor **107** and the yaw angle sensor **108** of the second embodiment

correspond to the vibration detector **405** of the first embodiment, and the anti-vibration control microcomputer **111** of the second embodiment correspond to the correction variable calculator **408** of the first embodiment.

An enlargement or magnifying process by the circuit **105** is to compensate for the difference in pixel number of the CCD **102** between in vertical and horizontal directions so that there occurs no difference in resolution between in the directions, and increases the number of apparent pixels by magnifying the image in the less direction in pixel number. The circuit **105** is also capable of performing pixel-interpolation process so as to generate a pixel at shift position where a shift amount of the pixel shift or displacement for anti-vibration includes a shift less than one pixel. Further, the circuit **105** is capable of shifting a read-out start position in the CCD **102**. In the second embodiment, since the interpolation process is performed accompanied with the pixel displacement operation, the pixel shift for anti-vibration includes the interpolation operation and the shifting of the read-out start position. Hereafter, a pixel shift operation by shifting the read-out start position will be referred to as "rough pixel shifting", while a pixel shifting in less than one pixel is as "fine pixel shifting".

Referring to FIG. **14**, light from an object passes through the lenses **101** and an image is formed on the image sensing device **102**. The image on the image sensing device **102** is photoelectrically converted, then amplified to an appropriate level by the amplifier **103**, inputted to the camera signal processor **104**, and converted to standard video signals.

The image sensing apparatus shown in FIG. **14** comprises an electronic image stabilization function. Activation or non-activation of this anti-vibration function is determined by detecting the state of the switch **112**. The pitch and yaw angular velocity sensors **107** and **108** detect vibration angular velocity of the image sensing apparatus. The angular velocity signals are amplified by the amplifiers **109** and **110**, and inputted to the anti-vibration control microcomputer **111**, then integrated and calculated as an angle displacement. In accordance with the displacement angle θ obtained in the foregoing manner and a focal point distance f of the optical system, the pixels (corresponding to $f\times\tan\theta$) displaced on the image sensing device **102** due to vibration are shifted to the direction opposite to the displaced direction, thereby performing vibration correction.

FIGS. **15**A and **15**B are explanatory views for explaining an image area extracted by electronic anti-vibration control. In FIG. **15**A, reference numeral **201** denotes an effective pixel area of the image sensing device **102**. The start point (x_0, y_0) of a section **202** (hereinafter referred to as a partial area **202**) of the effective pixel area is moved in the range of the effective pixel area **201** in a way that only the partial area **202** is extracted and vibration correction is performed. Then, the partial area **202** only is displayed on a monitor such as a video monitor or a finder or the like.

As a technique of such displaying operation, the first technique is to temporarily store an image for the effective pixel area **201** by using a field memory, and while reading the image for the partial area **202** from the memory, enlarge the image so as to fit in the area **203** shown in FIG. **15**B and interpolate the horizontal/vertical scan lines. The second technique is to employ a large CCD having high density and a large number of pixels as the image sensing device **102** so that the extraction area of the partial area **202** satisfies the number of scan lines necessary for the standard video signals. Both techniques require an expensive field memory or a large CCD. Therefore, the second embodiment of the present invention utilizes a CCD for the widely used PAL (phase alternation line) for an image sensing apparatus complying with the NTSC (National Television System Committee).

The CCD for PAL has a high pixel density in the vertical direction. Therefore, with respect to the vertical scan direction, an image may be extracted without further process by using the CCD driver **106**, e.g., a timing generator or the like. With respect to the horizontal scan direction, enlargement process is performed in a vertical-horizontal ratio by using a line memory. By this, an inexpensive vibration correction apparatus is realized.

The image sensing apparatus in FIG. **14** has a construction having the above-described correction system. When pixel shifting is performed in the vertical scan direction, rapid drain control is performed by the CCD driver **106** to extract a desired scan area. Specifically, in the second embodiment, image data is read out of the CCD **102**, alternately as illustrated in FIG. **8**B and FIG. **8**C. The alternate reading-out causes to change pixel combinations, the camera signal processor **104** is controlled such that color process corresponding to the pixel arrangement is performed. When pixel shifting is performed in the horizontal scan direction, a read-out start position of a horizontal scan image, stored in the enlargement/interpolation/pixel shifting circuit **105** where image signals processed by the camera signal processor **104** are inputted, is varied in accordance with the amount of pixel shifting for vibration correction, and the enlargement and interpolation are performed in an appropriate vertical-horizontal ratio. With regard to shifting an amount less than one pixel (hereinafter referred to as a "decimal fraction section"), the enlargement/interpolation/pixel shifting circuit **105** can perform fine pixel shifting.

Anti-vibration control operation of the image sensing apparatus according to the second embodiment will be described with reference to the flowcharts in FIGS. **16** and **17**.

The flowchart in FIG. **16** shows a process of calculating an angle displacement by integrating the angular velocity signals detected by the angular velocity sensors **107** and **108**. This process is a periodic interruption process executed by the anti-vibration control microcomputer **111**, and executed with a frequency ten times larger than the field frequency, i.e., 600 Hz in a case of the NTSC, in the second embodiment. This frequency corresponds to a sampling frequency of the angular velocity signal i.e., the frequency of the calculated angle displacement. The interruption process of the anti-vibration control microcomputer **111** starts when, for instance, a counter counting up/down at a predetermined frequency dividing of an oscillation clock coincides with data corresponding to $\frac{1}{600}$ sec. Although angular velocity signals are inputted to an A/D converter of the anti-vibration control microcomputer **111** as described in FIG. **14**, for the purpose of simple description of the present embodiment, it is assumed herein that the operation mode of the A/D converter is set in a scan mode in which A/D operation is repeated all the time.

Referring to FIG. **16**, first in step **S301**, angular velocity signals obtained as an A/D sample are subjected to high-pass filtering process so as to remove an influence of DC components. Next in step **S302**, the angular velocity signals, in which band area is limited, are integrated and an angle displacement is calculated. The calculated angle displacement corresponds to the displacement angle of the image sensing apparatus body. The processes performed during steps **S303** and **S305** are the routine for determining whether

or not displacement angle calculation is performed ten times in one field. More specifically, in step **S303**, a register m storing the number of times parameters is incremented by one. In step **S304**, it is determined whether or not m=10 is satisfied. If m=10 is satisfied, i.e., if the interruption process has been performed ten times, m=0 is set in step **S305** and initialization is performed for the next field. Then, the control operation ends.

Meanwhile, if m=10 is not satisfied in step **S304**, i.e., if the interruption process has not been performed ten times, the aforementioned step **S305** is skipped and the control operation ends.

The control steps shown in FIG. **17** are performed once for each processing period of one field. The control steps shown in FIG. **16** are executed ten times in the processing period of one field. The control steps in FIG. **17** are performed before starting the process for the next field, i.e., at the end of the process for the present field.

Referring to FIG. **17**, in step **S401**, determination of m=0 is made until m=0 is satisfied. When m=0 is satisfied, i.e., the interruption process has been performed ten times in the present field and m is initialized, it is determined in the next step **S402** whether or not anti-vibration function is activated based on the state of the switch **112**. If the switch **112** is ON, i.e., anti-vibration function is activated, the calculation process is executed for calculating target position coordinates (V_0, H_0) of the extraction position. Herein, the target position is given by the following equations (1) and (2) with reference to FIG. **18**:

$$V_0 = V_C \pm N_V = V_C \pm (-1) \cdot \frac{f \cdot \tan\theta_P}{L_V} \quad (1)$$

$$H_0 = H_C \pm N_V = H_C \pm (-1) \cdot \frac{f \cdot \tan\theta_Y}{L_H} \quad (2)$$

where V_C and H_C denote vertical and horizontal positions respectively where a reading out starts when the vibration correction is not necessary, θ_P and θ_Y denote displacement angles in pith and yaw directions, respectively, L_V and L_H are vertical and horizontal lengths of the CCD, respectively, and N_V and N_Y are numbers of shifting pixels for correcting displacement angle in the pitch and yaw directions.

H_0 and V_0 obtained by the above equations (1) and (2) are coordinates where the reading-our starts for anti-vibration control, and thus, is expected to have an integer part and a decimal fragment part. The decimal fragment part includes important information for performing the anti-vibration control with maintaining a resolution, and a shift amount represented by the part is less than one pixel. The rough pixel shift control performed by the circuit **105** is achieved by means of reading out of a memory each unit of which corresponds to one pixel. The information included in the decimal fragment part is utilized in the interpolation operation by the circuit **105**, namely the fine pixel shift control.

Reading out of the CCD **102** according to the second embodiment comprises interlaced readings at even number lines and odd number lines which occur every two lines (pixels in the vertical direction). Further, the readings every two pixels are only made for vertical readings but not for horizontal readings of the CCD **102**. Therefore, the fine pixel shifting according to the second embodiment must be different for in the vertical and horizontal directions from each other.

First, the method and scheme for shifting an extraction area and a fine pixel shifting in the vertical direction will be described below. Letting an integer part and decimal part of the shift amount V_0 in the vertical direction as $Int(V_0)$ and $Dec(V_0)$, respectively, the following equation holds:

$$V_0=Int(V_0)+Dec(V_0) \quad (3)$$

Where $Int(V_0)$ is odd number, and $Evn(V_0)$ denotes the greatest even number which does not exceed the number V_0, it holds:

$$V_0=Evn(V_0)+1+Dec(V_0) \quad (4)$$

and where $Int(V_0)$ is an even number, it holds:

$$V_0=Evn(V_0)+Dec(V_0) \quad (5)$$

The second embodiment performs an extraction operation of the image area accompanied with CCD reading-out as illustrated in FIG. **8**B, e.g., and an extraction operation accompanied with CCD reading-out as illustrated in FIG. **8**C. In the second embodiment, while the extraction operates is performed, a fine pixel shifting by less than one pixel is operated in accordance with the value of $Dec(V_0)$ for each pixel.

Described will be the fine pixel shifting in the vertical direction below.

In order to initiate the fine pixel shifting, it is necessary to determine a distribution ratio K between two adjacent pixels in step **S404**. At first, distribution ratio K_V in the vertical direction will be described. In the second embodiment, the distribution ratio in the vertical direction K_V is determined in accordance with $Dec(V_0)$ or $1+Dec(V_0)$, and is determined to be as 1/8 or 7/8.

As set forth above, CCD reading out according to the second embodiment is performed at two pixel pitch. Thus, fine pixel shifting with shift amount of less than one pixel would deteriorate resolution at interpolated pixels because the interpolations are made between two pixels with two pixel distance apart. The second embodiment performs interpolations as illustrated in FIG. **19** in order to achieve both the prevention of unevenness in resolution and high resolution. In FIG. **19**, the vertical axis represent image (pixel position). **500** to **503** represent an image signal (signals obtained by the reading-out as illustrated in FIG. **8**B), **504**–**506** denote image signals with one pixel shift with respect to the signals **500** to **503** (signals obtained by the reading-out as illustrated in FIG. **8**C). **600** to **612** are image signals generated by interpolating the image signals **500** to **508**. The interpolated image **600** is generated by a proportional distribution (ratio 1/8:7/8) of the image data **500** and **502**, and the interpolated image signal **603** is with proportional distribution ratio 7/8:1/8, from image signals **500** and **502**. On the other hand, the interpolated image **604** is generated by a proportional distribution (ratio 1/8:7/8) of the image data **502** and **503**, and the interpolated image signal **608** is with proportional distribution ratio 7/8:1/8, from image signals **502** and **503**.

FIG. **20** illustrates the image signals **502**, **503**, **505**, **506**, **604**, **605**, **606** and **607** extracted from FIG. **19** so that a reason why the uneven resolution is prevented according to the second embodiment is explained.

As seen from FIG. **20**, pixels of the interpolated images (that are output image signals) are apart from each adjacent pixel by ½ pixel distance. In other words, the interpolation image has twice as fine in space resolving power as original images. The image signal **604**, e.g. is generated by proportionally distributing the image signals **502** and **503** with ratio of 1:7, while the image signal **605** is generated by proportionally distributing the image signals **505** and **506** with ratio of 7:1. Thus, a resolution at the pixel **604** is identical with

that at the pixel **606**, and a resolution at the pixel **605** is identical with that at the pixel **606**. Further, a resolution at the pixel **606** is identical with that at the pixel **607**. Accordingly, the pixels **604**, **605**, **606** and **607** are arranged at even intervals in the vertical direction, and exhibit the same resolution. In other words, there are no uneven resolutions between the image signals **604**, **605**, **606** and **607**. More specifically, in the second embodiment, arbitrary two subsequent pixels are converted into four pixels between which there is no uneven resolution. This is because all the interpolated pixels are generated on the basis of the same pair of distribution ratio values (pairs of "1" and "7", or pairs of "⅛" and "⅞").

The subsequent two pixels include a pixel on an even number line and a pixel at an odd number line, as seen from FIGS. **8**B and **8**C. Thus, the value of Int(V_0) obtained from the equation (3) can indicate which should be referenced, pixels on an even number line or odd number line. Further, since the pitch of interpolated pixels is equal to ½ (=0.5) pixel, K_V can be set to ⅛ or ⅞ depending on whether Dec(V_0) is less than or greater than 0.5. As set forth above, the value of V_0−Evn(V_0) can be any value within 0 to 2. Therefore, in order to prevent uneven resolution, it is necessary to determine K_V to be either one of ⅛ or ⅞ by quantization.

FIG. **21** explains a distribution of values of K_V according to the second embodiment, and therefore, how K_V are quantized. In FIG. **21**, **700** denotes a position where an image extraction starts when Dec(V_0) is equal to "0", and points **701** to **704** denote a position where an image extraction starts when Dec(V_0) is unequal to "0". As set forth above, the decimal fragment part V_0−Evn(V_0) of the starting point V_0 can be within the range 0 to 2. Specifically, extraction starting point is coincident with:

point **701** when $0<V_0-Evn(V_0)\leqq 0.5$,

point **702** when $0.5<V_0-Evn(V_0)\leqq 1.0$,

point **703** when $1.0<v_0-Evn(V_0)\leqq 1.5$,

point **704** when $1.5<V_0-Evn(V_0)\leqq 2.0$.

As seen from the comparison of FIGS. **19** and **20**, if $(V_0-Evn(V_0))=0$, start point in the vertical direction is coincident with the point **700**. If $0<V_0-Evn(V_0)\leqq 0.5$, the start point **701** should be quantized into the pixel **600**, therefore, K_V is set to ⅛. In this case, normal image data which are not subjected to one pixel shifting (image data read-out in accordance with the FIG. **8**B timing) are used.

if $(V_0-Evn(V_0))=0$, the start point in the vertical direction is set to be coincident with the point **700**.

If $0<V_0-Evn(V_0)\leqq 0.5$, the start point **701** should be quantized into the pixel **600**, therefore, K_V is set to ⅛. In this case, normal image data which are not subjected to one pixel shifting (image data read-out in accordance with the FIG. **8**B timing) are used.

If $0.5<V_0-Evn(V_0)\leqq 1.0$, the start point **702** should be quantized into the pixel **603**, therefore, K_V is set to ⅞. In this case, normal image data which are not subjected to one pixel shifting (image data read-out in accordance with the FIG. **8**B timing) are used.

If $1.0<V_0-Evn(V_0)\leqq 1.5$, the start point **703** should be quantized into the pixel **602**, therefore, K_V is set to ⅛. In this case, normal image data which are subjected to one pixel shifting (image data read-out in accordance with the FIG. **8**C timing) are used.

If $1.5<V_0-Evn(V_0)\leqq 2.0$, the start point **704** should be quantized into the pixel **605**, therefore, K_V is set to ⅞. In this case, normal image data which are subjected to one pixel shifting (image data read-out in accordance with the FIG. **8***c* timing) are used.

The above describes how K_V is determined in step **S404** according to the second embodiment.

Next, the pixel shifting in the horizontal direction will be explained. As set forth above, reading out of the CCD **102** is performed in accordance with the read out sequence as illustrated in FIG. **8**B or that sequence as illustrated in FIG. **8**C. Such modulation according to the reading out has effects on only the vertical direction. Therefore, in the second embodiment, as for the horizontal direction, the switching control of readings out of CCD is not performed. Specifically, since

$$H_0=Int(H_0)+Dec(H_0) \tag{6}$$

holds, positions of interpolated pixels in the horizontal direction are determined to be intermediate between two adjacent pixels in the horizontal direction in accordance with the value of Dec(H_0). Specifically, if [Dec(H_0)] is an integer which does not exceed Dec (H_0), an interpolated pixel of n-th and (n+1)-th pixels is set at the position which is proportionally distributed in accordance with the ratio:

$$K_H:(1-K_H)$$

where K_H is defined as K_H=[Dec(H_0)].

Returning to the flowchart of FIG. **17**, in step **S404**, pixel shifting ratio data K_V and K_H are determined based on the decimal fraction part of the target position coordinate data expressed by the above-described number of pixels. In practice, pixel-shifting data K_V and K_H may be set to any value from 0 to 1. It is so set that pixel-shifting data K_V or K_H is 1 when the decimal fraction part is 0.

In the next step **S405** which is the process characteristic to the present invention and the details are set forth above. The correction variable data is regenerated so as to achieve constant resolution on the screen. In step **S406**, the target position coordinates (V_0, H_0) calculated in step **S403** are outputted as a command to the CCD driver **106** and the enlargement/interpolation/pixel shifting circuit **105** as the position to be extracted. In addition, the setting of color process of the camera signal processor **104** is changed in accordance with the setting of the extraction position (the camera signal processor **104**, enlargement/interpolation/pixel shifting circuit **105**, and CCD driver **106** operate such that the extraction position is outputted as commanded in the next field). Then, the process returns to step **S401** for processing the next field until integration is performed ten times.

Meanwhile, in the foregoing step **S402**, if the switch **112** is OFF, i.e., anti-vibration function is not activated, the value for pixel shifting is set to 1 in step **S407** (not performing pixel shifting), and a command for extracting the center of the screen and a pixel shifting value set in the foregoing step **S407** are respectively outputted in step **S408**.

Why the distribution ratio according to the second embodiment is set to 7:1 or 1:7 will be explained below.

As illustrated in FIGS. **19** and **20**, the second embodiment interpolates two pixels between two adjacent pixels so that the resolving power may be doubled. The second embodiment necessitates to generate the interpolated pixels so that they may have equally spaced. In order to achieve the double resolving power as well as the equal intervals, an interval between one pixel which is normally transferred (like pixel **502**) and one pixel which is shifted by one-pixel distance (like pixel **506**) have to be divided into divisional ratio 1:2:1. In other words, the interval between two pixels which are displaced from each other by one pixel distance must be divided into four subintervals. In this connection, the a pair

of two pixels (for instance, the pixels **502** and **506**) cannot be read out simultaneously, as shown in FIG. **8**. For this reason, the second embodiment divides into eight (8) subintervals, an interval between two pixels which are spaced by two pixel distance (pairs of pixels each of which are two pixels from the normal image signal, such as pixels **502** and **503**, or pairs of pixels each of which are two pixels from one-pixel-distance-shifted pixel, such as pixels **506** and **507**), and then proportionally divides the interval with ratio ⅛:⅞.

As has been described above, according to the image sensing method and apparatus of the second embodiment, pixel shifting operation is performed in combination with the operation of changing the pixel area normally transferred at one pixel pitch in anti-vibration operation. Each of these operations is controlled appropriately so as to use a predetermined correction position only. This attains the effects of securing a resolution necessary for anti-vibration, keeping the resolution constant on a screen, highly effective anti-vibration, and a stable screen image.

The present invention is not limited to the above embodiments and various changes and modifications can be made within the spirit and scope of the present invention. Therefore, to appraise the public of the scope of the present invention, the following claims are made.

What is claimed is:

1. An image sensing method comprising:

a vibration detecting step of detecting vibration of an image sensing apparatus main body;

a calculating step of calculating a correction variable based on vibration data indicative of the vibration of the image sensing apparatus main body detected in said vibration detecting step;

a control step of controlling a timing of reading an image signal from an image sensing device based on a calculating result of said calculating step;

a delaying step of delaying the read image signal by a predetermined time;

an adding step of adding first pixel data in the read image signal to second pixel data neighboring said first pixel data in the delayed image signal, delayed in said delaying step, in accordance with a predetermined addition ratio based on the calculating result of said calculating step in a moving image recording mode; and

an addition control step of prohibiting addition of said adding step in a still image recording mode;

a recording mode switching step of switching between the moving image recording mode and the still image recording mode;

a moving image recording step of recording the moving image when said recording mode switching step switches to the moving image recording mode, and said adding step adds the read image signal to the delayed image signal delayed in said delaying step in accordance with a predetermined addition ratio based on the calculating result of said calculating step; and

a still image recording step of recording the still image based on the read image signal when said recording mode switching step switches to the still image recording mode, and said adding step does not add the read image signal to the delayed image signal delayed in said delaying step.

2. An image sensing method comprising:

a vibration detecting step of detecting vibration of an image sensing apparatus main body;

a calculating step of calculating a correction variable based on vibration data indicative of the vibration of the image sensing apparatus main body detected in said vibration detecting step;

a control step of controlling a timing of reading an image signal from an image sensing device based on a calculating result of said calculating step;

a delaying step of delaying the read image signal by a predetermined time;

an adding step of adding first pixel data in the read image signal to second pixel data neighboring said first pixel data in the delayed image signal, delayed in said delaying step, in accordance with a predetermined addition ratio based on the calculating result of said calculating step in a moving image recording mode;

an addition control step of controlling the addition ratio, used in said adding step, to 1:0, in a still image recording mode;

a recording mode switching step of switching between the moving image recording mode and the still image recording mode;

a moving image recording step of recording the moving image when said recording mode switching step switches to the moving image recording mode, and said adding step adds the read image signal to the delayed image signal delayed in said delaying step in accordance with a predetermined addition ratio based on the calculating result of said calculating step; and

a still image recording step of recording the still image based on the read image signal when said recording mode switching step switches to the still image recording mode, and said adding step does not add the read image signal to the delayed image signal delayed in said delaying step.

3. An image sensing apparatus comprising;

vibration detecting means for detecting vibration of the image sensing apparatus main body;

calculating means for calculating a correction variable based on vibration data indicative of the vibration of the image sensing apparatus main body detected by said vibration detecting means;

control means for controlling a timing of reading an image signal from an image sensing device based on a calculating result of said calculating means;

delaying means for delaying the read image signal by a predetermined time;

adding means of adding first pixel data in the read image signal to second pixel data neighboring said first pixel data in the delayed image signal, detected by said delaying means, in accordance with a predetermined addition ratio based on the calculating result of said calculating means in a moving image recording mode;

addition control means for prohibiting addition of said adding means in a still image mode recording mode;

recording mode switching means for switching between the moving image recording mode and the still image recording mode;

moving image recording means for recording the moving image when said recording mode switching means switches to the moving image recording mode, and said adding means adds the read image signal to the delayed image signal delayed by said delaying means in accordance with a predetermined addition ratio based on the calculating result of said calculating means; and

still image recording means for recording the still image based on the read image signal when said recording mode switching means switches to the still image recording mode, and said adding means does not add the read image signal to the delayed image signal delayed by the delaying means.

4. The image sensing apparatus according to claim **3**, wherein said vibration detecting means is an angular velocity sensor.

5. An image sensing apparatus comprising;

vibration detecting means for detecting vibration of the image sensing apparatus main body;

calculating means for calculating a correction variable based on vibration data indicative of the vibration of the image sensing apparatus main body detected by said vibration detecting means;

control means for controlling a timing of reading an image signal from an image sensing device based on a calculating result of said calculating means;

delaying means for delaying the read image signal by a predetermined time;

adding means of adding first pixel data in the read image signal to second pixel data neighboring said first pixel data in the delayed image signal, detected by said delaying means, in accordance with a predetermined addition ratio based on the calculating result of said calculating means in a moving image recording mode;

addition ratio control means for controlling the addition ratio, used by said adding means, to 1:0, in a still image recording mode;

recording mode switching means for switching between the moving image recording mode and the still image recording mode;

moving image recording means for recording the moving image when said recording mode switching means switches to the moving image recording mode, and said adding means adds the read image signal to the delayed image signal delayed by said delaying means in accordance with a predetermined addition ratio based on the calculating result of said calculating means; and

still image recording means for recording the still image based on the read image signal when said recording mode switching means switches to the still image recording mode, and said adding means does not add the read image signal to the delayed image signal delayed by the delaying means.

6. The image sensing apparatus according to claim **5**, wherein said vibration detecting means is an angular velocity sensor.

7. A storage medium storing a control program for controlling an image sensing apparatus, said control program having control modules comprising the steps of:

detecting vibration of an image sensing apparatus main body;

calculating a correction variable based on vibration data indicative of the vibration of the image sensing apparatus main body detected in said vibration detecting step;

controlling a timing of reading an image signal from an image sensing device based on a calculating result of said calculating step;

delaying the read image signal by a predetermined time;

adding first pixel data in the read image signal to second pixel data neighboring said first pixel data in the delayed image signal, delayed in said delaying step, in accordance with a predetermined addition ratio based on the calculating result of said calculating step in a moving image recording mode;

controlling to prohibit the adding step in a still image recording mode;

switching between the moving image recording mode and the still image recording mode;

recording the moving image when said recording mode switching step switches to the moving image recording mode, and said adding step adds the read image signal to the delayed image signal delayed in said delaying step in accordance with a predetermined addition ratio based on the calculating result of said calculating step; and

recording the still image based on the read image signal when said recording mode switching step switches to the still image recording mode, and said adding step does not add the read image signal to the delayed image signal delayed in said delaying step.

8. A storage medium storing a control program for controlling an image sensing apparatus, said control program having control modules comprising the steps of:

detecting vibration of an image sensing apparatus main body;

calculating a correction variable based on vibration data indicative of the vibration of the image sensing apparatus main body detected in said vibration detecting step;

controlling a timing of reading an image signal from an image sensing device based on a calculating result of said calculating step;

delaying the read image signal by a predetermined time;

adding first pixel data in the read image signal to second pixel data neighboring said first pixel data in the delayed image signal, delayed in said delaying step, in accordance with a predetermined addition ratio based on the calculating result of said calculating step in a moving image recording mode;

controlling an addition ratio to 1:0 in a still image recording mode;

switching between the moving image recording mode and the still image recording mode;

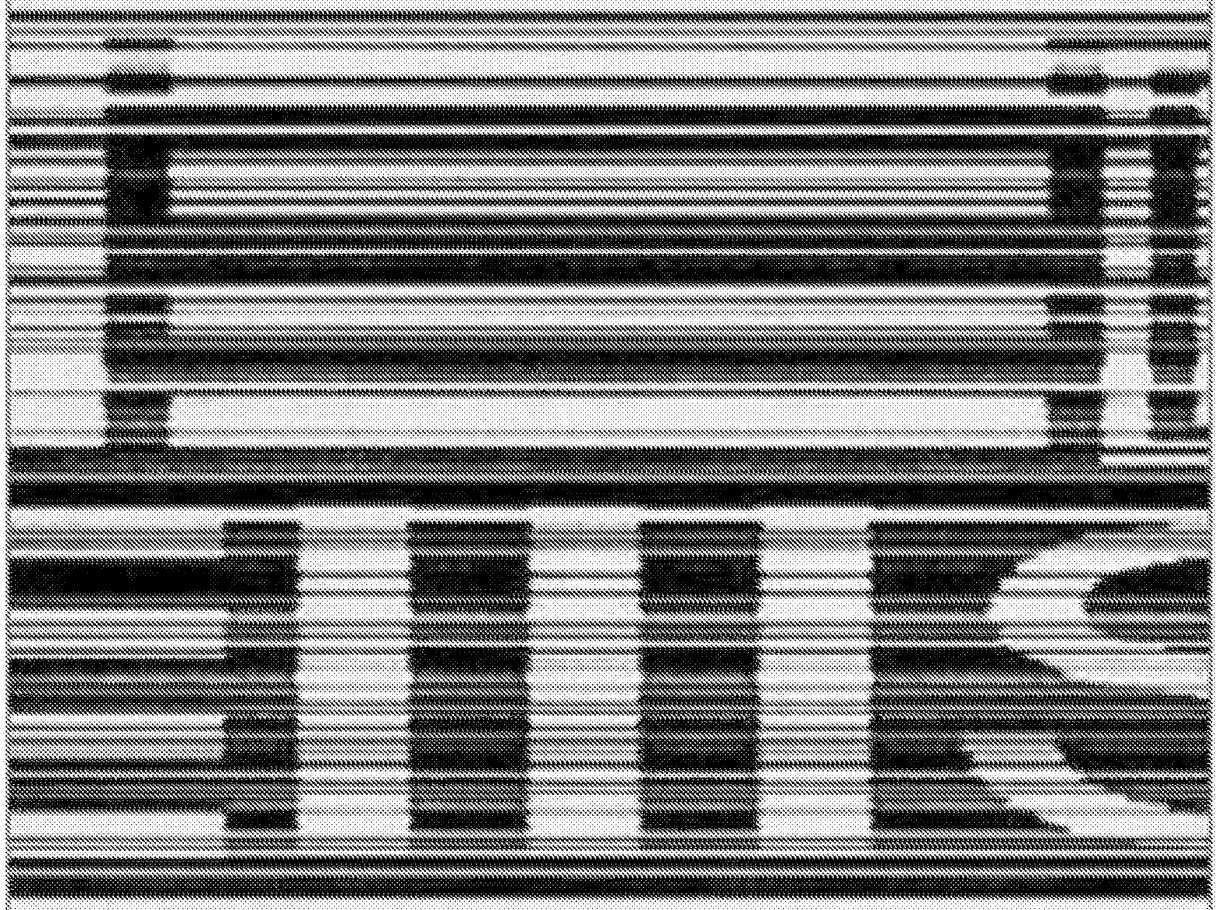
recording the moving image when said recording mode switching step switches to the moving image recording mode, and said adding step adds the read image signal to the delayed image signal delayed in said delaying step in accordance with a predetermined addition ratio based on the calculating result of said calculating step; and

recording the still image based on the read image signal when said recording mode switching step switches to the still image recording mode, and said adding step does not add the read image signal to the delayed image signal delayed in said delaying step.

* * * * *

EXHIBIT 1018

CCD ARRAYS CAMERAS and DISPLAYS



Gerald C. Holst

CCD ARRAYS, CAMERAS, and DISPLAYS

Second edition

Gerald C. Holst

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The second edition is dedicated to

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PREFACE to the SECOND EDITION

The first edition was published in January 1996. The response was overwhelming and it sold out in two years. Rather than reprint that edition, it was important to update the information. After all, technology moves rapidly. The first edition also had some typographic errors. I thank those who were gracious enough to point them out to me. Those errors have been corrected.

One major change is that "CCD array" was changed to "solid state array" throughout the text. This change allows flexibility in sensor type (e.g., CCD, CID, and CMOS). As new sensors enter the market place, the appropriate chapters in this book are still applicable. Camera operation is nearly independent of the specific sensor. The book title remains the same because of the preponderance of CCD arrays. Chapters 2, 5, 7, 11, and 12 are essentially the same. The reference lists have been updated and they now include books and journal articles published in 1996 and 1997.

Calling a sample a pixel does not seem bad. But "pixel" is used to denote a detector, an element of a computer stored data array, and the primary element of a monitor. Unfortunately, there is no *a priori* relationship between the various device pixels. As indicated in Chapter 1, the various samples are called pixels, datels, and disels. This clarifies the relationship between what the detector array produces and what is presented on the monitor. The general assumption is that there is a one-to-one relationship between these elements - but there is no requirement that this be so.

Chapter 3 was renamed *Solid State Arrays*. Both CID and CMOS detector technologies have been added. Photodiodes require transfer gates to move the stored charge into the CCD transfer register. Although these gates were not shown in the first edition, their inclusion provides further understanding of how the detectors operate. The antibloom drain section was expanded and its action as an electronic shutter is described. Dark current reduction, so important for low illumination imaging, is explained in more detail.

In Chapter 4, additional factors that affect the spectral responsivity are given. Although dynamic range would seem to be a straight forward concept, it has numerous definitions. Manufacturers specify minimum and maximum illumination levels as either scene illumination or faceplate illumination (Chapter

6). Since the manufacturer has no control over the user's selection of lenses, the faceplate illumination is more popular. Minimum illumination may create a full video signal or some lower value (e.g., 30, 50, or 80% video). Numerical examples illustrate the differences. The signal-to-noise section has been expanded.

An electronic imaging system has two major components: that which responds to scene variations (detector, optics, and the observer) and that which responds to time varying signals (electronics and display). To better describe the two concepts, "MTF theory" was renamed "linear system theory" in Chapters 8 and 9. This makes the approach more general and the nomenclature associated with Fourier transforms has been clarified.

In keeping with the various diverse components of a solid state camera, MTF analysis is possible in four different spatial frequency domains. These domains are related by simple equations (Chapter 10). A primary consideration in system design is the relationship between the optical resolution and the detector response. A camera may be either detector-limited or optics-limited. The transition from one to the other has a profound effect on imagery. More detail can be found in *Sampling, Aliasing, and Data Fidelity*, G. C. Holst, JCD Publishing (1998).

February 1998 Gerald C. Holst

PREFACE to the FIRST EDITION

Charge-coupled devices (CCDs) were invented by Boyle and Smith in 1970. CCDs have matured to the point where they are widely affordable and have spawned an explosion of applications. Some applications include high definition television for program production, consumer camcorders, electronic still cameras, industrial machine vision cameras, and optical character readers including bar code scanners and fax machines. Applications are only limited by man's imagination.

Linear and time-delay-and-integrate (TDI) sensors are appropriate for applications where the objects are continuously moving as in the lumber, paper, textile, steel, and aluminum forming industries. These sensors provide non-contact measurement during fabrication as well as information that allows analysis of surface conditions.

The CCD architecture has three basic functions: (a) charge collection, (b) charge transfer, and (c) the conversion of charge into a measurable voltage. Since most sensors operating in the visible region use CCD architecture to read the signal, they are popularly called CCD cameras. For these devices, charge generation is often considered as the initial function of the CCD.

Although silicon CCDs respond from 10^{-4} μm to 1.1 μm, only imaging applications in the visible and near infrared are considered here. The long wavelength response may be limited by the semiconductor band gap (equivalent to 1.1 μm for silicon), diffusion length (photoelectrons recombine with holes before reaching a charge well), or infrared blocking filter (limits the response to the visible region). The short wavelength response may be limited by the polysilicon electrode transmittance (opaque below 0.4 μm) or a glass protective cover (opaque below about 0.3 μm).

This book is not a design book. It highlights those features and specifications that are most often reported in data sheets. It provides the necessary information to compare and analyze camera systems. The material in this book is representative of solid state camera operation and architecture. A specific device may not have all the features listed or may have additional features not listed.

Arrays and cameras may be specified by radiometric or photometric units (Chapter 2). Emphasis is placed on the relationship between the spectral content of the lighting compared to the sensor's spectral response. CCD array operation is described in Chapter 3 and array specifications (performance parameters) are described in Chapter 4. Array specifications, capabilities, and limitations affect

the overall camera specifications. The camera manufacturer cannot increase the inherent signal-to-noise ratio of the array. He strives to maintain the array specifications without introducing additional noise or adversely affecting image quality. In Chapters 5 and 6, camera operation and specifications are related to the array values.

A camera is of no use by itself. Its value is only known when an image is evaluated. Therefore, the observer is a critical component of the imaging system. While the camera manufacturer strives to provide the highest possible resolution, he has no control over the display used. It is up to the end-user to select an adequate display. There is no advantage to using a high quality camera if the display cannot faithfully reproduce the image. Flat panel displays are an emerging technology but cathode ray tubes (CRT) will probably dominate the display market due to low cost, high resolution, wide color gamut, and long life. Chapter 7 discusses CRT-based display performance metrics.

Staring arrays are inherently undersampled. The highest spatial frequency that can be faithfully reproduced is the Nyquist frequency (Chapter 8). Many performance parameters are evaluated at the Nyquist frequency. The selection of Nyquist frequency is for convenience. Spatial frequencies above Nyquist frequency do not disappear. They are just distorted. Spatial sampling creates ambiguity in target edge location and produces moiré patterns when periodic targets are viewed.

Most of the chapters discuss imaging system phenomenology with minimal mathematics. Many examples are included to illustrate basic principles and back-of-the-envelope calculations. Detailed math is found in Chapters 9 and 10 (*MTF Theory* and *System MTF*).

Many image quality metrics are linked to the system's modulation transfer function (MTF) and therefore are listed in Chapter 11. Image quality, as specified in this book, does not include data compression effects, image processing, or machine vision algorithms since these are nonlinear operators. These processes can only be evaluated on a case-by-cases basis. As digital image processing capability is incorporated into cameras, they may be called sensors with built-in computers.

The military is interested in detecting, recognizing, and identifying targets at long distances, and the minimum resolvable contrast (MRC) is an appropriate figure of merit (Chapter 12). The MRC is a system performance metric that includes both resolution (via the MTF) and sensitivity measures. It is a measure of an observer's ability to detect a bar target embedded in noise.

Although this book is titled *CCD Arrays, Cameras, and Displays*, nearly all of the concepts apply to every staring array including charge injection devices (CIDs) and active pixels sensors (APS). The electronics cannot "know" what created the signal nor the spectral content associated with the signal. Similarly, without prior training, the observer will not know what sensor was used to collect the imagery. The MTFs are generic.

Emphasis is placed upon monochrome systems. Color camera design is quite complex and represents a separate book. As such, the topics on color systems are cursory. Chapter 3 introduces basic color array operation and Chapter 5 provides some aspects of color cameras. The literature is rich with visual data on which color camera operation is based. See, for example, J. Peddie, *High-Resolution Graphics Display Systems*, Chapter 2, Windcrest/McGraw-Hill, New York, NY (1993) or A. R. Robertson and J. F. Fisher "Color Vision, Representation, and Reproduction," in *Television Engineering Handbook*, K. B. Benson, ed., Chapter 2, McGraw Hill, New York, NY (1985).

This book is for the first time CCD buyer. It explains the basic operating concepts and what the specifications represent. The book is also for the experienced buyer for it provides the background material necessary to specify cameras. The electro-optical system analyst will use the MTF and MRC theory to describe performance. For the system integrator, it provides information on the entire system: scene-to-observer. For the manager, purchasing agent, and salesperson, it is a handy reference.

The author extends his deepest gratitude to all his coworkers and students who have contributed to the ideas in this book. They are too many to mention by name. The author especially thanks all those who read draft copies of the manuscript: Constantine Anagnostopoulos, Eastman Kodak; Peter Barten, Barten Consultancy; Mike Ensminger, Ball Aerospace; Chris Fritz, Texas Instruments; Paul Gallagher, EG&G Reticon; Ron Hamilton, Cohu; Richard Hofmeister, Pulnix; Herb Huey, Northrop; Lindon Lewis, Ball Aerospace; Terry Lomheim, The Aerospace Corporation; Hugh Masterson, Mitre Corporation; Ishai Nir, Princeton Instruments; Harold Orlando, Northrop; Mike Pappas, Northrop; Kenneth Parulski, Eastman Kodak; Mike Roggemann, Air Force Institute of Technology; Luke Scott, NV&ESD; Mark Sartor, Xybion; and Mark Stafford, Dalsa. Although these reviewers provided valuable comments, the accuracy of the text is the sole responsibility of the author. Jeff Odhner and Steve Kraemer provided the graphic arts.

February 1996 Gerald C. Holst

CCD ARRAYS, CAMERAS, and DISPLAYS

Second edition

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SYMBOL LIST

SYMBOL	DEFINITION	UNITS
α_{ABS}	spectrally averaged absorption coefficient	1/m
$\alpha_{ABS}(\lambda)$	spectral absorption coefficient	1/m
α_G	dark current factor	numeric
α_{ERROR}	target displacement in TDI systems	mm
α_m	display aspect ratio	numeric
β_1	eye filter 1	1/electrons^2
β_m	eye filter m	1/electrons^2
γ	gamma	numeric
ΔV	TDI velocity error	mm/s
$\Delta\lambda$	wavelength interval	μm
$\Delta\rho$	target-background reflectance difference	numeric
Δf_e	noise equivalent bandwidth	Hz
$\Delta n_{MINIMUM}$	minimum number of photoelectrons	numeric
Δn_{pe}	target-background photoelectron difference	numeric
Δt	time separation between two pulses	s
ϵ	charge transfer efficiency	numeric
η	quantum efficiency	numeric
$\eta_{CATHODE}$	intensifier photocathode quantum efficiency	numeric
η_{CCD}	CCD quantum efficiency	numeric
$\eta_{PHOTOCATHODE}$	intensifier photocathode quantum efficiency	numeric
η_{SCREEN}	intensifier screen quantum efficiency	numeric
λ	wavelength	μm
λ_{AVE}	average wavelength	μm
λ_{MAX}	maximum wavelength	μm
λ_{MIN}	minimum wavelength	μm
λ_O	selected wavelength	μm
λ_p	wavelength of peak response	μm
ρ	spectrally averaged reflectance	numeric
$\rho(\lambda)$	spectral reflectance	numeric
ρ_B	background reflectance	numeric
ρ_T	target reflectance	numeric
σ_{ATM}	atmospheric absorption	1/m
σ_H	component of three-dimensional noise model	rms
σ_{HV}	component of three-dimensional noise model	rms
σ_{IIT}	image intensifier tube 1/e spot size	mm

σ_{IS}	display 1/e spot size in image space	mm
σ_R	rms value of random motion	rms mm
σ_{SPOT}	display spot 1/e intensity size	mm
σ_T	component of three-dimensional noise model	rms
σ_{TH}	component of three-dimensional noise model	rms
σ_{TVH}	component of three-dimensional noise model	rms
σ_V	component of three-dimensional noise model	rms
$\Phi_{CATHODE}$	flux incident onto to intensifier photocathode	W
Φ_V	luminous flux	lumens
a_L	distance target has moved on detector	mm
$A_{CATHODE}$	area of photocathode	m^2
A_D	detector area	m^2
A_I	area of source in image plane	m^2
A_O	lens area	m^2
A_{PIXEL}	projected CCD pixel on intensifier photocathode	m^2
A_S	source area	m^2
c	speed of light, $c = 3 \times 10^8$	m/s
c_1	first radiation constant $c_1 = 3.7418 \times 10^8$	W-$\mu m^4/m^2$
c_2	second radiation constant $c_2 = 1.4388 \times 10^4$	μm-K
c_3	third radiation constant $c_3 = 1.88365 \times 10^{27}$	photons-μm^3/s-m^2
C	sense node capacitance	farad
C_O	target's inherent contrast	numeric
C_R	target's contrast at entrance aperture	numeric
CTE	charge transfer efficiency	numeric
d	detector width	mm
d_{CC}	detector pitch	mm
d_{CCH}	horizontal detector pitch	mm
d_{CCV}	vertical detector pitch	mm
d_H	horizontal detector size	mm
d_O	selected target dimension	mm
d_T	target detail	mm
d_V	vertical detector size	mm
D	observer to display distance	m
D_O	optical diameter	mm
DAS_H	horizontal detector angular subtense	mrad
DAS_V	vertical detector angular subtense	mrad
E_G	detector band gap	eV
E_T	impurity band gap	eV
f_{2D}	two-dimensional spatial frequency	cycles/mrad
f_{BOOST}	boost frequency	Hz
f_c	cutoff frequency of an ideal circuit	Hz
f_{CLOCK}	pixel clock rate	Hz
f_{DC}	detector cutoff frequency	cycles/mm
f_{e3dB}	one-half power frequency	Hz
f_e	electrical frequency	Hz

f_{EYE}	spatial frequency at eye	cycles/deg
f_i	image spatial frequency	cycles/mm
f_N	Nyquist frequency	cycles/mm
f_o	selected spatial frequency	cycles/mm
f_{OC}	optics cutoff frequency	cycles/mm
f_{PEAK}	peak frequency of eye MTF	cycles/deg
f_{RASTER}	raster frequency	cycles/mm
f_S	sampling frequency	cycles/mm
f_v	electrical frequency in the video domain	Hz
f_{v3dB}	one-half power frequency (video domain)	Hz
f_{vN}	Nyquist frequency in the video domain	Hz
f_{vS}	sampling frequency in the video domain	Hz
f_x	horizontal spatial frequency	cycles/mm
f_y	vertical spatial frequency	cycles/mm
fl	focal length	m
F	f-number	numeric
F_{MAX}	maximum frame rate	Hz
F_R	frame rate	Hz
G	on-chip amplifier gain	numeric
G_1	off-chip amplifier gain	numeric
G_{MCP}	microchannel gain	numeric
h	Planck's constant, $h = 6.626 \times 10^{-34}$	J-s
h_c	target critical dimension	m
H	target height	m
$H_{MONITOR}$	monitor height	m
HFOV	horizontal field-of-view	mrad
J_D	dark current density	A/cm^2
k	Boltzmann's constant, $k = 1.38 \times 10^{-23}$	J/K
k_1	a constant	numeric
$K_H(f)$	horizontal summary noise factor	
K_M	luminous efficacy, $K_M = 683$ (photopic)	lumens/W
k_{MCP}	microchannel excess noise	numeric
$K_V(f)$	vertical summary noise factor	
L_B	background luminance	$lumen/m^2\text{-}sr$
L_D	Depletion length	μm
L_{DIFF}	Diffusion length	μm
L_e	spectral radiant sterance	$W/(m^2\text{-}\mu m\text{-}sr)$
L_q	spectral photon sterance	$photons/(s\text{-}m^2\text{-}\mu m\text{-}sr)$
L_T	target luminance	$lumen/m^2\text{-}sr$
m	index	numeric
M_e	spectral radiant exitance	$W/(m^2\text{-}\mu m)$
M_{OPTICS}	optical magnification	numeric
$M_P(\lambda)$	spectral power	$W/\mu m$
M_q	spectral photon exitance	$photons/(s\text{-}m^2\text{-}\mu m)$

n	index	numeric
$n_{CATHODE}$	photons incident onto intensifier photocathode	numeric
n_{DARK}	number of dark electrons	numeric
$n_{DETECTOR}$	number of photons incident onto detector	numeric
n_e	number of electrons	numeric
n_{EYE}	number of photons incident onto eye	numeric
n_{IMAGE}	number of photons incident onto image plane	numeric
n_{LENS}	number of photons incident onto lens	numeric
n_{MCP}	number of photons incident on microchannel plate	numeric
n_{pe}	number of photoelectrons	numeric
$n_{pe\text{-}B}$	background photoelectrons	numeric
$n_{pe\text{-}T}$	target photoelectrons	numeric
$n_{PHOTON\text{-}CCD}$	number on photons incident onto CCD	numeric
n_{READ}	pixels between active array and sense node	numeric
n_{SCREEN}	photons incident onto intensifier screen	numeric
n_{WINDOW}	number of photons incident onto intensifier	numeric
N	index	numeric
N_{50}	Johnson's 50% probability	cycles
$N_{DETECTORS}$	total number of detectors	numeric
N_H	number of horizontal detectors	numeric
N_{LINE}	number of raster lines	numeric
N_T	equivalent number of cycles on target	cycles
N_{TDI}	number of TDI elements	numeric
N_{TRANS}	number of charge transfers	numeric
N_{TV}	display resolution	TVL/PH
N_V	number of vertical detectors	numeric
N_{WELL}	charge well capacity	numeric
P	display line spacing or pixel spacing	mm/line
PAS_H	horizontal pixel angular subtense	mrad
PAS_V	vertical pixel angular subtense	mrad
q	electron charge, $q = 1.6 \times 10^{-19}$	coul
R	range to target	m
R_1	distance from lens to source	m
R_2	distance from lens to detector	m
R_{AVE}	spectral averaged responsivity	$V/(\mu J\text{-}cm^{-2})$ or $DN/(\mu J\text{-}cm^{-2})$
R_e	average spectral responsivity	A/W
$R_e(\lambda)$	spectral responsivity	A/W
R_P	peak responsivity	A/W
$R_{PHOTOMETRIC}$	responsivity	V/lux
R_q	spectrally averaged quantum efficiency	numeric
$R_q(\lambda)$	spectral quantum efficiency	numeric
R_R	raster resolution	lines/mm
R_{TVL}	horizontal display resolution	TVL/PH
R_V	responsivity	A/lumen
$R_{VERTICAL}$	vertical display resolution	lines
S	display spot size (FWHM intensity)	mm

t_{ARRAY}	time to clock out the full array	s
t_{CLOCK}	time between pixels	s
t_e	eye integration time	s
$t_{H\text{-}LINE}$	time to read one pixel line	s
t_{INT}	integration time	s
t_{LINE}	video active line time	s
T	absolute temperature	Kelvin
T/#	T-number	numeric
T_{ASPECT}	target aspect ratio	numeric
T_{ATM}	spectrally averaged atmospheric transmittance	numeric
$T_{ATM}(\lambda)$	spectral atmospheric transmittance	numeric
T_{fo}	fiber optic bundle transmittance	numeric
T_{illum}	absolute temperature of illuminating source	K
$T_{IR\text{-}FILTER}$	spectrally averaged transmittance of IR filter	numeric
T_{OPTICS}	spectrally averaged optical transmittance	numeric
$T_{OPTICS}(\lambda)$	spectral optical transmittance	numeric
$T_{RELAY\ LENS}$	relay lens transmittance	numeric
T_{WINDOW}	transmittance of intensifier window	numeric
u_d	horizontal spatial frequency (display space)	cycles/mm
u_i	horizontal spatial frequency (image space)	cycles/mm
u_{iC}	horizontal optical cutoff (image space)	cycles/mm
u_{iD}	horizontal detector cutoff (image space)	cycles/mm
u_{iN}	horizontal Nyquist frequency (image space)	cycles/mm
u_{ob}	horizontal spatial frequency (object space)	cycles/mm
U	photoresponse nonuniformity	numeric
v_d	vertical spatial frequency (display space)	cycles/mm
v_i	vertical spatial frequency (image space)	cycles/mm
v_{iD}	vertical detector cutoff (image space)	cycles/mm
v_{iN}	vertical Nyquist frequency (image space)	cycles/mm
$V(\lambda)$	photopic or scotopic eye response	numeric
V_{CAMERA}	camera output voltage	V
V_{GRID}	voltage on CRT grid	V
V_{LSB}	voltage of the least significant bit	V
V_{MAX}	maximum signal	numeric
V_{MIN}	minimum signal	numeric
V_{NOISE}	noise voltage after on-chip amplifier	V rms
V_{OUT}	voltage after on-chip amplifier	V
V_R	viewing ratio	numeric
V_{RESET}	reset voltage after on-chip amplifier	V
V_{SCENE}	video voltage before gamma corrector	V
V_{SIGNAL}	signal voltage after on-chip amplifier	V
V_{VIDEO}	video voltage after gamma corrector	V
VFOV	vertical field-of-view	mrad
W	target width	m
$W_{MONITOR}$	monitor width	m
x	horizontal distance	m
y	vertical distance	m

$\langle n_1 \rangle$	noise source 1	rms electrons
$\langle n_{ADC} \rangle$	quantization noise	rms electrons
$\langle n_{CCD\text{-}DARK} \rangle$	dark current CCD noise in an ICCD	rms electrons
$\langle n_{CCD\text{-}PHOTON} \rangle$	noise before CCD in an ICCD	rms electrons
$\langle n_{CCD} \rangle$	CCD noise in an ICCD	electrons rms
$\langle n_{DARK} \rangle$	dark current shot noise	rms electrons
$\langle n_{FLOOR} \rangle$	noise floor	rms electrons
$\langle n_{FPN} \rangle$	fixed pattern noise	rms electrons
$\langle n_{MCP} \rangle$	microchannel noise	rms electrons
$\langle n_m \rangle$	noise source m	rms electrons
$\langle n_{OFF\text{-}CHIP} \rangle$	off-chip amplifier noise	rms electrons
$\langle n_{ON\text{-}CHIP} \rangle$	on-chip amplifier noise	rms electrons
$\langle n_{PATTERN} \rangle$	pattern noise	rms electrons
$\langle n_{PC\text{-}DARK} \rangle$	intensifier dark current shot noise	rms electrons
$\langle n_{PC\text{-}SHOT} \rangle$	intensifier photon shot noise	rms electrons
$\langle n_{pe} \rangle$	photon shot noise	rms electrons
$\langle n_{PRNU} \rangle$	photoresponse nonuniformity noise	rms electrons
$\langle n_{RESET} \rangle$	reset noise	rms electrons
$\langle n_{SCREEN} \rangle$	intensifier screen noise	rms electrons
$\langle n_{SHOT} \rangle$	shot noise	rms electrons
$\langle n_{SYS} \rangle$	system noise	rms electrons
$\langle V_N \rangle$	noise voltage	rms V

1

INTRODUCTION

Charge-coupled devices (CCDs) were invented by Boyle and Smith[1,2] in 1970. Since then, considerable literature[3-7] has been written on CCD physics, fabrication, and operation. However, the array does not create an image by itself. It requires an optical system to image the scene onto the array's photosensitive area. The array requires a bias and clock signals. Its output is a series of analog pulses that represent the scene intensity at a series of discrete locations.

Devices may be described functionally according to their architecture (frame transfer, interline transfer, etc.) or by application. Certain architectures lend themselves to specific applications. For example, astronomical cameras typically use full frame arrays whereas consumer video systems use interline transfer devices.

The heart of the solid state camera is the solid state array. It provides the conversion of light intensity into measurable voltage signals. With appropriate timing signals, the temporal voltage signal represents spatial light intensities. When the array output is amplified and formatted into a standard video format, a solid state camera is created. Because CCDs were the first solid state detectors, cameras are popularly called CCD cameras even though they may contain charge injection devices (CIDs) or complementary metal-oxide-semiconductors (CMOS) as detectors. These are solid state cameras.

The array specifications, while the first place to start an analysis, are only part of the overall system performance. The system image quality depends on all the components. Array specifications, capabilities, and limitations are the basis for the camera specifications. Camera manufacturers cannot change these. A well-designed camera will not introduce additional noise nor adversely affect image quality provided by the array.

A camera is of no use by itself. Its value is only known when an image is evaluated. The camera output may be directly displayed on a monitor, stored on video tape or disk for later viewing, or processed by a computer. The computer may be part of a machine vision system, be used to enhance the imagery, or be used to create hard copies of the imagery. If interpretation of image quality is performed by an observer, then the observer becomes a critical component of

the imaging system. Consideration of human visual system attributes should probably be the starting point of the camera design. But some machine vision systems may not create a "user friendly" image. These systems are designed from a traditional approach: resolution, high signal-to-noise ratio, and ease of operation.

Effective camera design requires an orderly integration of diverse technologies and languages associated with radiation physics, optics, solid state sensors, electronic circuitry, and image processing algorithms. Each field is complex and is a separate discipline.

Electro-optical imaging system analysis is a mathematical construct that provides an optimum design through appropriate tradeoff analyses. A comprehensive model includes the target, background, the properties of the intervening atmosphere, the optical system, detector, electronics, display, and the human interpretation of the displayed information. While any of these components can be studied in detail separately, the electro-optical imaging system cannot. Only complete end-to-end analysis (scene-to-observer interpretation) permits system optimization.

1.1. SOLID STATE DETECTORS

CCD refers to a semiconductor architecture in which charge is read out of storage areas. The CCD architecture has three basic functions: (a) charge collection, (b) charge transfer, and (c) the conversion of charge into a measurable voltage. The basic building block of the CCD is the metal-oxide-semiconductor (MOS) capacitor. The capacitor is called a gate. By manipulating the gate voltages, charge can be either stored or transferred. Charge generation in most devices occurs under a MOS capacitor (also called a photogate). For some devices (notably interline transfer devices) photodiodes create the charge. After charge generation, the transfer occurs in the MOS capacitors for all devices.

Because most sensors operating in the visible region use a CCD type architecture to read the signal, they are popularly called CCD cameras. For these devices, charge generation is often considered as the initial function of the CCD. More explicitly, these cameras should be called *solid state cameras with a CCD readout*.

CCDs and detectors can be integrated either monolithically or as hybrids. Monolithic arrays combine the detector and CCD structure on a single chip. The most common detectors are sensitive in the visible region of the spectrum. They use silicon photogates or photodiodes and are monolithic devices. CCDs have been successfully used for infrared detectors such as Schottky barrier devices that are sensitive to 1.2 μm to 5 μm radiation.

Hybrid arrays avoid some pitfalls associated with growing different materials on a single chip and provide a convenient bridge between well-developed but otherwise incompatible technologies. HgCdTe (sensitive to 8 to 12 μm radiation) is bump bonded to a CCD readout using indium as the contact and, as such, is a hybrid array.

With charge-injection devices (CID), the pixels consist of two MOS capacitors whose gates are separately connected to rows and columns. Usually the column capacitors are used to integrate charge while the row capacitors sense the charge after integration. With the CID architecture, each pixel is addressable, i.e., it is a matrix-addressable device.

CID readout is accomplished by transferring the integrated charge from the column capacitors to the row capacitors. After this nondestructive signal readout, the charge moves back to the columns for more integration or is injected (discarded) back into the silicon substrate. By suspending charge injection, the user initiates "multiple frame integration" (time lapse exposure) and can view the image on a display as the optimum exposure develops. Integration may proceed for a few milliseconds up to several hours. With individual capacitors on each sensing pixel, blooming is not transported so overloads cannot propagate.

Recently, active pixels have been introduced. These devices are fabricated with complementary-metal-oxide-semiconductor (CMOS) technology. The advantage is that one or more active transistors can be integrated into the pixel. As such, they become fully addressable (can read selected pixels) and can perform on-chip image processing.

1.2. IMAGING SYSTEM APPLICATIONS

There are four broad applications: general imagery (which includes both professional television broadcast and consumer camcorder systems), machine vision, scientific, and military. Trying to appeal to all four applications, manufacturers use words such as low noise, high frame rate, high resolution,

reduced aliasing, and high sensitivity. These words are simply adjectives with no specific meaning. They only become meaningful when compared (i.e., camera A has low noise compared to camera B).

Table 1-1 lists several design categories. While the requirements vary by category, a camera may be used for multiple applications. For example, a consumer video camera often is adequate for many scientific experiments. A specific device may not have all the features listed or may have additional features not listed. The separation between professional broadcast, consumer video, machine vision, scientific, and military devices becomes fuzzy as technology advances.

Color cameras are used for professional television, camcorder, and film replacement systems. With machine vision systems, color cameras are used to verify the color consistency of objects such as printed labels or paint mixture colors. While color may not be the primary concern, it may be necessary for image analysis when color is the only information to distinguish boundaries.

While consumers demand color camera systems, this is not true for other applications. Depending on the application, monochrome (black and white) cameras may be adequate. A monochrome camera has higher sensitivity and therefore is the camera of choice in low light level conditions.

Image enhancement applies to those systems that have a human observer and helps the observer extract data. Some images belong to a small precious data set (e.g., remote sensing imagery from interplanetary probes). The images must be processed repeatedly to extract every piece of information. Some images are part of a data stream that are examined once (e.g., real-time video) and others have become popular and are used routinely as standards. These include the three-bar or four-bar test patterns, Lena, and the African mandrill.

The camera cannot perfectly reproduce the scene. The array spatially samples the image, and noise is injected by the array electronics. Spatial sampling creates ambiguity in target edge location and produces moiré patterns when viewing periodic targets. While this is a concern to scientific and military applications, it typically is of little consequence to the average professional television broadcast and consumer markets.

Table 1-1
DESIGN GOALS

DESIGN CATEGORY	GENERAL IMAGERY	MACHINE VISION	SCIENTIFIC	MILITARY
Image processing algorithms	Gamma correction	Application specific	Menu-driven multiple options	Application specific
Image processing time	Real time	Application specific with emphasis on high speed operation	Real time not usually required	Real time
Resolution	Matched to video format (e.g., EIA 170)	For a fixed field-of-view, increased resolution is desired	High resolution	High resolution
Dynamic range	8 bits/color	8 bits/color	Up to 16 bits	10 or 12 bits
Sensitivity (high signal-to-noise ratio)	High contrast targets (noise not necessarily a dominant design factor)	Application specific - not necessarily an issue because lighting can be controlled	Low noise operation	Low noise operation

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Table 1-1 listed several design goals by application category. To some extent these goals are incompatible, thereby dictating design compromises. The demand for machine vision systems is increasing dramatically. Smaller target detail can be discerned with magnifying optics. However, this reduces the field-of-view. For a fixed field-of-view, higher resolution (more pixels) cameras are required to discern finer detail. When selecting an imaging system, the environment, camera, data storage, and final image format must be considered (Table 1-2).

Table 1-2
SYSTEM DESIGN CONSIDERATIONS

ENVIRONMENT	CAMERA	TRANSMISSION and STORAGE	DISPLAY
Target size Target reflectance Distance to target Atmospheric transmittance Lighting conditions	Noise Frame rate Sensitivity Detector size Array format Dynamic range Color capability	Data rate Type of storage Storage capacity Video compression	Hard copy Soft copy Resolution

Finally, the most convincing evidence of system performance is a photograph of an image. Every time an image is transferred to another device, that device's tonal transfer and modulation transfer function will affect the displayed image. Video recorders degrade resolution. Imagery may look slightly different on different displays. Similarly, hard copies produced by different printers may appear different, and there is no guarantee that the hard copy will look the same as the soft copy in every respect. Hard copies should only be considered as representative of system capability. Even with its over 100-year history, wet film developing and printing must be controlled with extreme care to create "identical" prints.

1.2.1. GENERAL IMAGERY

Cameras for the professional broadcast television and consumer camcorder markets are designed to operate in real time with an output that is consistent with a standard broadcast format. The resolution, in terms of array size, is matched to the bandwidth recommended in the standard. An array that provides an output of 768 horizontal by 484 vertical pixels creates a satisfactory image for conventional television. Eight bits (256 intensity levels or gray levels) provide an acceptable image in the broadcast and camcorder industry. The largest consumer market presently is the camcorder market.

Because solid state cameras have largely replaced image vacuum tubes, the terminology associated with these tubes is also used with solid state cameras. For example, compared to image vacuum tubes, solid state cameras have no image burn-in, no residual imaging, and usually are not affected by microphonics.

The current accepted meaning of high definition television (HDTV) is a television system providing approximately twice the horizontal and vertical resolution of present NTSC, PAL, and SECAM systems (discussed in Section 5.2.1., *Video Timing*). HDTV is envisioned as a system that provides high resolution on large displays and projection screens. The goal is to have world-wide compatibility so that HDTV receivers can display NTSC, PAL, and SECAM transmitted imagery. With today's multimedia approach, any new standard must be compatible with a variety of imaging systems ranging from 35-mm film to the various motion picture formats.

The Federal Communication Commission (FCC) adopted a HDTV transmission standard in December 1996 and broadcasting should begin between 1998 and 2000. HDTV camera descriptions and receivers will appear in many journals over the next few years.

1.2.2. MACHINE VISION

In its simplest version, a machine vision system consists of a light source, camera, and computer software that rapidly analyzes digitized images with respect to location, size, flaws, and other preprogrammed data. Unlike other types of image analysis, a machine vision system also includes a mechanism that immediately reacts to images that do not conform to the parameters stored in the computer. For example, defective parts are taken off a production line conveyor belt.

Machine vision functions include location, inspection, gauging, counting, identification, recognition, and motion tracking. These systems do not necessarily need to operate at a standard frame rate. For industrial inspection, linear arrays operating in the time delay and integration (TDI) mode can be used to measure objects moving at a high speed on a conveyor belt.

While a multitude of cues are used for target detection, recognition, or identification, machine vision systems cannot replace the human eye. The eye processes intensity differences over 11 orders of magnitude, color differences, and textual cues. The solid state camera, on the other hand, can process limited

data much faster than the human. Many operations can be performed faster, cheaper, and more accurately by machines than by humans. Machine vision systems can operate 24 hours a day without fatigue. They operate consistently whereas variability exists among human inspectors. Furthermore, these cameras can operate in harsh environments that may be unfriendly to humans (e.g., extreme heat, cold, or ionizing radiation).

1.2.3. SCIENTIFIC APPLICATIONS

For scientific applications, low noise, high responsivity, large dynamic range, and high resolution are dominant considerations. To exploit a large dynamic range, scientific cameras may digitize the signal into 12, 14, or 16 bits. Array linearity and analog-to-digital converter linearity are important. Resolution is specified by the number of detector elements, and scientific arrays may have 5000 × 5000 detector elements.[8] Theoretically, the array can be any size but manufacturing considerations may ultimately limit the array size.

Low noise means low-dark current and low readout noise. The dark current can be minimized by cooling the CCD. Long integration times can increase the signal value so that the readout noise is small compared to the photon shot noise.

Although low light level cameras have many applications, they tend to be used for scientific applications. There is no industry-wide definition of a "low light level" imaging system. To some, it is simply a solid state camera that can provide a usable image when the lighting conditions are less than 1 lux. To others, it refers to an intensified camera and is sometimes called a low light level television (LLLTV) system. An image intensifier amplifies a low light level image so that it can be sensed by a solid state camera. The image-intensifier/CCD camera combination is called an intensified CCD or ICCD. The image intensifier provides tremendous amplification but also introduces additional noise.

1.2.4. MILITARY APPLICATIONS

The military is interested in detecting, recognizing, and identifying targets at long distances. This requires high resolution, low noise sensors. Target detection is a perceptible act. A human determines if the target is present. The military uses the minimum resolvable contrast (MRC) as a figure of merit.

Solid state cameras are popular because of their ruggedness and small size. They can easily be mounted on remotely piloted vehicles. They are replacing wet-film systems used for mapping and photo interpretation.

1.3. CONFIGURATIONS

Imaging systems for the four broad application categories may operate in a variety of configurations. The precise setup depends on the specific requirements. Figure 1-1 is representative of a closed circuit television system where the camera output is continuously displayed. The overall image quality is determined by the camera capability (which is based on the array specifications), the bandwidth of the video format used (e.g., EIA 170, NTSC, PAL, or SECAM), the display performance, and the observer. EIA 170 was formerly called RS 170 and the NTSC standard is also called RS 170A.

Figure 1-2 illustrates a generic transmission system. The transmitter and receiver must have sufficient electronic bandwidth to provide the desired image quality. For remote sensing, the data may be compressed before the link. Compression may alter the image and the effects of compression will be seen on selected imagery. However, compression effects are not objectionable in most imagery.

For remote applications the image may be recorded on a separate video recorder[9,10] (Figure 1-3) or may be obtained with a camcorder. The most popular player is the video cassette recorder (VCR). The recorder further modifies the image by reducing the signal-to-noise ratio (SNR) and image sharpness. As the desire for portability increases, cameras and recorders will shrink in size.[10-13]



Figure 1-1. A closed circuit television system. Image quality is determined by an observer.

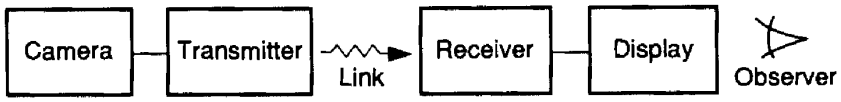


Figure 1-2. Generic remote transmission system. The transmitter and receiver must have adequate electronic bandwidth to support the image quality created by the solid state camera.



Figure 1-3. Imagery can be stored on video tape. However, the recorder circuitry may degrade the image quality.

For scientific applications, the camera output is digitized and then processed by a computer (Figure 1-4). After processing, the image may be presented on a monitor (soft copy), printed (hard copy), or stored. The digital image can also be transported to another computer via the Internet, local area net, floppy disc, or magnetic tape. For remote applications, the digital data may be stored on a digital recorder (Figure 1-5).[14-16]

Perhaps the most compelling reason for adopting digital technology is the fact that the quality of digital signals remains intact through copying and reproduction unless the signals are deliberately altered. Digital signal "transmission" was first introduced into tape recorders. Because a bit is either present or not, multiple generation copies retain high image quality.

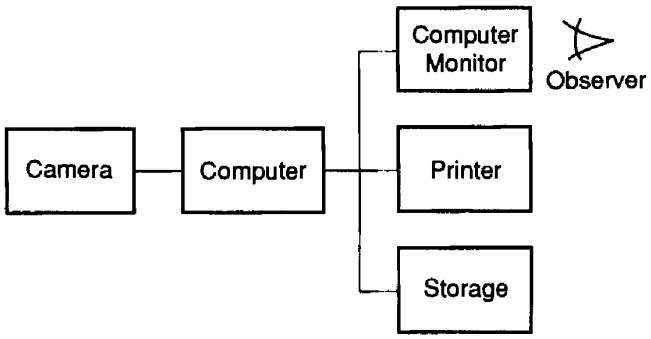


Figure 1-4. Most imagery today is enhanced through image processing. The camera may view a scene directly or may scan a document. The computer output hard copy may be used in newspapers, advertisements, or reports.

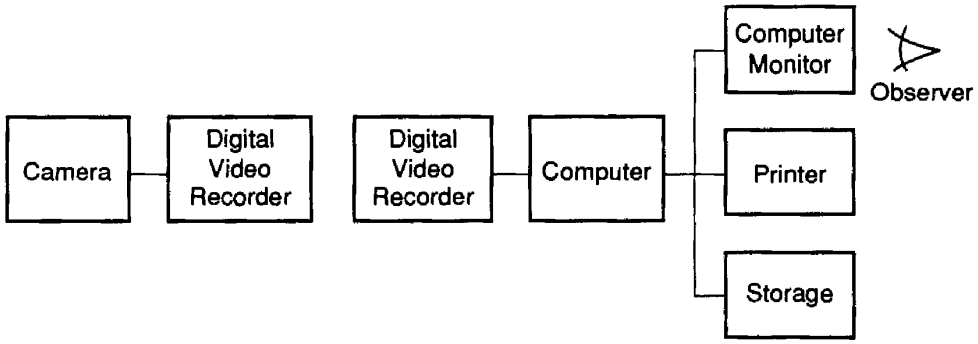


Figure 1-5. Digital systems can provide very high quality imagery. Electronic bandwidth limitations may impose data compression requirements. Data compression may alter the image but this alteration may not be obvious on general imagery.

In comparison, analog recorders, such as in video home systems (VHS), provide very poor quality after just a few generations. The first digital recorder used a format called D-1 and it became known as the CCIR 601 component digital standard. Digital recording formats now include[16] D-1, D-2, D-3, D-4, D-5, and D-6. Error correcting codes can be used to replace missing bits.

New digital recorders combine advanced technologies in electronics, video compression, and mechanical transport design. Real-time digital video systems operate at data rates that are faster than most computers. While errors in the imagery are never considered desirable, the eye is very tolerant of defects. In comparison, a computer is considered worthless if the error rate was high.

When it comes to displaying images (either hard copy or soft copy), the range of the camera digitizer is often greater than the display device. A camera may offer 12, 14, or 16 bits whereas the display may only be 8 bits. Here, a look-up table is employed to match the camera output to the display. This may be a simple linear relationship or specific expansion of a part of the camera's gray scale. False color can also be introduced to enhance the displayed image. False color is often useful for the human observer but serves no function in machine vision systems.

While a machine vision system does not require a monitor (Figure 1-6), a monitor is often used during system setup and for diagnostic evaluation. That is, a computer algorithm compares an image to a stored standard. If the target does not compare favorably to the standard, then the process is changed. For example, this may mean sending a rejected item for rework or changing the light intensity.



Figure 1-6. Machine vision systems do not require a monitor. The computer output controls the manufacturing process. Monitors are used for setup and diagnostic evaluation.

1.4. IMAGE QUALITY

Image quality is a subjective impression ranking of imagery from poor to excellent. It is a somewhat learned skill. It is a perceptual ability, accomplished by the brain, affected by and incorporating other sensory systems, emotions, learning, and memory. The relationships are many and not well understood. Perception varies between individuals and over time. There exist large variations in an observer's judgment as to the correct rank ordering from best to worst and therefore image quality cannot be placed on an absolute scale. Visual psychophysical investigations have not measured all the properties relevant to imaging systems.

Many formulas exist for predicting image quality. Each is appropriate under a particular set of viewing conditions. These expressions are typically obtained from empirical data in which multiple observers view many images with a known amount of degradation. The observers rank order the imagery from worst to best and then an equation is derived that relates the ranking scale to the amount of degradation.

Early metrics were created for film-based cameras. Image quality was related to the camera lens and film modulation transfer functions (MTFs). With the advent of televisions, image quality centered on the perception of raster lines and the minimum SNR required for *good* imagery. Here, it was assumed that the studio camera provided a perfect image and only the receiver affected the image quality.

The system MTF is the major component of system analysis. It describes how sinusoidal patterns propagate through the system. Because any target can be decomposed into a Fourier series, the MTF approach indicates how imagery will appear on the display.

Many tests have provided insight into image metrics that are related to image quality. Most metrics are related to the system MTF, resolution, or the signal-to-noise ratio. In general, images with higher MTFs and less noise are judged as having better image quality. There is no single *ideal* MTF shape that provides best image quality.

Digital processing is used for image enhancement and analysis. Because the pixels are numerical values in a regular array, mathematical transforms can be applied to the array. The transform can be applied to a single pixel, group of pixels, or the entire image. Many image processing designers think of images as an array of numbers that can be manipulated with little regard to who is the final interpreter.

With a solid state camera system, the lens, array architecture, array noise, and display characteristics all affect system performance. Only an end-to-end assessment will determine the overall image quality. For example, there is no advantage to using a high quality camera if the display cannot produce a faithful image. Often, the display is the limiting factor in terms of image quality and resolution. No matter how good the camera is, if the display resolution is poor, then the overall system resolution is poor. Only if the display's contrast and spatial resolution are better than the camera will the camera image quality be preserved.

For consumer applications, system resolution is important with SNR being secondary. Scientific applications may place equal importance on resolution and MTF. The military, interested in target detection, couples the system MTF and system noise to create the perceived signal-to-noise ratio (SNR_P).

$$SNR_P = k\frac{MTF_{SYS}\,\Delta I}{(system\ noise)}\ \frac{1}{(eye\ spatial filter)(eye\ temporal filter)}\ , \qquad (1\text{-}1)$$

where ΔI is the intensity difference between the target and its immediate background. The factor k is a proportionality constant that depends on the specific camera characteristics (aperture diameter, focal length, quantum efficiency, etc.).

When the perceived SNR is above a threshold value, the target is just perceived. Selecting a threshold SNR and solving the equation for ΔI provides the minimum resolvable contrast (MRC). When the MRC is coupled with the target description and atmospheric transmittance effects, the target range can be predicted.

1.5. PIXELS, DATELS, DISELS, and RESELS

The overall system may contain several independent sampling systems. The array spatially samples the scene, the computer may have its own digitizer, and the monitor may have a limited resolution. A monitor "pixel" may or may not represent a "pixel" in camera space. The designer and user must understand the differences among the sampling lattices.

Sampling theory describes the requirements that lead to the reconstruction of a digitized signal. The original analog signal is digitized, processed, and then returned to the analog domain. For electrical signals, each digitized value is simply called a sample and the digitization rate is the sampling rate.

Electronic imaging systems are more complex and several sampling lattices are present. The detector output represents a sampling of the scene. The detector output is digitized and placed in a memory. After image processing, the data are sent to a display medium. Although the display medium provides an analog signal, it is typically digitally controlled.

Each device has its own minimum sample size or primary element. Calling a sample a pixel or pel (picture element) does not seem bad. Unfortunately, there is no *a priori* relationship between the various device pixels. The various digital samples in the processing path are called pixels, datels, and disels (sometimes called dixels). For analog systems, the minimum size is the resel (Table 1-3). Each "-el" is mapped onto the next (Figure 1-7). However, there is no standard definition for a resel. For optical systems it may be the Airy disk or Rayleigh criterion. For electronic circuits, it is related to the bandwidth but the definition has not been standardized. When a conversion takes place between the analog and digital domains, the resel may be different from the digital sample size. The analog signal rather than the digital sample may limit the system resolution. In oversampled systems, the resel consists of many samples.

Table 1-3
THE "-ELS"

ELEMENT	DESCRIPTION
Pixel or pel (picture element)	A sample created by a detector.
Datel (data element)	Each datum is a datel. Datels reside in a computer memory.
Disel (display element)	The smallest element (sample) that a display medium can access.
Resel (resolution element)	The smallest signal supported by an analog system.

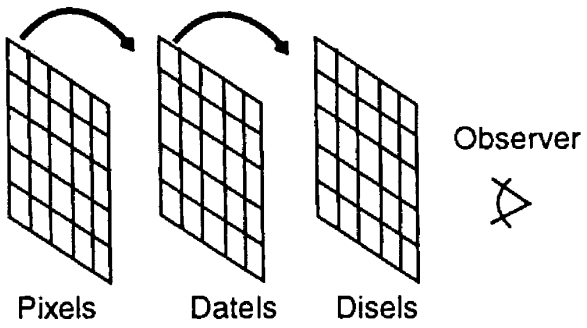


Figure 1-7. Each array is mapped onto the next. The number of elements in each array may be different. Not every array exists in every system.

For staring arrays, the total number of pixels is equal to the number of detectors. The detector's spatial response is determined by the detector's size (e.g., photosensitive area). If the extent is d_H in the horizontal direction and the optics focal length is fl, then the horizontal detector-angular-subtense (DAS_H) is

$$DAS_H = \frac{d_H}{fl}. \tag{1-2}$$

Similarly, in the vertical direction,

$$DAS_V = \frac{d_V}{fl}. \tag{1-3}$$

Staring arrays are often specified by the detector center-to-center spacing (pitch). The horizontal pixel-angular-subtense (PAS_H) is

$$PAS_H = \frac{d_{CCH}}{fl}, \tag{1-4}$$

where d_{CCH} is the horizontal pitch. Similarly, in the vertical direction

$$PAS_V = \frac{d_{CCV}}{fl}. \tag{1-5}$$

The fill factor is the ratio of areas:

$$Fill\ factor = \frac{d_H d_V}{d_{CCH} d_{CCV}}. \tag{1-6}$$

With a staring array that has a 100% fill factor, the PAS is equal to the DAS (e.g., $d_H = d_{CCH}$ and $d_V = d_{CCV}$).

If the Airy disk (a resel) is much larger than the PAS, then the optical resel determines the system resolution. If the number of pixels across this resel is large, the sampling theorem can be satisfied. If the electronic imaging system output is in a digital format, then the number of datels (samples) equals the number of pixels. If the camera's analog output is digitized, then the number of datels is linked to the frame grabber's digitization rate. This number can be much greater than the number of pixels. This higher number does not create more resolution in terms of the "-els." However, the higher sampling frequency may improve the overall system MTF.

Image processing algorithms operate on datels. A datel may not represent a pixel or a resel. Because there must be two samples to define a frequency, the Nyquist frequency associated with pixels, datels, and disels may be different. If there are more datels than pixels, the Nyquist frequency associated with an image processing algorithm is higher than that for the detector array. Most image processing books illustrate datels and call them pixels. The image processing specialist must understand the differences between the sampling lattices and take into account who will be the final data interpreter.

After image processing, the datels are output to a display medium. For monitors, each datel is usually mapped, one-to-one, onto each disel. Monitors are often specified by the number of addressable pixels (defined as disels in this text). Although the number of addressable pixels (disels) may be large for cathode ray tube based monitors, the monitor resel may be limited by the electron beam diameter. With most display media, the finite-sized spots of two adjacent disels overlap to provide an analog (continuous) image.

Finally, the system designer must be aware of which subsystem limits the overall system resolution. In some respects, the starting point for system design should begin with the final interpreter of the data. The minimum "-el" should be discernible by the interpreter to ensure maximum transfer of information. However, the observer may not find this image aesthetically pleasing.

1.6. REFERENCES

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2

RADIOMETRY and PHOTOMETRY

The radiometric/photometric relationship between the scene and camera is of primary importance. It determines the output signal. The second radiometric/photometric consideration is the match between the display's spectral output and the eye's spectral response. Display manufacturers have considered this in detail and this reduces the burden on the system designer. However, the displayed image typically is not a precise reproduction of the scene. While the displayed image usually represents the scene in spatial detail, the intensity and color rendition may be different.

Scenes in the visible and near infrared are illuminated by the sun, moon, starlight, night glow, or artificial sources. Since both the target and its background are illuminated by the same source, targets are detected when differences in reflectance exist. The camera's output voltage depends on the relationship between the scene spectral content and the spectral response of the camera.

Historically, cameras were designed to operate in the visible region only. For those systems, it was reasonable to specify responsivity in photometric units (e.g., volts/lux). However, when the spectral response extends past the visible region as with silicon photodetectors, the use of photometric units can be confusing and even misleading.

Radiometry describes the energy or power transfer from a source to a detector. When normalized to the eye's response, photometric units are used. Radiometric and photometric quantities are differentiated by subscripts: e is used for radiometric units, q for photons, and v is used for photometric units.

The symbols used in this book are summarized in the *Symbol List* (page xviii) which appears after the *Table of Contents*.

2.1. RADIATIVE TRANSFER

Spectral radiant sterance, L_e, is the basic quantity from which all other radiometric quantities can be derived. It contains both the areal and solid angle concept[1] that is necessary to calculate the radiant flux incident onto a system. It is the amount of radiant flux, (watts), per unit wavelength (micrometers) radiated into a cone of incremental solid angle (steradians) from a source whose area is measured in meters (Figure 2-1)

$$L_e(\lambda) = \frac{\partial^2 \Phi(\lambda)}{\partial A_S \, \partial \Omega} \quad \frac{W}{m^2 - \mu m - sr} . \tag{2-1}$$

Similarly, L_q is the spectral photon sterance expressed in photons/(s-m^2-μm-sr). The variables L_e and L_q are invariant for an optical system that has no absorption or reflections. That is, L_e and L_q remain constant as the radiation transverses through the optical system. Table 2-1 provides the standard radiometric units.

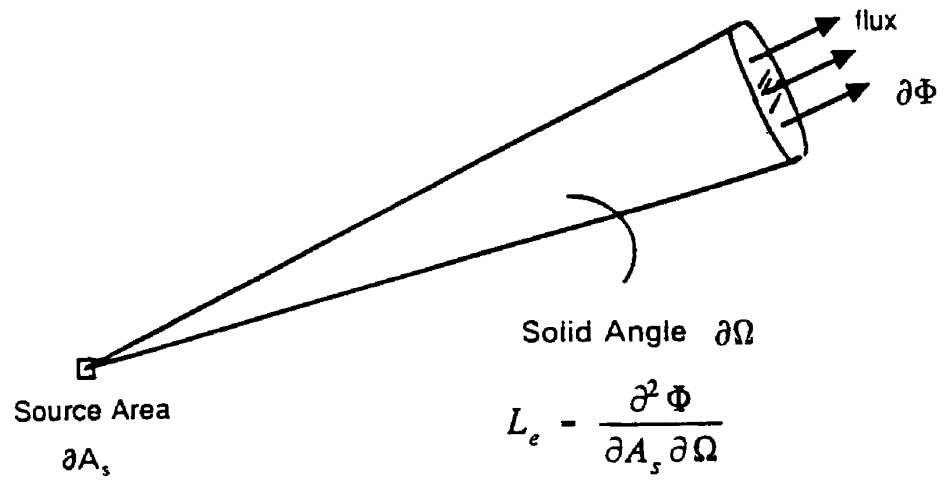


Figure 2-1. Radiant sterance.

Table 2-1
STANDARD SPECTRAL RADIOMETRIC UNITS

DEFINITION	SYMBOL	UNITS
Radiant energy	Q_e	Joule (J)
Radiant flux	Φ_e	Watts (W)
Spectral radiant intensity	I_e	W/(m^2-μm-sr)
Spectral radiant exitance (from a source) (also radiant emittance)	M_e	W/(m^2-μm)
Spectral radiant incidance (onto a target) (also irradiance)	E_e	W/(m^2-μm)
Spectral radiant sterance (also radiance)	L_e	W/(m^2-μm-sr)

For Lambertian sources, the radiance is emitted into a hemisphere. Then the spectral radiant exitance is related to the spectral radiant sterance by

$$L_e(\lambda) = \frac{M_e(\lambda)}{\pi} \quad \frac{W}{m^2-\mu m-sr} \tag{2-2}$$

and

$$L_q(\lambda) = \frac{M_q(\lambda)}{\pi} \quad \frac{photons}{s-m^2-\mu m-sr} . \tag{2-3}$$

2.2. PLANCK'S BLACKBODY LAW

The spectral radiant exitance of an ideal blackbody source whose absolute temperature is T (Kelvin), can be described by Planck's blackbody radiation law

$$M_e(\lambda,T) = \frac{c_1}{\lambda^5}\left(\frac{1}{e^{(c_2/\lambda T)} - 1}\right) \quad \frac{W}{m^2-\mu m}, \tag{2-4}$$

where the first radiation constant is $c_1 = 3.7418 \times 10^8$ W-μm^4/m^2, the second radiation constant is $c_2 = 1.4388 \times 10^4$ μm-K, and λ is the wavelength expressed in micrometers. The value T is also called the color temperature. Figure 2-2 illustrates Planck's spectral radiant exitance in logarithmic coordinates. Since a photodetector responds linearly to the available power, linear coordinates may provide an easier representation to interpret (Figure 2-3). Each curve has a maximum at λ_{PEAK}. Wien's displacement law provides $\lambda_{PEAK}\,T = 2898$ μm-K. A source must have an absolute temperature above about 700 K to be perceived by the human eye.

The spectral photon exitance is simply the spectral radiant exitance divided by the energy of one photon (hc/λ):

$$M_q(\lambda,T) = \frac{\lambda}{hc} M_e(\lambda,T) \tag{2-5}$$

or

$$M_q(\lambda,T) = \frac{c_3}{\lambda^4}\left(\frac{1}{e^{(c_2/\lambda T)} - 1}\right) \quad \frac{photons}{s-m^2-\mu m}, \tag{2-6}$$

where h is Planck's constant ($h = 6.626 \times 10^{-34}$ J-s), c is the speed of light ($c = 3 \times 10^8$ m/s), and the third radiation constant is $c_3 = 1.88365 \times 10^{27}$ photons-μm^3/s-m^2. Figures 2-4 and 2-5 provide the spectral photon exitance in logarithmic and linear coordinates, respectively, for sources typically used for CCD calibration. These curves have a maximum at $\lambda_{PEAK}\,T = 3670$ μm-K.

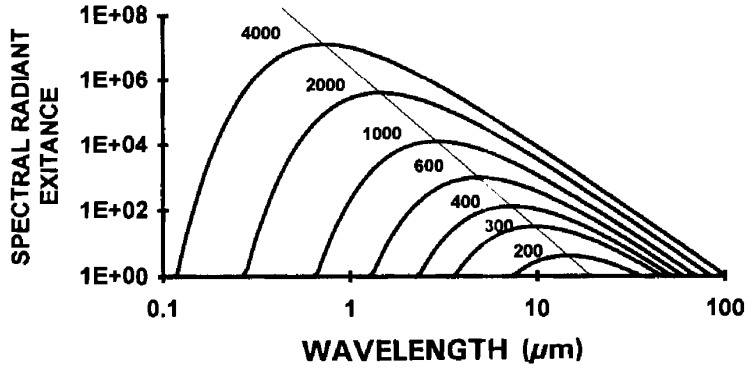


Figure 2-2. Planck's spectral radiant exitance plotted in logarithmic coordinates. The units are W/(m^2-μm). The light line is Wien's law.

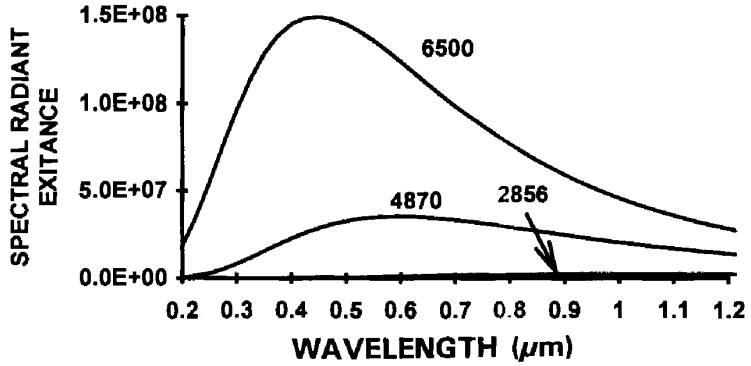


Figure 2-3. Planck's spectral radiant exitance plotted in linear coordinates for typical sources used for calibrating CCD arrays. The units are W/(m^2-μm). The maximum values occur at 1.01, 0.60, and 0.45 μm for color temperatures of 2856, 4870, and 6500K, respectively.

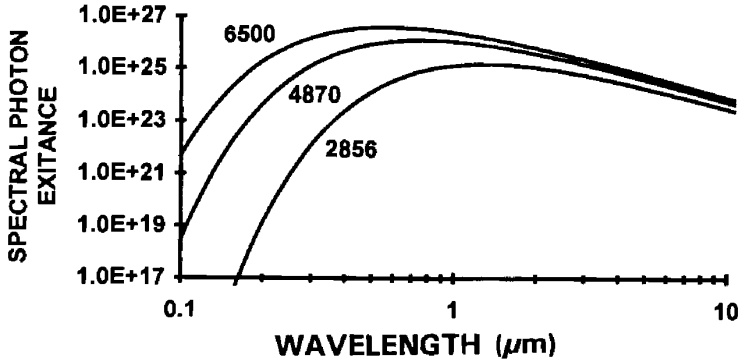


Figure 2-4. Planck's spectral photon exitance for T = 2856, 4870, and 6500 K. The maximum values occur at 1.29, 0.75, and 0.56 μm, respectively. The units are photons/(s-m^2-μm).

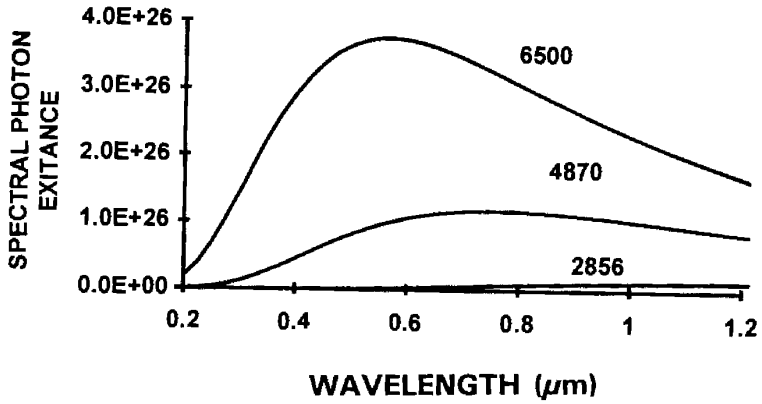


Figure 2-5. Planck's spectral photon exitance plotted in linear coordinates. The units are photons/(s-m^2-μm).

2.3. PHOTOMETRY

Photometry describes the radiative transfer from a source to a detector where the units of radiation have been normalized to the spectral sensitivity of the eye. Photometry applies to all systems that are sensitive to visible radiation. The luminous flux emitted by a source is

$$\Phi_v = K_M \int_{0.38\mu m}^{0.75\mu m} V(\lambda)\, M_p(\lambda)\, d\lambda \quad lumens\ , \tag{2-7}$$

where $M_p(\lambda)$ is the power expressed in units of W/μm and K_M is the luminous efficacy for photopic vision. It is 683 lumens/W at the peak of the photopic curve ($\lambda \approx 0.55$ μm) and 1746 lumens/W for the scotopic region at $\lambda \approx 0.505$ μm. Although both photopic and scotopic units are available, usually only the photopic units are used (Table 2-2 and Figure 2-6). At very low light levels (less than 5×10^{-3} lux), the eye's rods operate (scotopic response). For light levels above 5×10^{-2} lux, the eye's cones (photopic response) respond.

Table 2-2
PHOTOPIC and SCOTOPIC EYE RESPONSE

Wavelength nm	Photopic V(λ)	Scotopic V'(λ)	Wavelength nm	Photopic V(λ)	Scotopic V'(λ)
380		0.00059	570	0.952	0.2076
390	0.00012	0.00221	580	0.870	0.1212
400	0.0004	0.00929	590	0.757	0.0655
410	0.0012	0.03484	600	0.631	0.03315
420	0.0040	0.0966	610	0.503	0.01593
430	0.0116	0.1998	620	0.381	0.00737
440	0.023	0.3281	630	0.265	0.00335
450	0.038	0.455	640	0.175	0.00150
460	0.060	0.567	650	0.107	0.00067
470	0.091	0.676	660	0.061	0.00031
480	0.139	0.793	670	0.032	
490	0.208	0.904	680	0.017	
500	0.323	0.982	690	0.0082	
510	0.503	0.997	700	0.0041	
520	0.710	0.935	710	0.0021	
530	0.862	0.811	720	0.00105	
540	0.954	0.650	730	0.00052	
550	0.995	0.481	740	0.00025	
560	0.995	0.3288	750	0.00012	

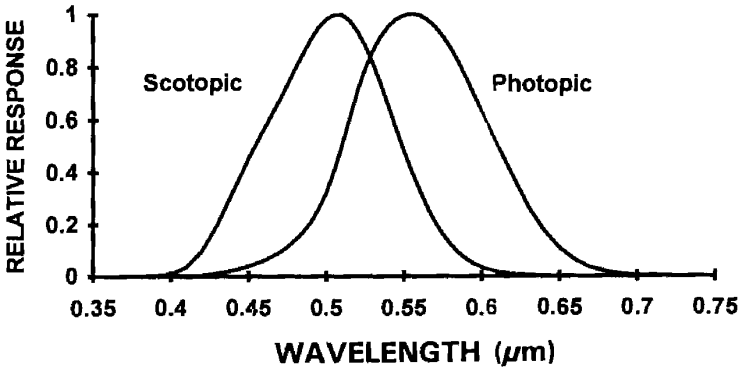


Figure 2-6. Photopic and scotopic eye responses.

2.3.1. UNITS

Unfortunately, there is overabundance of terminology being used in the field of photometry (Table 2-3). The SI units are recommended. Luminance emittance and illuminance are sometimes used as alternatives to luminous exitance and luminous incidance, respectively. Brightness and luminance may be used in place of luminous sterance. For convenience, luminance sterance has been labeled as the normalized intensity or nit. For Lambertian sources, the luminance is emitted into a hemisphere whose solid angle is 2π. The luminous exitance of a Lambertian surface is simply the luminance exitance given in Table 2-3 divided by π. For Lambertian sources, the luminance exitance terms are the apostilb (abs), Lambert (L), and foot-Lambert (fL) for the SI, CGS and English systems, respectively.

Figure 2-7 illustrates the geometric relationship between the SI, CGS, and English luminous incidance units. The numeric relationship is provide in Table 2-4.

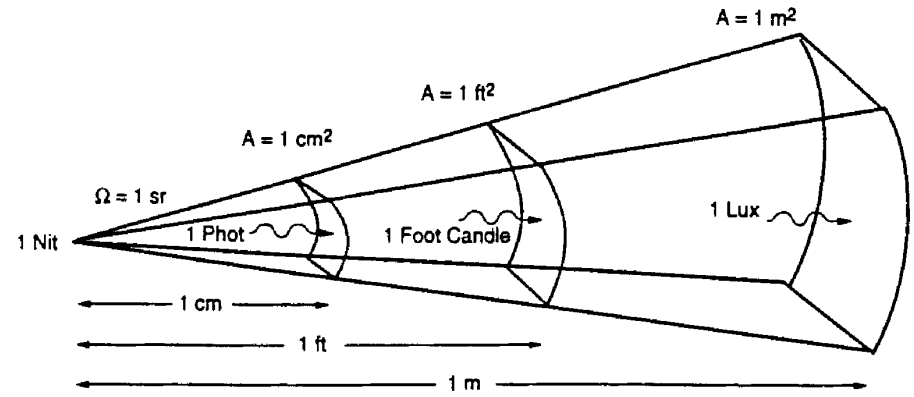


Figure 2-7. Geometric relationship between the SI, CGS, and English luminous incidance units. The solid angle is one steradian. (Not to scale).

Table 2-3
STANDARD PHOTOMETRIC UNITS
(The SI units are recommended)

DEFINITION	SYMBOL	SI and MKS UNITS	CGS UNITS	ENGLISH UNITS
Luminous energy	Q_v	Talbot (T)	Talbot (T)	Talbot (T)
Luminous flux	Φ_v	Lumen (lm)	Lumen (lm)	Lumen (lm)
Luminous intensity	I_v	Candela (cd) lm/sr	Candela (cd) lm/sr	Candela (cd) lm/sr
Luminous exitance (from a source) (also luminous emittance)	M_v	Lux (lx) lumen/m^2	Phot (ph) lumen/cm^2	Footcandle (fc) lumen/ft^2
Luminous incidance (onto a target) (also illuminance)	E_v	Lux (lx) Lumen/m^2	Phot (ph) lumen/cm^2	Footcandle (fc) lumen/ft^2
Luminous sterance (also brightness and luminance)	L_v	Nit Lumen/m^2-sr or cd/m^2	Stilb (sb) cd/cm^2	candela/ft^2

Table 2-4
CONVERSION BETWEEN SI, CGS, and ENGLISH UNITS

	PHOT	FOOTCANDLE	LUX
1 Phot =	1	929	1×10^4
1 Footcandle =	1.076×10^{-3}	1	10.764
1 Lux =	1×10^{-4}	0.0929	1

2.3.2. TYPICAL ILLUMINATION LEVELS

Natural lighting levels can vary by over 9 orders of magnitude (Table 2-5). The minimum level is limited by night glow and the maximum level is provided by the sun. At very low light levels (less than 5×10^{-3} lux), the eye's rods operate (scotopic response). For light levels above 5×10^{-2} lux, the eye's cones (photopic response) respond. Between these two values, both rods and cones are operating and the eye's response is somewhat between the two values. This composite response is called the mesopic response. Table 2-6 provides typical artificial lighting levels.

The eye automatically adapts to the ambient lighting conditions to provide an optimized image. Cameras may need neutral density filters if the light level is too high. Cameras may have an automatic iris and shutter speed to optimize the image on the detector array. If the light level is too low, an intensified camera may be necessary.

Table 2-5
NATURAL ILLUMINANCE LEVELS

SKY CONDITION	EYE RESPONSE	AVERAGE LUMINOUS INCIDANCE (lux)
Direct sun	Photopic	10^5
Full daylight	Photopic	10^4
Overcast sky	Photopic	10^3
Very dark day	Photopic	10^2
Twilight	Photopic	10
Deep twilight	Photopic	1.0
Full moon	Photopic	10^{-1}
Quarter moon	Mesopic	10^{-2}
Moonless, clear night (starlight)	Scotopic	10^{-3}
Moonless, overcast (night glow)	Scotopic	10^{-4}

Table 2-6
TYPICAL ARTIFICIAL ILLUMINANCE LEVELS

LOCATION	AVERAGE LUMINOUS INCIDANCE (lux)
Hospital operating theater	10^5
TV studio	10^3
Shop windows	10^3
Drafting office	500
Business office	250
Good street lighting	20
Poor street lighting	10^{-1}

2.4. SOURCES

As shown in Figure 2-3 (page 22), the peak wavelength shifts toward the blue end of the spectrum as the color temperature increases. This puts more energy in the visible region. There is approximately 70% more luminous flux available from a lamp operating at 3200 K than a light operating at 3000 K based on blackbody curves. This is the basis for using a higher color temperature lamp for higher illumination levels. However, the lifetime of tungsten halogen bulbs decreases dramatically with increasing color temperature. It is far better to use more lamps to increase the luminous flux than to increase the color temperature and sacrifice lifetime.

2.4.1. CALIBRATION SOURCES

The CIE (Commission Internationale de l'Eclairage or International Commission on Illumination) recommended four illuminants that could be used for calibration of cameras sensitive in the visible region (Table 2-7). Commercially available sources simulate these illuminants only over the visible range (0.38 to 0.75 μm). The source intensity is not specified; only the effective color temperature is specified. Illuminants A and D_{65} are used routinely whereas illuminants B and C are of historical interest.

Table 2-7
CIE RECOMMENDED ILLUMINANTS

CIE ILLUMINANT	EFFECTIVE COLOR TEMPERATURE	DESCRIPTION
A	2856 K	Light from an incandescent source
B	4870 K	Average noon sunlight
C	6770 K	Average daylight (sun + sky)
D_{65} or D_{6500}	6500 K	Daylight with a corrected color temperature

Illuminant A is a tungsten filament whose output follows Planck's blackbody radiation law. The other illuminants are created by placing specific filters in front of illuminant A. These filters have spectral characteristics that, when combined with illuminant A, provide the relative outputs illustrated in Figure 2-8. On a relative basis, the curves can be approximated by blackbodies whose color temperatures are 4870, 6770, and 6500 K for illuminant B, C, D_{65}, respectively.

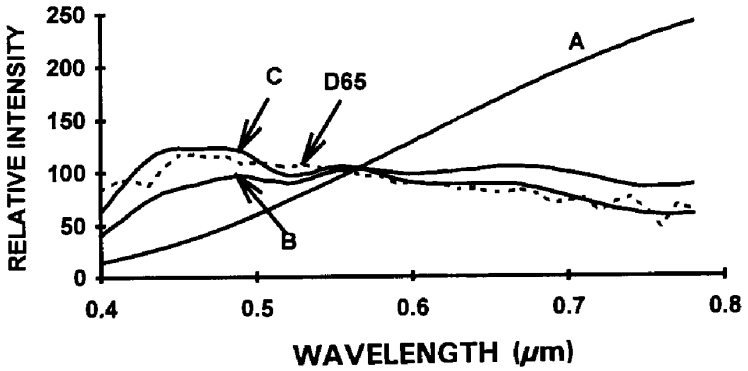


Figure 2-8. Relative output of the standard illuminants. Compare the shapes to Figure 2-3, page 22.

2.4.2. REAL SOURCES

A tungsten filament bulb emits light that is closely matched to an ideal blackbody radiator. This is not so for discharge lamps such as fluorescent lamps. For these lamps, a blackbody curve that approximates the output is fit to the spectral radiant exitance (Table 2-8). This approximation is for convenience and should not be used for scientific calculations. The actual spectral photon sterance must be used for nonideal sources[2] (discussed in the next three sections). Although many discharge lamps seem uniform white in color, they have peaks in the emission spectra (Figure 2-9). The apparent solar color temperature depends upon latitude, time of day, and a variety of environmental conditions (e.g., aerosols, pollutants, and cloud cover). The standardization of illuminant C at 6770 K was arbitrary. It was considered representative of "average" daylight.

Table 2-8
APPROXIMATE COLOR TEMPERATURE

SOURCE	APPROXIMATE COLOR TEMPERATURE
Northern sky light	7500 K
Average daylight	6500 K
Xenon (arc or flash)	6000 K
Cool fluorescent lamps	4300 K
Studio tungsten lamps	3200 K
Warm fluorescent lamps	3000 K
Floodlights	3000 K
Domestic tungsten lamps	2800 - 2900 K
Sunlight at sunset	2000 K
Candle flame	1800 K

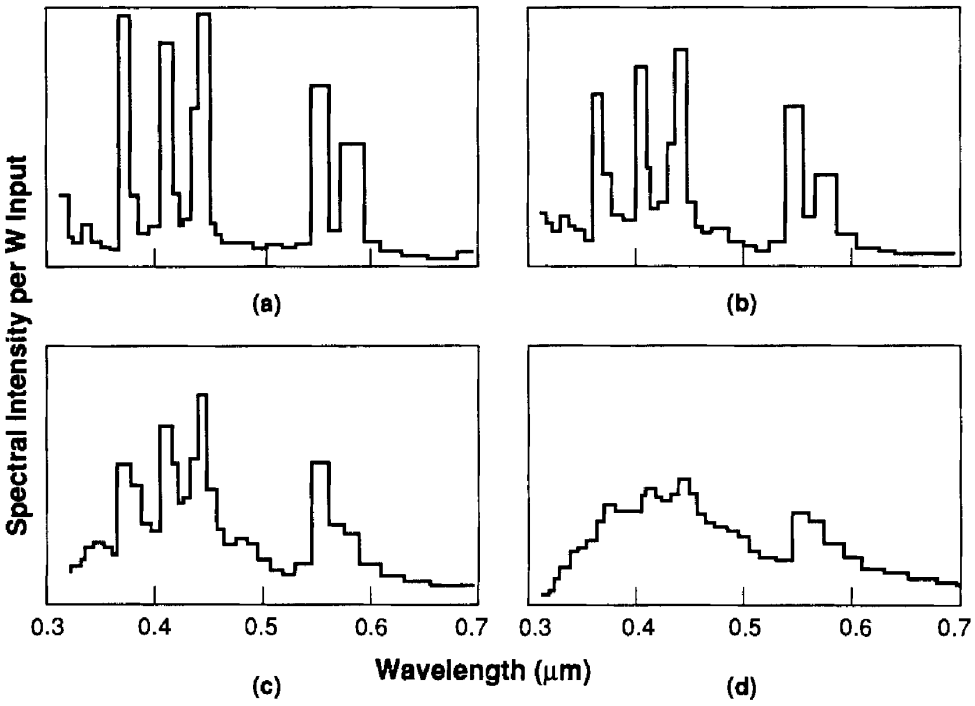


Figure 2-9. Relative output of a mercury arc lamp as a function of pressure.[3] (a) 21 atm, (b) 75 atm, (c) 165 atm, and (d) 285 atm.

Usually there is no relationship between the color temperature and contrast of a scene and what is seen on a display. This is not the fault of the camera and display manufacturers; they strive for compatibility. The observer, who usually has no knowledge of the original scene, will adjust the display for maximum visibility and aesthetics.

The video signal is simply a voltage with no color temperature associated with it. The display gain and offset can be adjusted such that a white target appears as if it was illuminated by a source whose color temperature is between 3200 K and 10,000 K. Most displays are preset to either 6500 K or 9300 K (Figure 2-10). As the color temperature increases, whites appear to change from a yellow tinge to a blue tinge. The perceived color depends on the adapting illumination (e.g., room lighting) Setting the color temperature to 9300 K provides aesthetically pleasing imagery and this setting is unrelated to the actual scene color temperature.

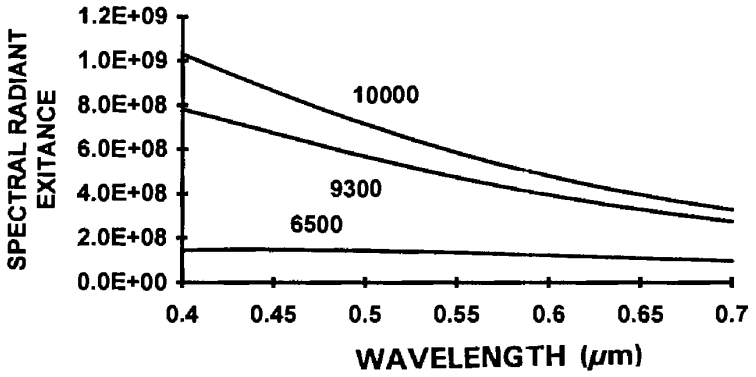


Figure 2-10. Display color temperature is typically preset at either 6500 or 9300 K. Some displays allow tuning from 3200 to 10,000 K. The displayed color temperature is independent of the scene color temperature. A scene illuminated with a 2854 K source (yellow tinge) can appear bluish when displayed at 9300 K.

2.5. CAMERA FORMULA

If an imaging system is at a distance R_1 from a source (Figure 2-11), the number of photons incident onto the optical system of area A_o is during time t_{INT} is

$$n_{LENS} = L_q \frac{A_o}{R_1^2} A_S T_{ATM} t_{INT} \quad , \tag{2-8}$$

where the small angle approximation was used (valid when $R_1^2 \gg A_o$). T_{ATM} is the intervening atmospheric transmittance. The number of on-axis photons reaching the image plane is:

$$n_{IMAGE} = L_q \frac{A_o}{R_2^2} A_S T_{OPTICS} T_{ATM} t_{INT} \quad , \tag{2-9}$$

where T_{OPTICS} is the system's optical transmittance.

When the image size is much larger than the detector area ($A_I \gg A_D$), the source is said to be resolved or the system is viewing an extended source. Equivalently, the detector is flood-illuminated. In most solid state camera applications, the source is resolved. The value A_D is the effective sensitive detector area. Microlenses (discussed in Section 3.11.1., *Microlenses*) and optical anti-alias filters (discussed in Section 10.3.4., *Optical Anti-alias Filter*) increase the effective area.

The number of photons incident onto the detector is simply the ratio of the areas:

$$n_{DETECTOR} = n_{IMAGE} \frac{A_D}{A_I} \quad . \tag{2-10}$$

Using the small angle approximation for paraxial rays,

$$\frac{A_S}{R_1^2} = \frac{A_I}{R_2^2} \quad . \tag{2-11}$$

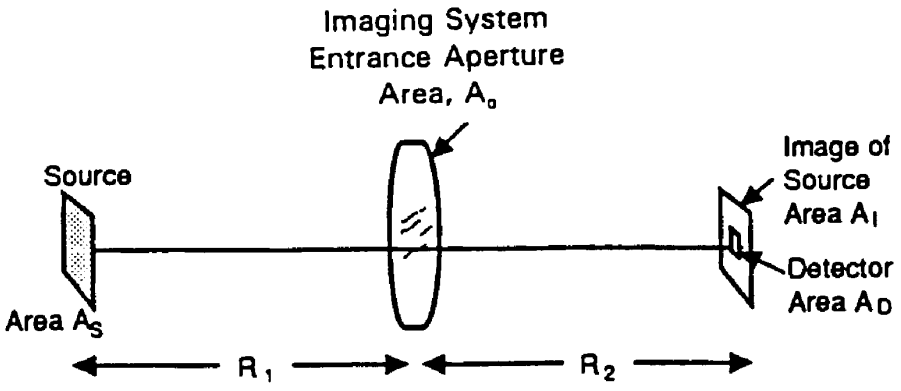


Figure 2-11. An imaging system directly viewing a source.

The number of photons reaching the detector becomes:

$$n_{DETECTOR} = \frac{L_q A_o A_D}{fl^2 (1 + M_{OPTICS})^2} T_{OPTICS} T_{ATM} t_{INT} \quad . \tag{2-12}$$

The optical magnification is $M_{OPTICS} = R_2/R_1$. Here, R_1 and R_2 are related to the system's effective focal length, fl, by

$$\frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{fl} \quad . \tag{2-13}$$

Assuming a circular aperture ($A_o = \pi D^2/4$) and defining the f-number as F = fl/D (see Appendix):

$$n_{DETECTOR} = \frac{\pi}{4} \frac{L_q A_D}{F^2 (1 + M_{OPTICS})^2} T_{OPTICS} T_{ATM} t_{INT} \quad . \tag{2-14}$$

An off-axis image will have reduced incidance compared to an on-axis image by cosine$^4\theta$. As required, cosine$^4\theta$ can be added to all the equations.

Many of the variables are a function of wavelength. The number of photoelectrons generated in a solid state detector is

$$n_{pe} = \int_{\lambda_1}^{\lambda_2} R_q(\lambda) n_{DETECTOR}(\lambda)\, d\lambda \qquad (2\text{-}15)$$

or

$$n_{pe} = \int_{\lambda_1}^{\lambda_2} R_q(\lambda) \frac{\pi}{4} \frac{L_q(\lambda)\, t_{INT}\, A_D}{F^2 (1 + M_{OPTICS})^2} T_{OPTICS}(\lambda)\, T_{ATM}(\lambda)\, d\lambda \ , \qquad (2\text{-}16)$$

where $R_q(\lambda)$ has units of electrons per photon and is simply the detector's quantum efficiency and t_{INT} becomes is the integration time. As the source moves to infinity, M_{OPTICS} approaches zero.

In photography, shutter speeds (exposure times) vary approximately by a factor of two (e.g., 1/30, 1/60, 1/125, 1/250, etc.). Thus, changing the shutter speed by one setting changes n_{pe} approximately by a factor of 2. f-stops have been standardized to 1, 1.4, 2, 2.8, 4, 5.6, 8..... The ratio of adjacent f-stops is $\sqrt{2}$. Changing the lens speed by one f-stop changes the f-number by a factor of $\sqrt{2}$. Here, also, the n_{pe} changes by a factor of 2.

In an actual application, what is of interest is the signal difference produced by a target and its immediate background. Here, both the target and the background are assumed to be illuminated by the same source (artificial lighting, sun, moon, night glow, star light). Let $\Delta\rho = \rho_T(\lambda) - \rho_B(\lambda)$ where $\rho_T(\lambda)$ and $\rho_B(\lambda)$ are the spectral reflectances of the target and background, respectively. Although the number of electrons is used for solid state array calculations, the camera output is a voltage:

$$\Delta V_{CAMERA} = G_{CAMERA}\, \Delta n_{pe} \ , \qquad (2\text{-}17)$$

where

$$\Delta n_{pe} = \int_{\lambda_1}^{\lambda_2} R_q(\lambda) \frac{\pi}{4} \frac{\Delta\rho\, E_{q\text{-}SCENE}(\lambda)\, t_{INT}\, A_D}{F^2 (1 + M_{OPTICS})^2} T_{OPTICS}(\lambda)\, T_{ATM}(\lambda)\, d\lambda \ . \qquad (2\text{-}18)$$

The value G_{CAMERA} contains both the array output conversion gain (units of volts/electron) and the subsequent amplifier gain. Tables 2-5 and 2-6 provide nominal values for $E_{e\text{-}SCENE}$.

It would appear that by simply decreasing the f-number, n_{pe} or Δn_{pe} would increase. Often, lower f-number lens systems have more optical elements and therefore may have lower transmittance. The value T_{OPTICS}/F^2 must increase to increase n_{pe} or Δn_{pe}. Lens systems may be described by the T-number:

$$T/\# = \frac{F}{\sqrt{T_{OPTICS}}} . \qquad (2\text{-}19)$$

If T_{OPTICS} is a function of wavelength, then T/# will also be a function of wavelength. Here T_{OPTICS}/F^2 in Equation 2-16 or 2-18 is replaced by $1/(T/\#)^2$.

For back-of-the-envelope calculations, the atmospheric transmittance is assumed to have no spectral features $T_{ATM}(\lambda) \approx T_{ATM}$ (discussed in Section 12.6.1., *Contrast Transmittance*). For detailed calculations, the exact spectral transmittance[4] must be used.

☞

Example 2-1
VISUAL THRESHOLD

An object is heated to incandescence. What is the approximate color temperature for it to be just perceived? Let the object area be 1 cm^2. The observer is 1 m from the object.

After adapting to the dark at least 60 min, the eye can perceive a few photons per second (absolute threshold). Here, the pupil dilates to about 8 mm ($A_o = 5 \times 10^{-5}\ m^2$). When the eye is dark adapted, only the rods are functioning and the eye's spectral response is approximately 0.38 μm to 0.66 μm. The number of photons per second reaching the eye from a Lambertian source is

$$n_{EYE} = \int_{0.38\,\mu m}^{0.66\,\mu m} \frac{A_o}{R_1^2} \frac{M_q(\lambda,T)}{\pi} A_S d\lambda \approx \frac{A_o}{R_1^2} \frac{M_q(\lambda_o,T)}{\pi} A_S \Delta\lambda , \qquad (2\text{-}20)$$

where $\Delta\lambda = 0.28\,\mu m$. The peak scotopic eye response occurs at $\lambda_o = 0.515\,\mu m$. The observer can just perceive this object at 640 K when he is in a completely blackened room. As the ambient illumination increases, the pupil constricts (A_o decreases). Furthermore, the eye's detection capability depends on the ambient lighting. As the light level increases, the target flux must also increase to be perceptible.

The eye's ability to just discern intensity differences depends on the intensity of the surrounding illuminance. At 0.01 lux the object must provide 10 times more flux than the background to be discerned by the eye. If the surround is at 700 K, than the target must be at 750 K to be perceptible. At 1000 lux, the object must provide 1000 times more flux then the surround. If the surround color temperature is 1000 K, then the target must be heated to 1350 K to be perceptible. Photometric units are not linearly related to color temperature.

These back-of-the-envelope calculations do not include the eye's spectral response (Table 2-2, page 24) and therefore only illustrate required intensity differences. The eye changes its ability to perceive differences with the surround illumination. This explains, in part, why television receiver imagery appears so bright in a darkened room and cannot be seen in bright sunlight.

2.6. NORMALIZATION

"Normalization .... is the process of reducing measurement results as nearly as possible to a common scale"[5]. Normalization is essential to ensure that appropriate comparisons are made. Figure 2-12 illustrates the relationship between the spectral response of a system to two different sources. The output of a system depends on the spectral features of the input and the spectral response of the imaging system. Simply stated, the camera output depends on the source used.

Variations in output can also occur if "identical" systems have different spectral responses. Equation 2-16 (page 35) is integrated over the wavelength interval of interest. Since arrays may have different spectral responses, an imaging system whose spectral response is 0.4 to 0.7 μm may have a different responsivity than a system that operates 0.38 to 0.75 μm although both systems are labeled as visible systems. The spectral response of solid state arrays varies from manufacturer to manufacturer (discussed in Section 4.1.1., *Spectral Response*). Systems can be made to appear as equivalent or one can be made to provide better performance by simply selecting an appropriate source.

While the sensor may be calibrated with a standard illuminant, it may not be used with the same illumination. Calibration with a standard illuminant is useful for comparing camera responsivities under controlled conditions. However, if the source characteristics in a particular application are significantly different from the standard illuminant, the selection of one sensor over another must be done with care. For example, street lighting from an incandescent bulb is different from that of mercury-arc lights (compare Figure 2-8 with Figure 2-9, pages 30 and 31, respectively). The only way to determine the relative responsivities is to perform the calculation indicated in Equation 2-16.

The effect of ambient lighting is particularly noticeable when using low light level televisions at nighttime. The spectral output of the sky (no moon) and moon (clear night) are significantly different. Figure 2-13 illustrates the natural night sky luminous incidence. Since an abundance of photons exists in the near infrared (0.7 to 1.1 μm), most night vision systems (e.g., image intensifiers, starlight scopes, snooper scopes, etc.) are sensitive in this region.

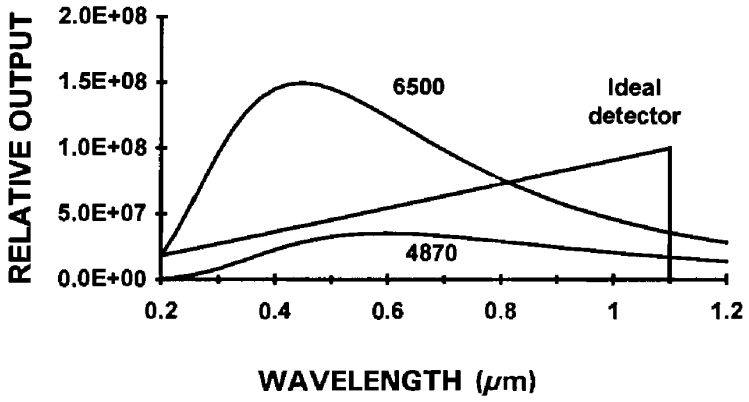


Figure 2-12. Sources with different spectral outputs can produce different system outputs. The 6500-K source provides more in-band radiant flux than the 4870-K source. The system output will be higher when viewing the 6500-K source.

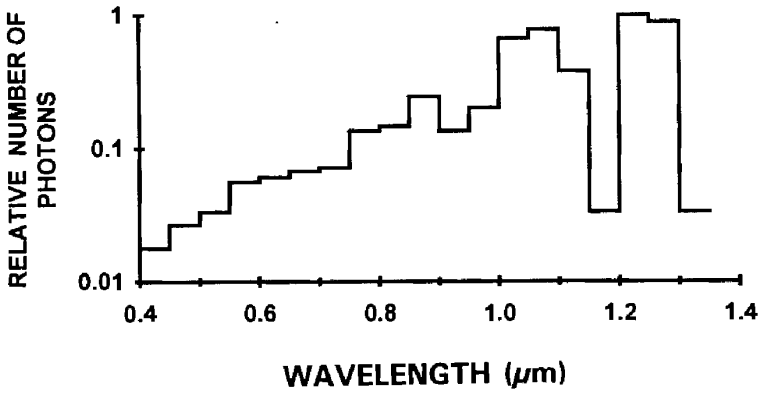


Figure 2-13. Night sky luminous incidance (From Reference 6).

2.7. NORMALIZATION ISSUES

A camera output depends on both the system spectral response and the color temperature of the illuminating source (Equation 2-16, page 35). When the camera spectral response is within the eye's response, then photometric units are reasonable. When the camera's response is outside the eye's response curve, photons contribute to signal but the photometry remains constant. Even though two sources may provide the same luminous incidance, the camera output can be quite different. Sometimes an infrared filter is used to restrict the wavelength response. When the filter is added, the average responsivity becomes

$$R_v = \frac{\int_{\lambda_1}^{\lambda_2} T_{IR-FILTER} R_e(\lambda) M_e(\lambda)\, d\lambda}{683 \int_{0.38}^{0.75} V(\lambda) M_e(\lambda,T)\, d\lambda} \quad \frac{A}{lumens} . \tag{2-21}$$

This average type responsivity is useful for comparing the performance of cameras with similar spectral responses. It is appropriate if the source employed during actual usage is similar to the one used for the calibration.

For ideal photon detectors the spectral responsivity (expressed in A/W) is:

$$R_e(\lambda) = \frac{\lambda}{\lambda_P} R_P \quad when \quad \lambda \le \lambda_p \qquad (2\text{-}22)$$

$$= 0 \quad elsewhere \quad ,$$

where R_P is the peak responsivity and λ_P is the wavelength at which R_P occurs. Since R_q is the quantum efficiency, $R_e = (q\lambda/hc)R_q$. When the wavelength is expressed in micrometers, $R_e = (\lambda/1.24)R_q$ and $R_P = R_q/E_G$. For silicon, the band gap is $E_G = 1.12$ eV resulting in a cutoff wavelength of $\lambda_P \approx 1.24/E_G \approx 1.1$ μm. The quantity q is the electron charge ($q = 1.6 \times 10^{-19}$ coul).

The ideal silicon detector response is used to estimate the relative outputs of two systems: one with an ideal IR filter (transmittance is unity from 0.38 to 0.70 μm and zero elsewhere) and one without. The relative outputs are normalized to that expected when illuminated with a CIE A illuminant (Table 2-9). The sources are considered ideal blackbodies with exitances that follow Equation 2-4 (page 21). As the source temperature increases, the output increases but not linearly with color temperature.

Table 2-9
RELATIVE OUTPUT
This is assuming ideal blackbodies and ideal Si spectral response.
A specific sensor may deviate significantly from these values.

SOURCE TEMPERATURE	RELATIVE OUTPUT (0.38 to 1.1 μm)	RELATIVE OUTPUT (0.38 to 0.70 μm)
2856	1.00	0.196
3200	1.96	0.482
4870	15.7	6.95
6500	48.9	27.4
6770	56.5	32.4

Only photons within the visible region affect the number of available lumens. For the system without the IR filter, the detector is sensing photons whose wavelengths are greater than 0.7 μm even though the number of lumens is not affected by these photons (Figure 2-14). As the color temperature increases, the flux available to the observer (lumens) increases faster than the output voltage. As a result, responsivity, expressed in A/lumen, decreases with increasing color temperature (Table 2-10). This decrease affects the wide spectral response systems to a greater extent. Specifying the output in lumens is of little value for an electro-optical sensor whose response extends beyond the eye's response. Radiometric units are advised here.

The values in Tables 2-9 and 2-10 should be considered as illustrative. Solid state detectors do not follow the ideal response (discussed in Section 4.1.1., *Spectral Response*). The IR filter cutoff also varies by manufacturer. Only a detailed spectral response evaluation permits correct comparisons among detectors. Since there is considerable variation in spectral response and type of IR filter used, it is extremely difficult to compare systems based on responsivity values only.

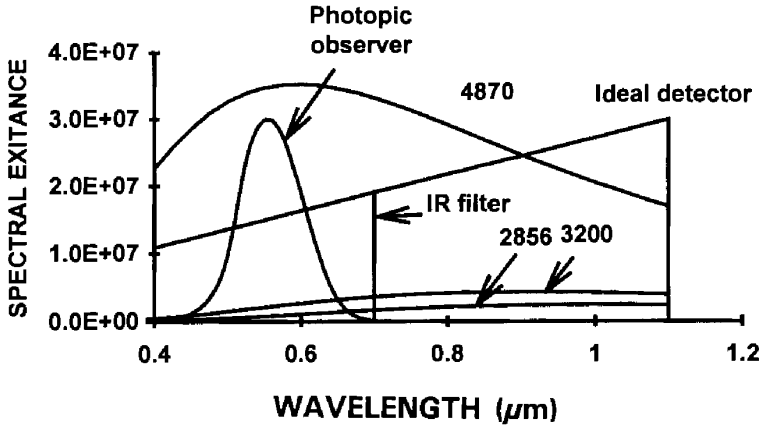


Figure 2-14. Spectral relationship between source characteristic, detector response, and the photopic observer. As the color temperature increases, the energy available to the observer increases rapidly. Therefore, the number of lumens increases dramatically.

Table 2-10
RELATIVE RESPONSIVITY (A/lumen)
A specific sensor may deviate significantly from these values

SOURCE TEMPERATURE	RELATIVE RESPONSIVITY (0.38 to 1.1 μm)	RELATIVE RESPONSIVITY (0.38 to 0.70 μm)
2856	1.00	0.196
3200	0.754	0.185
4870	0.387	0.171
6500	0.314	0.176
6770	0.308	0.177



Example 2-2
SOURCE SELECTION

A camera's signal-to-noise ratio is too small. The engineer can either change the light source to one with a higher color temperature or add more lamps. What are the differences?

With an ideal blackbody, the color temperature completely specifies the luminous exitance. Increasing the color temperature (by increasing the voltage on the bulb) will increase the luminous flux. For real sources, the color temperature is used only to denote the relative spectral content. A 50-W bulb whose output approximates a 3200-K source will have a lower photometric output than a 1000-W bulb operating at 2856 K. Adding more lamps does not change the relative spectral content but increases the luminous flux.



Example 2-3
RELATIVE VERSUS ABSOLUTE OUTPUT

Should a detector be calibrated with a 5- or 1000-W bulb?

If the relative spectral output of the two bulbs is the same (e.g., CIE A), the responsivity is independent of the source flux. The bulb intensity should be sufficiently high to produce a good signal-to-noise ratio. It should not be so high that the detector saturates.

System output does not infer anything about the source other than that an equivalent blackbody of a certain color temperature would provide the same output. This is true no matter what output units are used (volts, amps, or any other arbitrary unit). These units, by themselves, are not very meaningful for system-to-system comparison. For example, ΔV_{CAMERA} (and equivalently the camera responsivity) can be increased by increasing the system gain. As such, it is dangerous to compare system response based on only a few numbers.

Arrays may be specified by their radiometric responsivity ($V/(J\text{-}m^{-2})$) or by their photometric responsivity (V/lux). The relationship between the two depends on the spectral content of the source and the spectral response of the array (further discussed in Section 4.1.2., *Responsivity*). In principle, the source can be standardized (e.g., selection of the CIE A illuminant), but the array spectral response varies among manufacturers and may vary within one manufacturing environment if different processes are used. Therefore, there is no simple (universal) relationship between radiometric and photometric responsivities.

The correct analysis method is to perform a radiometric calculation using the source spectral output (which may not be an ideal blackbody) and using the spectral response of the camera system. Using standard sources for quality control on a production line is valid since the spectral response of the detectors should not change very much from unit to unit. The camera spectral response must include the optical spectral transmittance of all filters present.

A 3200-K color temperature source is not well matched to the eye's response. The eye peaks at 0.555 μm but the source peaks at 0.90 μm. With silicon detectors, the spectral response tends to match the output of a 3200-K source. Thus CCD detectors will perform rather well with ambient lighting. For machine vision systems, the infrared-blocking filter is not typically used.

However, since the human observer is not familiar with infrared images, the imagery may appear slightly different compared to that obtained with the IR-blocking filter.

Low light level televisions can have a variety of spectral responses (discussed in Section 5.4.2., *Intensified Solid State Cameras*). The methodology presented in this chapter can be used to calculate responsivity and output voltage. The results given in Tables 2-9 and 2-10 do not apply to intensified systems.

2.8. REFERENCES

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2. D. Kryskowski and G. H. Suits, "Natural Sources," in *Sources of Radiation*, G. J. Zissis, ed., pp. 151-209, Volume 1, *The Infrared and Electro-Optical Systems Handbook*, J. S. Accetta and D. L. Shumaker, eds., copublished by Environmental Research Institute of Michigan, Ann Arbor, MI, and SPIE Press, Bellingham, WA (1993).
3. E. B. Noel, "Radiation from High Pressure Mercury Arcs," *Illumination Engineering*, Vol. 36, pg. 243 (1941).
4. The ONTAR Corporation, 129 University Road, Brookline, MA 02146-4532, offers a variety of atmospheric transmittance codes.
5. F. E. Nicodemus, "Normalization in Radiometry," *Applied Optics*, Vol. 12(12), pp. 2960-2973 (1973).
6. *Burle Electro-Optics Handbook*, TP-135, pg. 73, Burle Industries, Inc., Lancaster, PA (1974). Formerly known as the *RCA Electro-Optics Handbook*.

3

SOLID STATE ARRAYS

CCD refers to a semiconductor architecture in which charge is transferred through storage areas. The CCD architecture has three basic functions: (a) charge collection, (b) charge transfer, and (c) the conversion of charge into a measurable voltage. A CCD can be attached to a variety of detectors. The basic building block of the CCD is the metal-insulator-semiconductor (MIS) capacitor. It is also called a gate. The most important MIS is the metal-oxide-semiconductor (MOS). Because the oxide of silicon is an insulator, it is a natural choice.

For monolithic devices, charge generation is often considered as the initial function of the CCD. With silicon photodetectors, each absorbed photon creates an electron-hole pair. Either the electrons or holes can be stored and transferred. For frame transfer devices, charge generation occurs under a MOS capacitor (also called a photogate). For some devices (notably interline transfer devices) photodiodes create the charge. The charge created at a pixel site is in proportion to the incident light level present. The aggregate effect of all the pixels is to produce a spatially sampled representation of the continuous scene.

Because most sensors operating in the visible region use a CCD architecture to move a charge packet, they are popularly called CCD arrays. However, the charge injection device (CID) does not use a CCD for charge transfer. Rather, two overlapping silicon MOS capacitors share the same row and column electrode. Pixel readout occurs by sensing the charge transfer between the capacitors at the pixel site.

Recently, active pixels have been introduced. These devices are fabricated with complementary-metal-oxide-semiconductor (CMOS) technology. The advantage is that one or more active transistors can be integrated into the pixel. As such, they become fully addressable (can read selected pixels) and can perform on-chip image processing.

Considerable literature[1-8] has been written on the physics, fabrication, and operation of CCDs. The charge transfer physics is essentially the same for all CCD arrays. However, the number of phases and number and location of the serial shift readout registers vary by manufacturer. The description that follows should be considered as illustrative. A particular design may vary significantly

from the simplified diagrams shown in this chapter. A specific device may not have all the features listed or may have additional features not listed.

Although CCD arrays are commonplace, the fabrication is quite complex. Theuwissen[9] provides an excellent step-by-step procedure for fabricating CCDs. He provides a 29-step procedure supplemented with detailed diagrams. Actual CCDs may require over 150 different operations. The complexity depends upon the array architecture.

Devices may be described functionally according to their architecture (frame transfer, interline transfer, etc.) or by application. To minimize cost, array complexity, and electronic processing, the architecture is typically designed for a specific application. For example, astronomical cameras typically use full frame arrays whereas video systems generally use interline transfer devices. The separation between general imagery, machine vision, scientific, and military devices becomes fuzzy as technology advances.

The symbols used in this book are summarized in the *Symbol List* (page xviii) which appears after the *Table of Contents*.

3.1. PHOTODETECTION

When an absorbed photon creates an electron-hole pair, the photodetection process has occurred. To be a useful detector in a solid state array, the photogenerated carrier must be collected in a storage site. The absorption coefficient is wavelength specific and decreases with increasing wavelength. Some of the incident photons will be reflected at the array's surface. The remainder may pass through layers of electrodes and insulators before reaching the photoactive material. Thus, the absorption characteristics of the overlying layers, thickness of the photoactive material, and the location of the storage site determine the spectral quantum efficiency (discussed in Section 4.1.1., *Spectral Response*).

After photodetection, the stored charge is read out. The array architecture often is optimized for a specific application. General imagery systems are designed for interlace operation consistent with a standard video (e.g., EIA 170). Research devices may operate in the progressive scan mode. This reduces some image distortion when the object is moving. For scientific applications the output may be in the slow scan mode, which simply means that the data read out rate is lower than a standard frame rate (e.g., EIA 170).

3.1.1. PHOTOGATE

The photogate is a photoactive MOS capacitor where the photogenerated carriers are stored in a depletion region. The storage capacity depends upon substrate doping, gate voltage, and oxide thickness. Very large capacities are possible. Because photogates have overlaying electrodes, the quantum efficiency in the blue region of the spectrum is reduced.

3.1.2. PHOTODIODE

With photodiodes, a depletion region is formed between the n- and p-type regions. The photogenerated carriers are usually stored at the junction until readout. The width of the junction limits the storage capability. The junction is initially reverse biased by a MOS gate. As the electrons, n_e, are collected, the voltage drops by

$$\Delta V = \frac{n_e q}{C} . \tag{3-1}$$

After readout, the voltage is reset to its original value. If the number of electrons is large, the voltage is reduced to zero and saturation occurs. Excess photoelectrons will diffuse to neighboring wells and create blooming. Photodiodes do not have an overlaying structure and therefore have higher quantum efficiency than comparable photogates.

With a photodiode, a transfer gate is required to move the stored electrons into the CCD. Devices with photodiodes are often labeled as CCPD for charge-coupled photodiodes. While transfer gates are essential for CCPDs, they may also exist in devices with photogates.

The hole accumulation diode (HAD) is a pinned photodiode that offers the best features of the photogate and photodiode. It offers the high blue response of the photodiode and large well capacity of the photogate.

3.2. CCD ARRAY OPERATION

Applying a positive voltage to the CCD gate causes the mobile positive holes in the p-type silicon to migrate toward the ground electrode because like charges repel. This region, which is void of positive charge, is the depletion region (Figure 3-1). If a photon whose energy is greater than the energy gap is

absorbed in the depletion region, it produces an electron-hole pair. The electron stays within the depletion region whereas the hole moves to the ground electrode. The amount of negative charge (electrons) that can be collected is proportional to the applied voltage, oxide thickness, and gate electrode area. The total number of electrons that can be stored is called the well capacity.

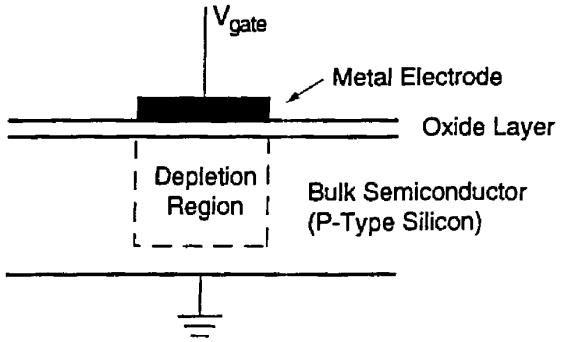


Figure 3-1. Metal-oxide-semiconductor (MOS) gate for p-type silicon. Although the depletion region (charge well) is shown to have an abrupt transition, its actual shape is gradual. That is, the well is formed by a two-dimensional voltage gradient.

The CCD register consists of a series of gates. Manipulation of the gate voltage in a systematic and sequential manner transfers the electrons from one gate to the next in a conveyor-belt-like fashion. For charge transfer, the depletion regions must overlap. The depletion regions are actually gradients and the gradients must overlap for charge transfer to occur. Efficient overlap occurs when the gate electrodes overlap (Figure 3-2). The multilevel polysilicon structure minimizes the gap between adjacent electrodes. Without this structure, charge transfer would be poor. For clarity, throughout the remainder of the text, the structure will be illustrated as adjacent, non-overlapping gates.

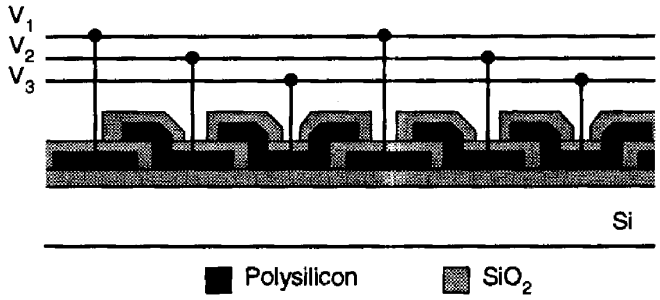


Figure 3-2. Three-phase CCD. The gates must overlap for efficient charge transfer.

Each gate has its own control voltage that is varied as a function of time. The voltage is called the clock or clocking signal. When the gate voltage is low, it acts as a barrier whereas when the voltage is high, charge can be stored. Initially, a voltage is applied to gate 1 and photoelectrons are collected in well 1 (Figure 3-3b). When a voltage is applied to gate 2, electrons move to well 2 in a waterfall manner (Figure 3-3c). This process is rapid and the charge quickly equilibrates in the two wells (Figure 3-3d). As the voltage is reduced on gate 1, the well potential decreases and electrons again flow in a waterfall manner into well 2 (Figure 3-3e). Finally, when gate 1 voltage reaches zero, all the electrons are in well 2 (Figure 3-3f). This process is repeated many times until the charge is transferred through the shift register.

The CCD array is a series of column registers (Figure 3-4). The charge is kept within rows or columns by channel stops or channel blocks and the depletion regions overlap in one direction only. At the end of each column is a horizontal register of pixels. This register collects a line at a time and then transports the charge packets in a serial fashion to an output amplifier. The entire horizontal serial register must be clocked out to the sense node before the next line enters the serial register. Therefore, separate vertical and horizontal clocks are required for all CCD arrays. This process creates a serial data stream that represents the two-dimensional image.

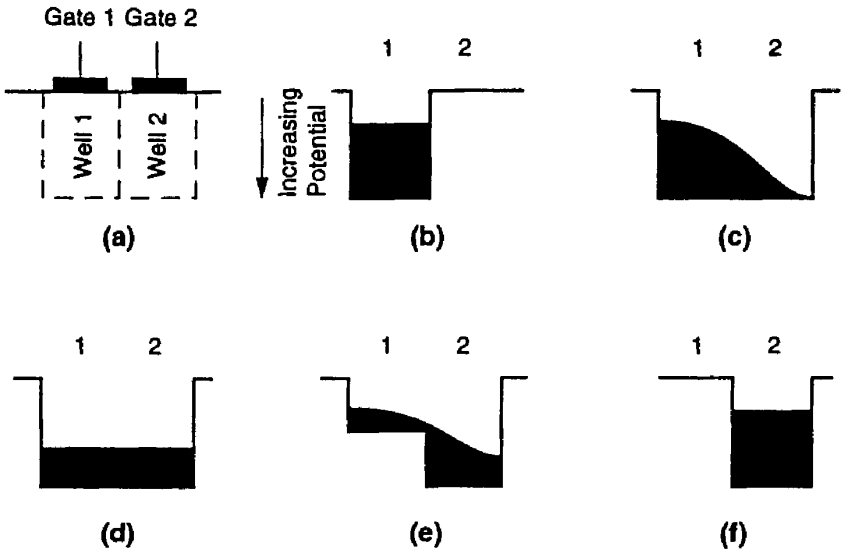


Figure 3-3. Charge transfer between two wells. (a) Adjacent wells. (b) Charge in well 1. (c) After a voltage is applied to gate 2, electrons flow into well 2. (d) Equilibration of charge. (e) Reduction of gate 1 voltage causes the electrons in well 1 to transfer into well 2. (f) All electrons have been transferred to well 2.

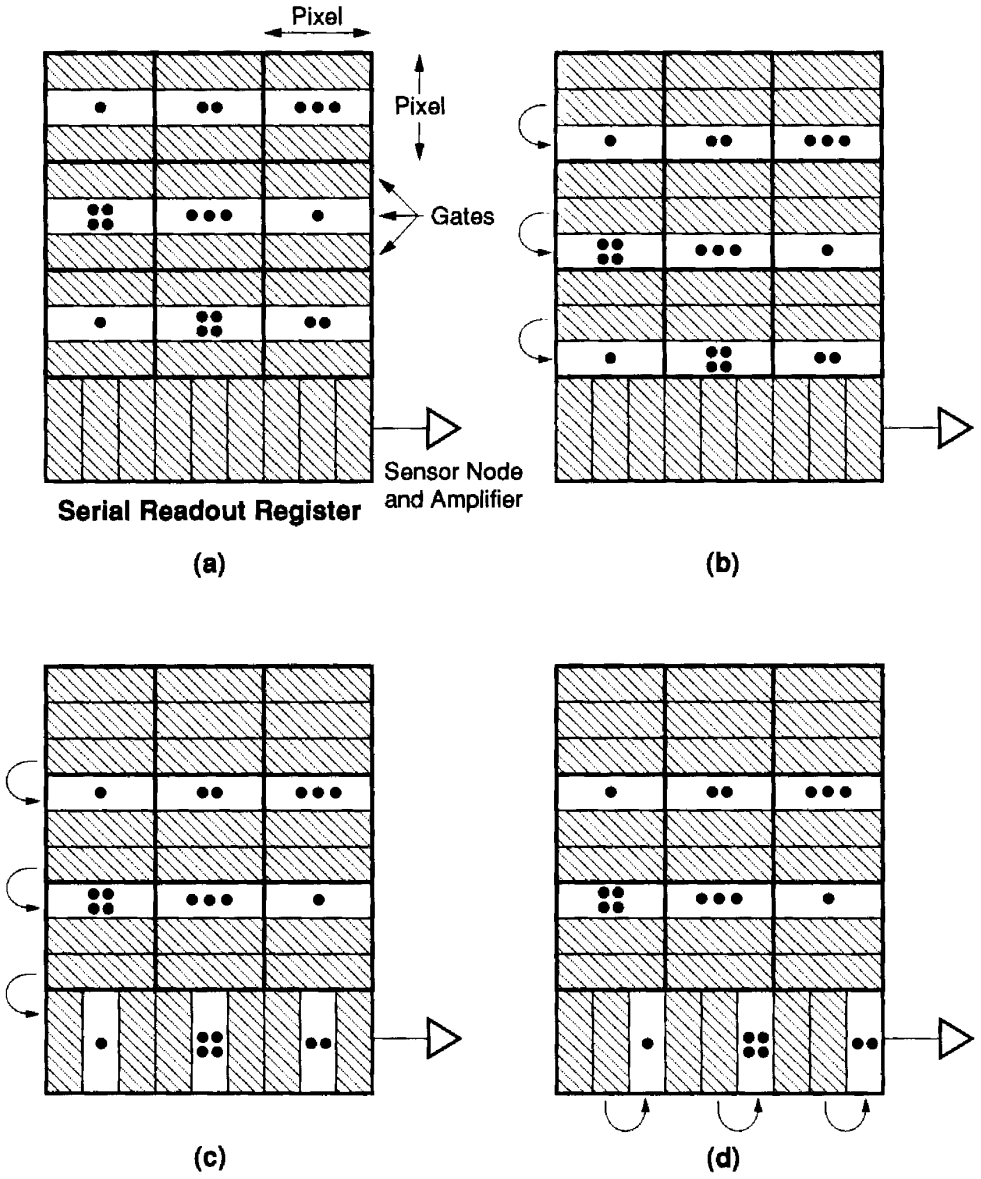


Figure 3-4. Representative CCD operation of a 3 × 3 array with three gates per pixel. Nearly all the photoelectrons generated within a pixel are stored in the well beneath that pixel. (a) The CCD is illuminated and an electronic image is created. (b) The columns are shifted down in parallel, one gate at a time. (c) Once in the serial row register, the pixels are shifted right to the output node. (d) The entire serial register must be clocked out before the next packet can be transferred into the serial readout register.

Although any number of transfer sites (gates) per detector area can be used, it generally varies from two to four. With a four-phase device, the charge is stored under two or three wells depending upon the clock cycle. Figure 3-5 represents the steady state condition after the gates have switched and the charge has equilibrated within the wells. It takes a finite time for this to happen. Figure 3-6 illustrates the voltage levels that created the wells shown in Figure 3-5. The time that the charge has equilibrated is also shown. The clock rate is $f_{CLOCK} = 1/t_{CLOCK}$ and is the same for all phases. The output video is valid once per clock pulse (selected as T_2) and occurs after the charge has equilibrated (e.g., Figure 3-3b or Figure 3-3f). Only one master clock is required to drive the array. Its phase must be varied for the gates to operate sequentially. An anti-parallel clocking scheme is also possible. Here V_3 is the inverse of V_1 and V_4 is the inverse of V_2. That is, when V_1 is high, V_3 is low. The anti-parallel clock system is easier to implement because phasing is not required. With the anti-parallel scheme, charge is always stored in two wells. For equal pixel sizes, four-phase devices offer the largest well capacity compared to the two- or three-phase systems. With the four-phase system, 50% of the pixel area is available for the well.

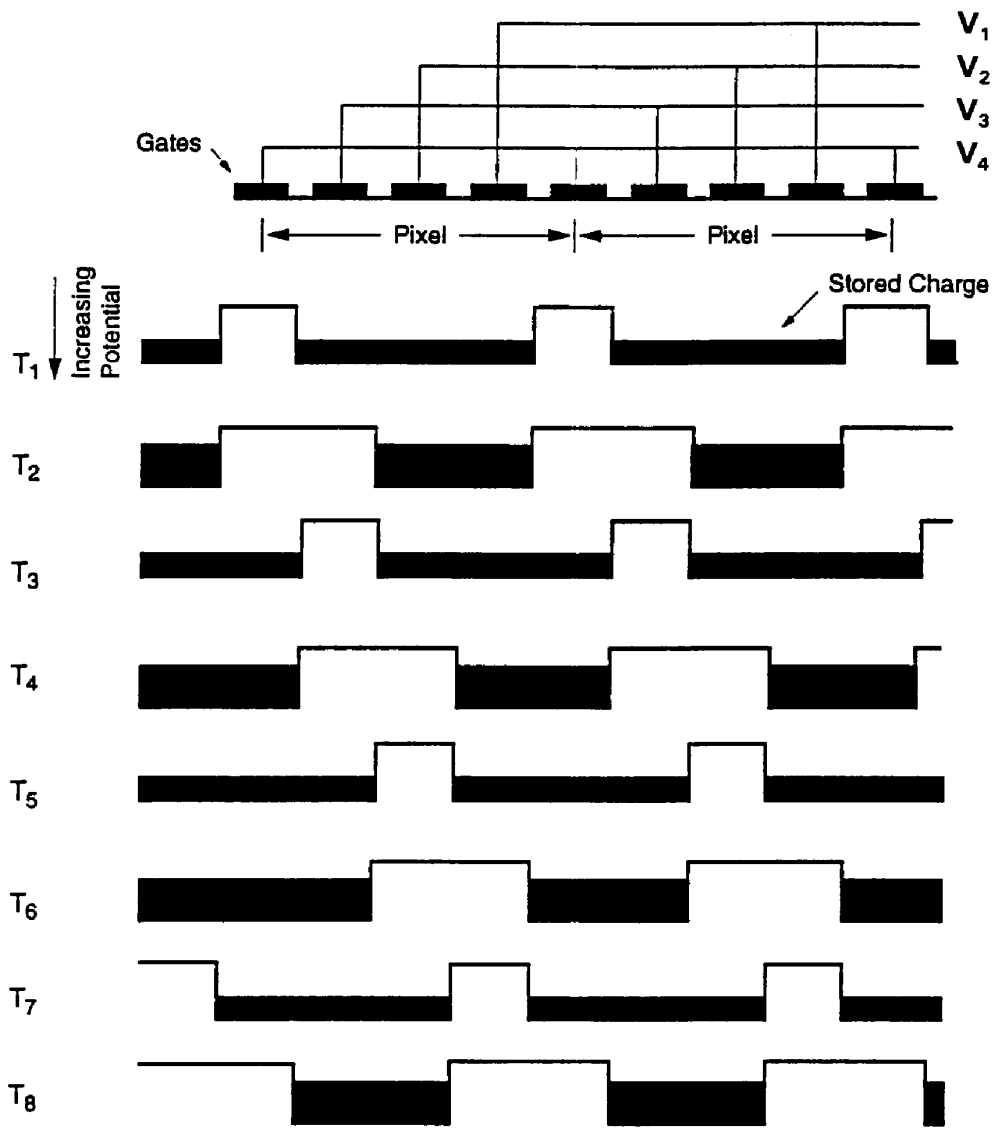


Figure 3-5. Charge transfer in a four-phase device after equilibration. This represents one column. Rows go into the paper. Charge is moved through storage sites by changing the gate voltages as illustrated in Figure 3-6. A four-phase array requires four separate clock signals to move a charge packet to the next pixel. A four-phase device requires eight steps to move the charge from one pixel to the next. (After Reference 10).

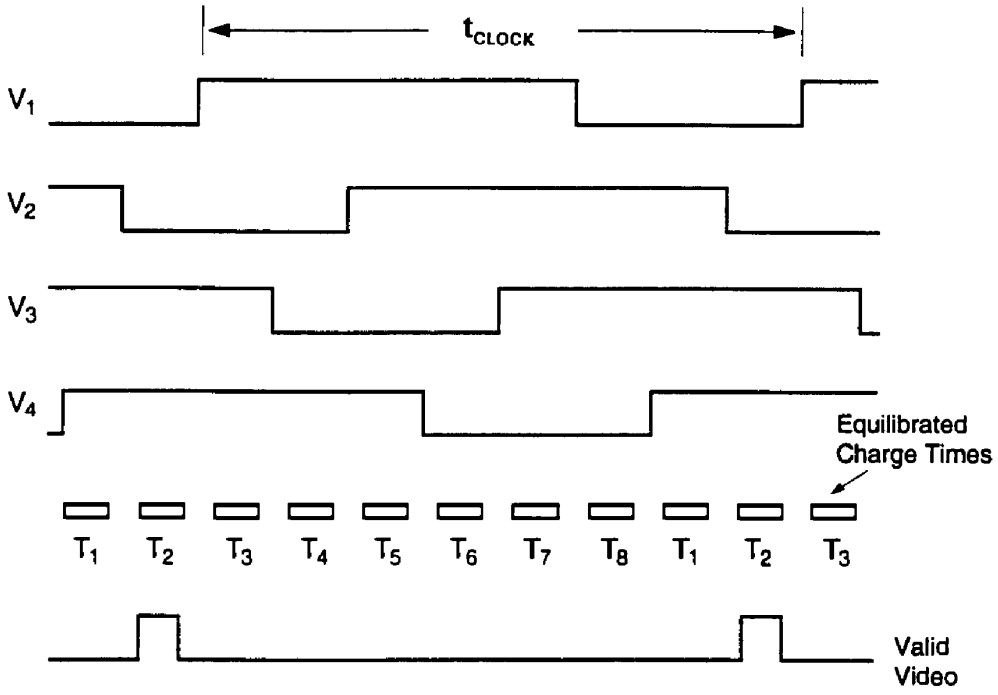


Figure 3-6. Voltage levels for a four-phase system. As the voltage is applied, the charge packet moves to that well. By sequentially varying the gate voltage, the charge moves off the horizontal shift register and onto the sense capacitor. The clock signals are identical for all four phases but offset in time (phase). The valid video is available once per clock pulse (selected as T_2). (After Reference 10).

The three-phase system (Figure 3-7 and Figure 3-8) stores the charge under one or two gates. Only 33% of the pixel area is available for the well capacity. With equal potential wells, a minimum number of three phases are required to clock out charge packets efficiently.

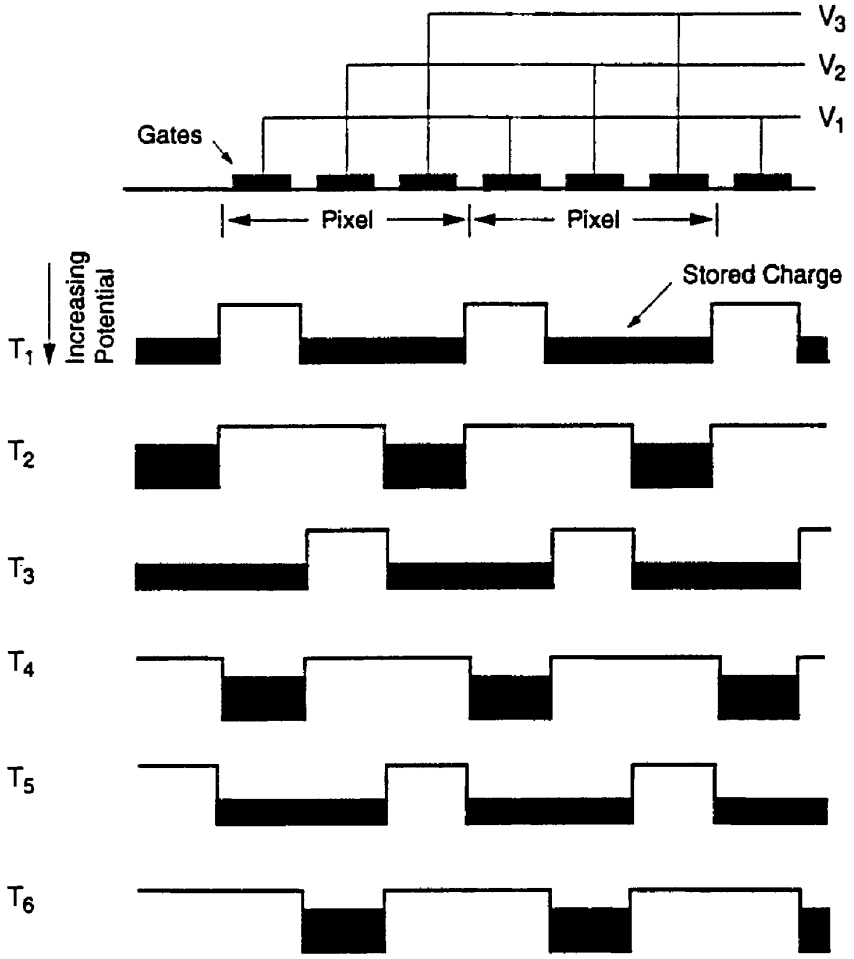


Figure 3-7. Charge transfer in a three-phase device. This represents one column. Rows go into the paper. Six steps are required to move the charge one pixel. (After Reference 10).

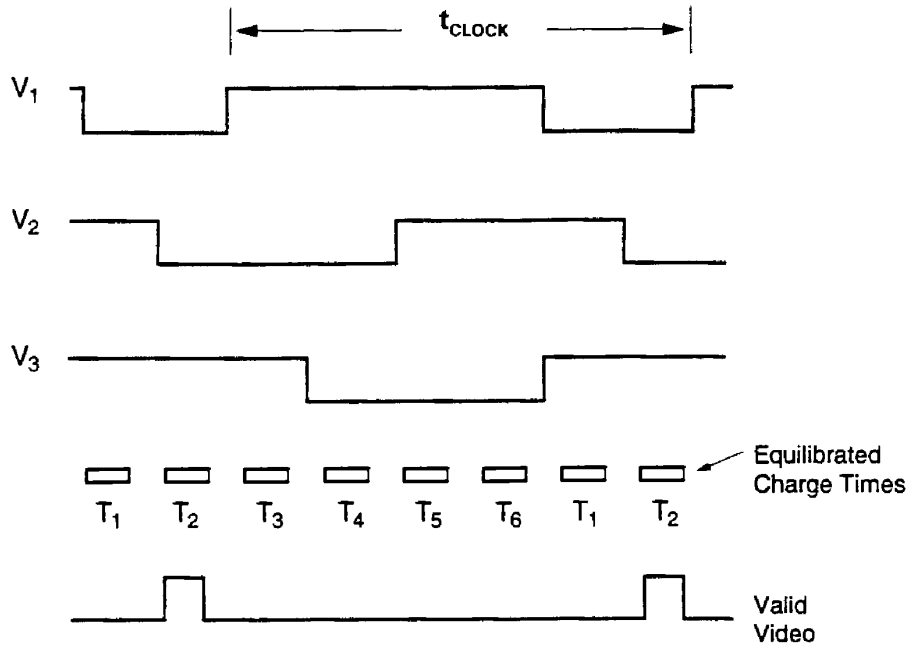


Figure 3-8. Voltage levels for a three-phase system. The clock signals are identical for all three phases but offset in time. T_2 was selected as the valid video time. Valid video exists only after the charge has equilibrated. (After Reference 10).

The well potential depends on the oxide thickness underneath the gate. In Figure 3-9, the alternating gates have different oxide thicknesses and therefore will create different well potentials. With different potentials it is possible to create a two-phase device. Charge will preferentially move to the right-hand side of the pixel where the oxide layer is thinner. Assume initially that the wells controlled by V_2 are empty. This will occur after a few clock pulses. At time T_1, both clocks are low. When V_2 is raised, the potential increases as shown at time T_2. Because the effective potential increases across the gates, the charge cascades down to the highest potential. Then V_2 is dropped to zero and the charge is contained under the V_2 gate at time T_3. This process is repeated until the charge is clocked off the array. The voltage timing is shown in Figure 3-10. While Figure 3-9 illustrates variations in the oxide layer, the potential wells can also be manipulated though ion implantation. As with the four-phase device, the two-phase device can also be operated in the anti-parallel mode: V_2 is a mirror image of V_1. That is, when V_1 is high, V_2 is low.

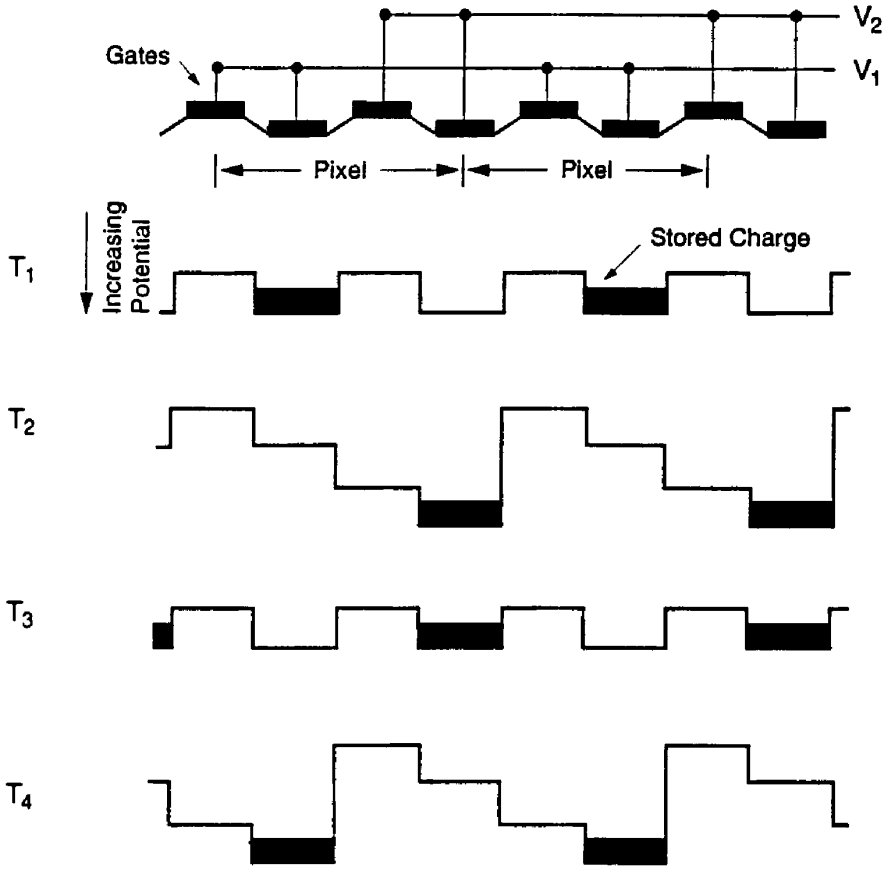


Figure 3-9. Charge transfer in a two-phase device. Well potential depends on the oxide thickness. (After Reference 10).

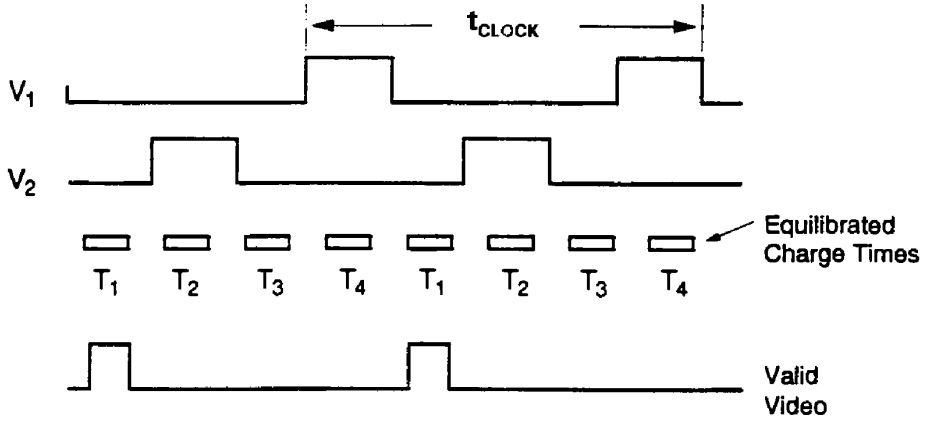


Figure 3-10. Voltage levels for a two-phase system. (After Reference 10).

The virtual phase device requires only one clock (Figure 3-11). Additional charge wells are created by internally biased gates. Charge is stored either beneath the active gate or the virtual gate. When V_1 is low, the charge will cascade down to the highest potential (which is beneath the virtual well). When V_1 is applied at T_2, the active gate potential increases and the charge moves to the active gate well.

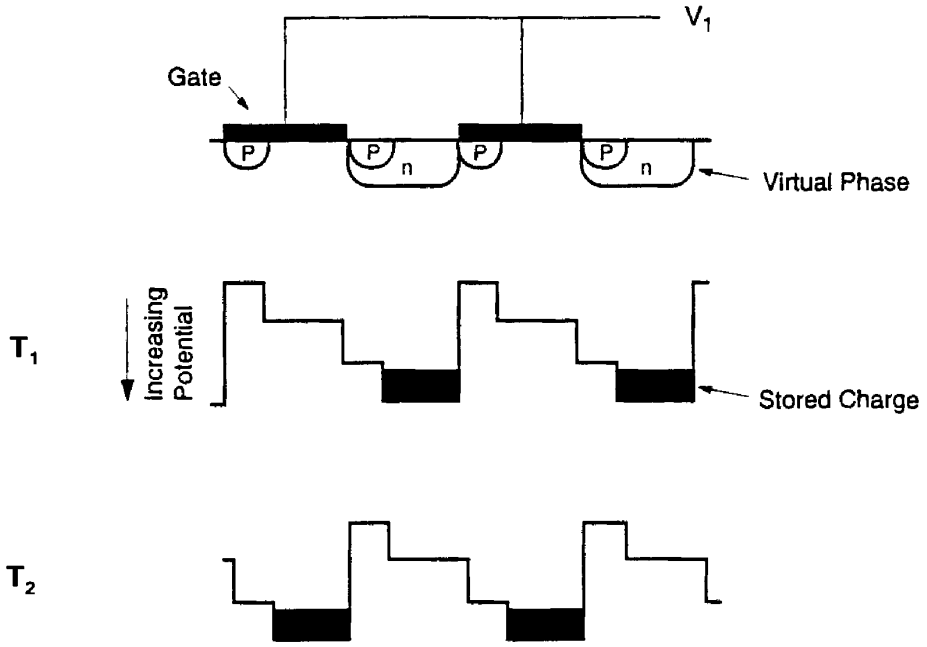


Figure 3-11. Charge transfer in a device with a virtual phase. The virtual well is created by p- and n-material implants. These ions create a fixed bias and therefore a well with fixed potential. By changing V_1, the active gate potential can be lower than the virtual well (T_1) or higher (T_2). This represents one column. Rows go into the paper.

The final operating step is to convert the charge packet to a measurable voltage. This is accomplished by a floating diode or floating diffusion. The diode, acting as a capacitor, creates a voltage proportional to the number of electrons [discussed in Section 3.5., *Charge Conversion (Output Structure)*]. With many arrays, it is possible to shift more than one row of charge into the serial register. Similarly, it is possible to shift more than one serial register element into a summing gate just before the output node. This is called charge grouping, binning, super pixeling, or charge aggregation. Binning increases

signal output and dynamic range at the expense of spatial resolution. Because it increases the signal-to-noise ratio, binning is useful for low light level applications for those cases where resolution is less important. Serial registers and the output node require larger capacity charge wells for binning operation. If the output capacitor is not reset after every pixel, then it can accumulate charge.

3.3. CCD ARRAY ARCHITECTURE

Array architecture is driven by the application. Full frame and frame transfer devices tend to be used for scientific applications. Interline transfer devices are used in consumer camcorders and professional television systems. Linear arrays, progressive scan, and time delay and integration (TDI) are used for industrial applications. Despite an ever increasing demand for color cameras, black and white cameras are widely used for many scientific and industrial applications.

3.3.1. LINEAR ARRAYS

The simplest arrangement is the linear array or single line of detectors. While these could be photogates, photodiodes are used more often because they have higher quantum efficiency. Linear arrays are used in applications where either the camera or object is moving in a direction perpendicular to the row of sensors. They are used where rigid control is maintained on object motion such as in document scanning.

Located next to each sensor is the transfer gate and then the CCD shift register (Figure 3-12a). The shift register is also light sensitive and is covered with a metal light shield. Overall pixel size is limited by the photodiode size. For example, with a three-phase system, the pixel width is three times the width of a single gate. For a fixed gate size, the active pixel width can be reduced with a bilinear readout (Figure 3-12b). Because resolution is inversely related to the detector-to-detector spacing (pixel pitch), the bilinear readout has twice the resolution. For fixed pixel size, the bilinear readout increases the effective charge transfer efficiency because the number of transfers is reduced by a factor of 2 (discussed in Section 3.4., *Charge Transfer Efficiency*).

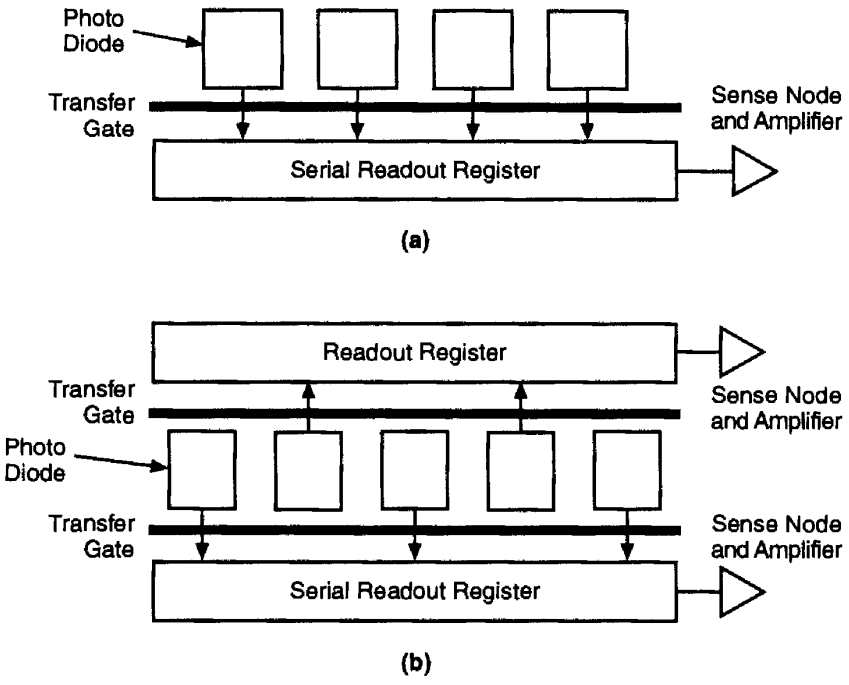


Figure 3-12. Linear array. (a) Simple structure and (b) bilinear readout. The transfer gate clock pulse allows charge to move from the photodiode into the CCD transfer register.

3.3.2. FULL FRAME ARRAYS

Figure 3-13 illustrates a full frame transfer (FFT) array. After integration, the image pixels are read out line-by-line through a serial register that then clocks its contents onto the output sense node (see Figure 3-4, page 50). All charge must be clocked out of the serial register before the next line can be transferred. In full frame arrays, the number of pixels is often based upon powers of 2 (e.g., 512 × 512, 1024 × 1024) to simplify memory mapping. Scientific arrays have square pixels and this simplifies image processing algorithms.

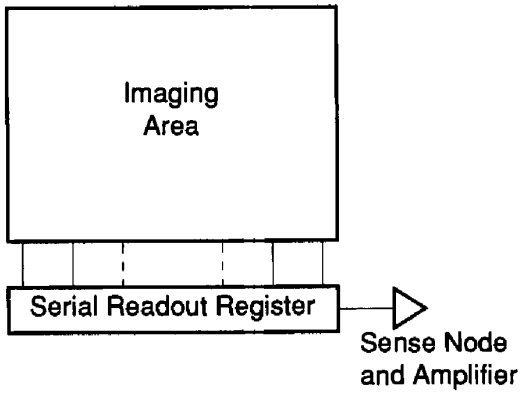


Figure 3-13. Full frame architecture. Because photogates are used, transfer gates are not essential.

During read out, the photosites are continually illuminated resulting in a smeared image. The smear will be in the direction of the charge transport in the imaging part of the array. A mechanical or external electronic shutter can be used to shield the array during readout to avoid smear. When using strobe lights to illuminate the image, no shutter is necessary if the transfer is between strobe flashes. If the image integration time is much longer than the readout time, then the smear may be considered insignificant. This situation often occurs with astronomical observations.

Data rates are limited by the amplifier bandwidth and, if present, the conversion capability of the analog-to-digital converter. To increase the effective readout rate, the array can be divided into subarrays that are read out simultaneously. In Figure 3-14, the array is divided into four subarrays. Because they are all read out simultaneously, the effective clock rate increases by a factor of 4. Software then reconstructs the original image. This is done in a video processor external to the CCD device where the serial data are decoded and reformatted.

Large area devices often allow the user to select one subarray for readout. Thus, the user can trade frame rate against image size. This allows the user to obtain high frame rates over the area of interest (discussed in Section 4.5., *Frame Rates*).

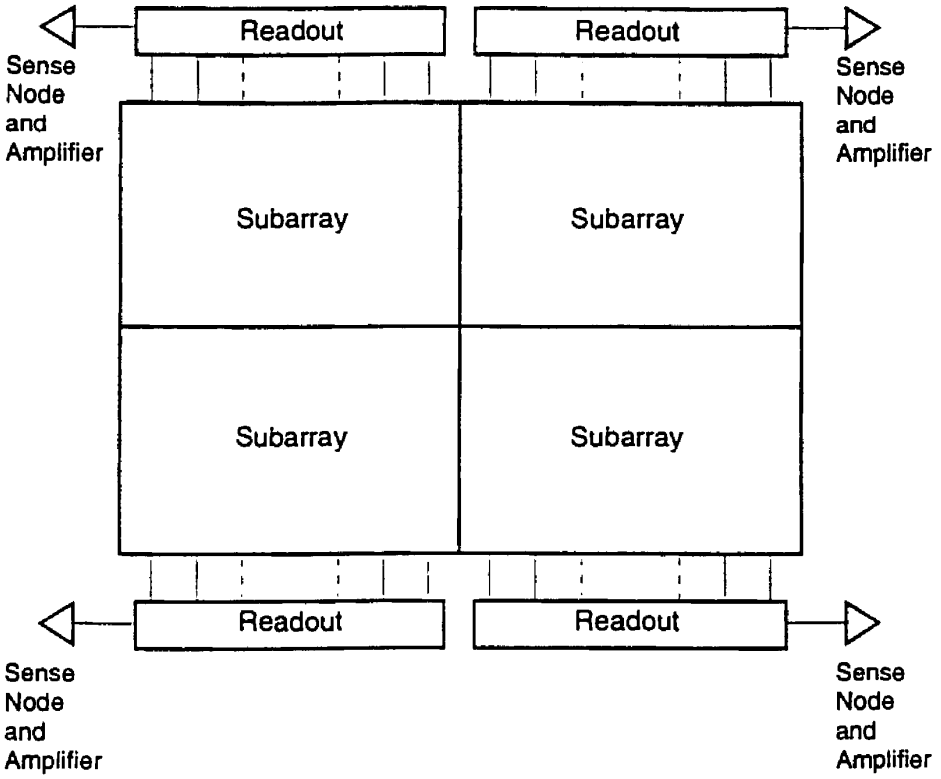


Figure 3-14. A large array divided into four subarrays. Each subarray is read out simultaneously to increase the effective data rate. Very large arrays may have up to 32 parallel outputs. The subimages are reassembled in electronics external to the device to create the full image.

3.3.3. FRAME TRANSFER

A frame transfer (FT) imager consists of two almost identical arrays, one devoted to image pixels and one for storage (Figure 3-15). The storage cells are identical in structure to the light sensitive cells but are covered with a metal light shield to prevent any light exposure. After the integration cycle, charge is transferred quickly from the light sensitive pixels to the storage cells. Transfer time to the shielded area depends upon the array size but is typically less than 500 μs. Smear is limited to the time it takes to transfer the image to the storage area. This is much less time than that required by a full frame device.

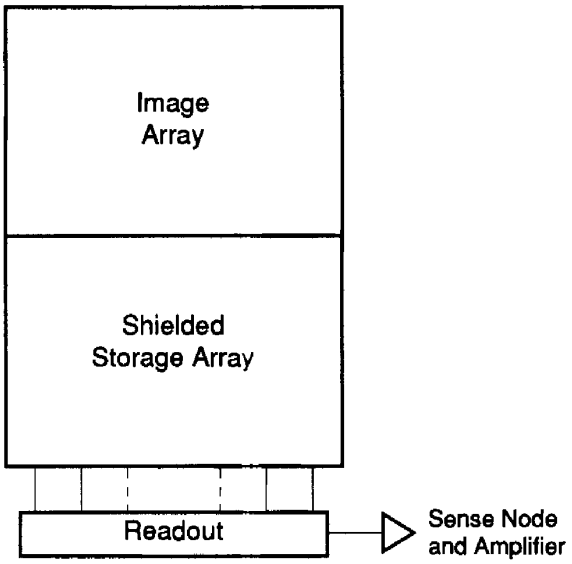


Figure 3-15. Basic architecture for a full frame CCD. Frame transfer devices can also have a split architecture similar to that shown in Figure 3-14.

The array may have a few dummy charge wells between the active and storage areas. These wells collect any anticipated light leakage and their data are ignored. Some arrays do not have the integral light shield. These arrays can either be operated in the full frame mode (e.g., 512 × 512) or in the frame transfer mode (e.g., 256 × 512). Here, it becomes the user's responsibility to design the light shield for the frame transfer mode.

☞

Example 3-1
SHIELD DESIGN

A camera manufacturer buys a full frame transfer array (512 × 512) but wants to use it in a frame transfer mode (256 × 512). An engineer designs an opaque shield that is placed 1 mm above the array. He is using f/5 optics. What is the usable size of the array if the pixels are 20 μm square and the shield edge is centered on the array?

When placed near the focal plane, the shield edge will create a shadow that is approximately the distance from the focal plane (d = 1 mm) divided by the f-number (F = 5). The full shadow is 200 μm or 10 pixels. One-half of the shadow falls on the active pixels and one-half illuminates the pixels under the shield. This results in a usable array size of 251 × 512. An alignment error of 0.5 mm adds an additional 25 pixels. If the alignment error covers active pixels, the active area is reduced to 226 × 512. If the error covers shielded pixels, the storage area is reduced to 226 × 512. Either way, the usable array is 226 × 512.

Example 3-2
USEFUL ARRAY SIZE

A consumer wants to operate the camera designed in Example 3-1 under relatively low illumination levels. He changes the lens to one with f-number of 1.25. Will he be satisfied with the imagery?

The lower f-number increases the shadow to 40 pixels. Assuming an alignment error of 0.5 mm, the minimum usable area size has dropped to 211 × 512 with a "soft edge" of 40 pixels. Acceptability of this image size depends upon the application.

3.3.4. INTERLINE TRANSFER

The interline transfer (IL) array consists of photodiodes separated by vertical transfer registers that are covered by an opaque metal shield (Figure 3-16). Although photogates could be used, photodiodes offer higher quantum efficiency (discussed in Section 4.1.1., *Spectral Response*). After integration, the charge generated by the photodiodes is transferred to the vertical CCD registers in about 1 μs and smear is minimized. The main advantage of interline transfer is that the transfer from the active sensors to the shielded storage is quick. There is no need to shutter the incoming light. The electronic shutter open time can be variable if an antibloom drain is present (discussed in Section 3.8., *Antibloom Drain*). The shields act like a Venetian blind that obscures half the information that is available in the scene. The area fill-factor may be as low as 20%. Because the detector area is only 20% of the pixel area, the output voltage is only 20% of a detector that would completely fill the pixel area. Microlenses increase the optical fill-factor (discussed in Section 3.11.1., *Microlenses*).

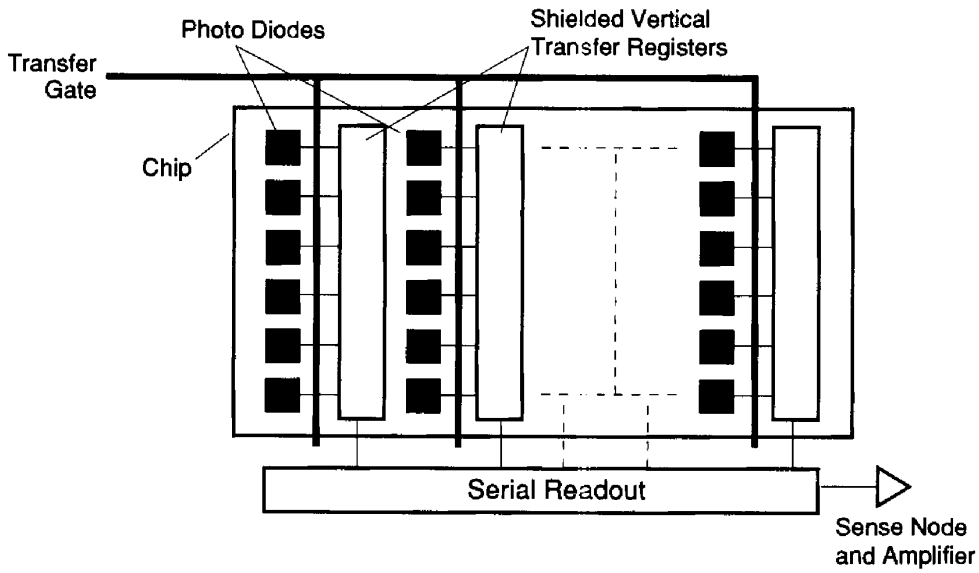


Figure 3-16. Interline transfer architecture. The charge is rapidly transferred to the interline transfer registers via the transfer gate. The registers may have three or four gates. Interline transfer devices can also have a split architecture similar to that shown in Figure 3-14 (page 61).

The combination of the capacitances associated with the photodiode and transfer gate provide a time constant that limits the speed of transfer to the vertical CCD register. As a result not all the charge is read out and some is left behind. This residual charge is added to the next frame and results in image lag. That is, with photodiodes, the remaining charge is drained in successive readouts causing an after-image. But hole accumulation devices can be completely emptied and no image lag occurs.

A fraction of the light can leak into the vertical registers. This effect is most pronounced when viewing an ambient scene that has a bright light in it. For professional television applications, the frame interline transfer (FIT) array was developed to achieve even lower smear values (Figure 3-17).

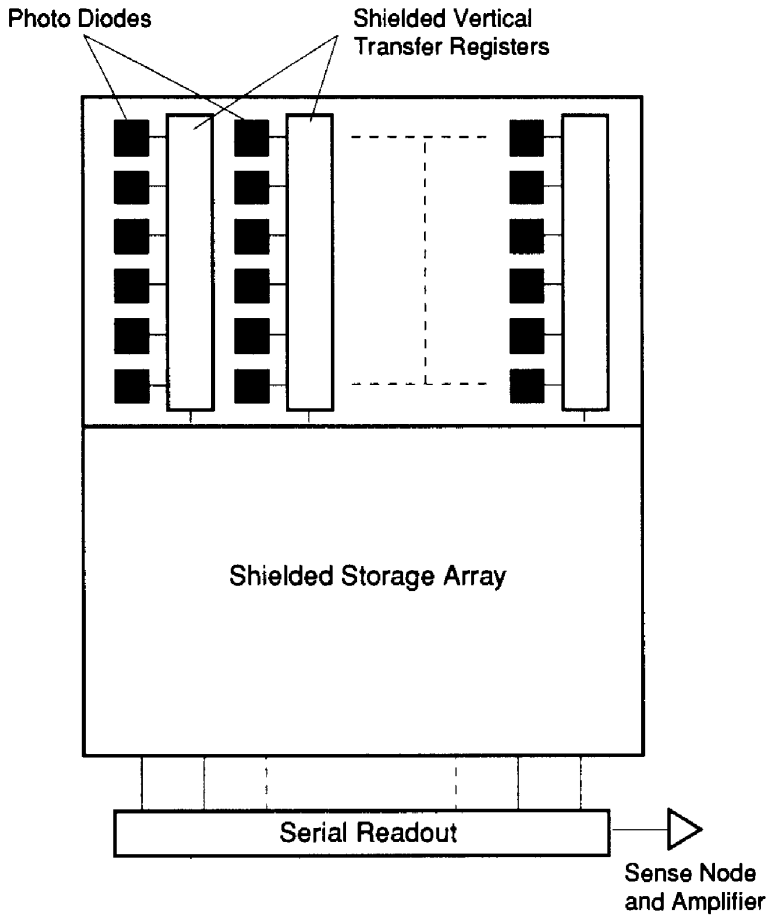


Figure 3-17. Frame interline transfer architecture. Both the vertical transfer registers and storage area are covered with an opaque mask to prevent light exposure. The transfer gates are not shown.

A variety of transfer register architectures are available. A register can operate with virtual, two, three, or four phases. The number of phases selected depends upon the application. Because interline devices are most often found in general imagery products, most transfer register designs are based upon standard video timing (discussed in Section 5.2.1., *Video Timing*). Figure 3-18 illustrates a four-phase transfer register that stores charge under two gates. With 2:1 interlace, both fields are collected simultaneously but are read out alternately. This is called frame integration. With EIA 170 (formerly called RS 170), each field is read every 1/60 s. Because the fields alternate, the maximum integration time is 1/30 s for each field.

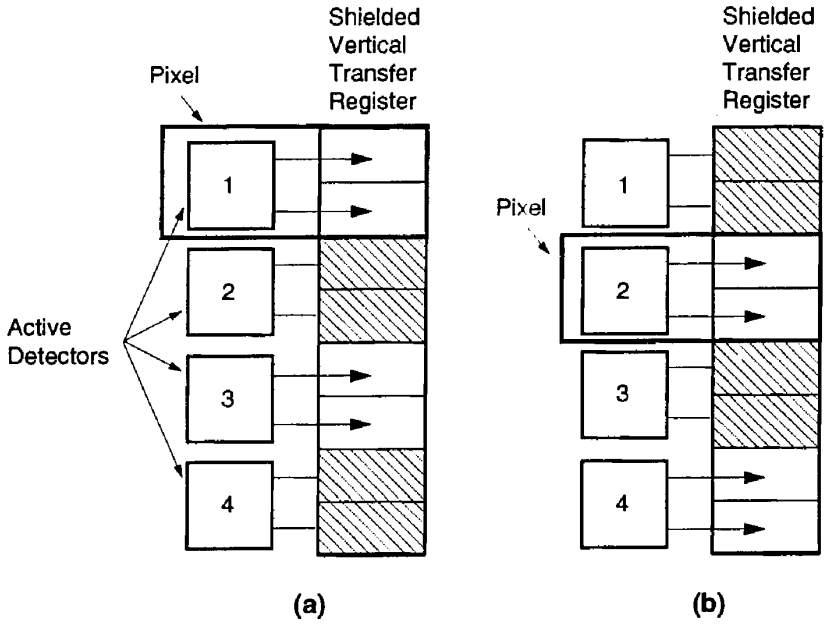


Figure 3-18. Detailed layout of the 2:1 interlaced array. (a) The odd field is clocked into the vertical transfer register and (b) the even field is transferred. The vertical transfer register has four gates and charge is stored under two wells. The pixel is defined by the detector center-to-center spacing and it includes the shielded vertical register area. The transfer gate is not shown. (After Reference 11).

Pseudo-interlacing (sometimes called field integration) is shown in Figure 3-19. Changing the gate voltage shifts the image centroid by one-half pixel in the vertical direction. This creates 50% overlap between the two fields. The pixels have twice the vertical extent of standard interline transfer devices and therefore have twice the sensitivity. An array that appears to have 240 elements in the vertical direction is clocked so that it creates 480 lines. However, this reduces the vertical MTF (discussed in Section 8.3.2., *Detector Array Nyquist Frequency*). With some devices, the pseudo-interlace device can also operate in a standard interlace mode.

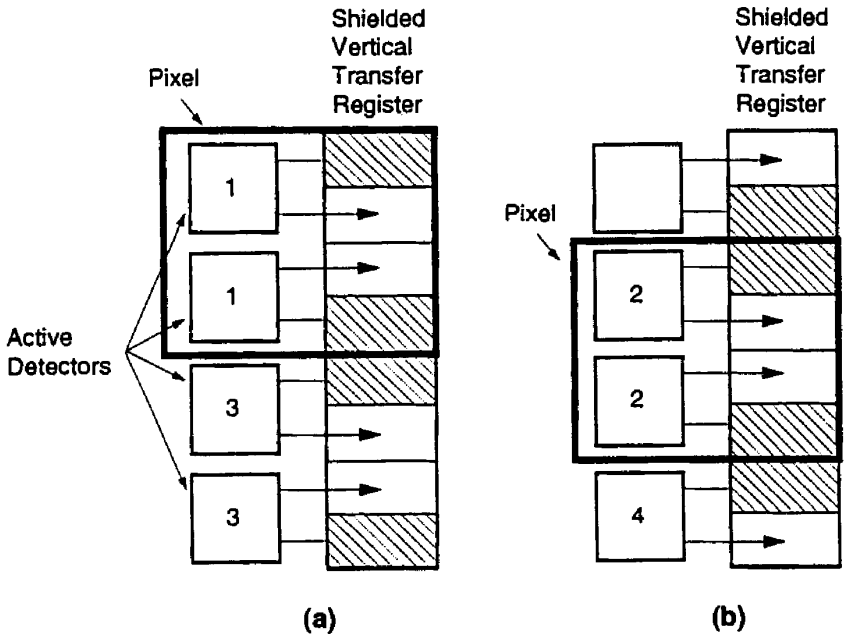


Figure 3-19. Pseudo-interlace. By collecting charge from alternating active detector sites, the pixel centroid is shifted by one-half pixel. (a) Odd field and (b) even field. The detector numbers are related to the "scan" pattern shown in Figure 3-20b. The transfer gate is not shown. (After Reference 11).

While any architecture can be used to read the charge, the final video format generally limits the selection. Although the charge is collected in rows and columns, the camera reformats the data into a serial stream consistent with the monitor requirements. This serial stream is related to a fictitious "scan" pattern. Figure 3-20 illustrates the video lines and field-of-view of a standard format imaging system. Figure 3-20a represents the "scan" pattern created by the interlace device shown in Figure 3-18 whereas Figure 3-20b represents the pseudo-interlace "scan" pattern of the device shown in Figure 3-19. Although the dissected scene areas overlap in Figure 3-20b, the video timing is consistent with the video format.

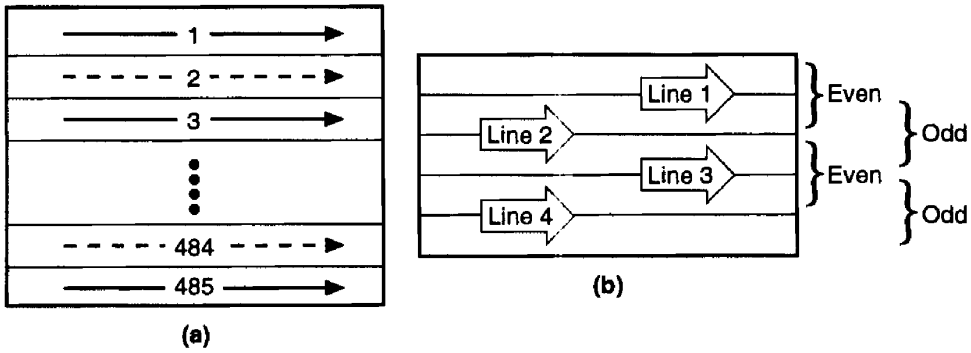


Figure 3-20. Fictitious "scan" patterns. The scan patterns help to visualize how the scene is dissected by the array architecture. (a) Interlace "scanning" achieved with the array shown in Figure 3-18. The solid lines are the odd field and the dashed lines are the even field. (b) Pseudo-interlace "scanning" provided by the array shown in Figure 3-19.

3.3.5. PROGRESSIVE SCAN

CCD arrays do not scan the image, but it is convenient to represent the output as if it were scanned. Progressive scan simply means the noninterlaced or sequential line-by-line scanning of the image. This is important to machine vision because it supplies accurate timing and has a simple format. Any application that requires digitization and a computer interface will probably perform better with progressively scanned imagery.

The primary advantage of progressive scan is that the entire image is captured at one instant of time. In contrast, interlaced systems collect fields sequentially in time. Any vertical image movement from field-to-field smears the interlaced image in a complex fashion. Horizontal movement serrates vertical lines. With excessive movement, the two fields will have images that are displaced one from the other (Figure 3-21).

If a strobe light is used to stop motion, the image will appear only in the field that was active during the light pulse. Because of image motion effects, only one field of data can be used for image processing. This reduces the vertical resolution by 50% and will increase vertical image aliasing.

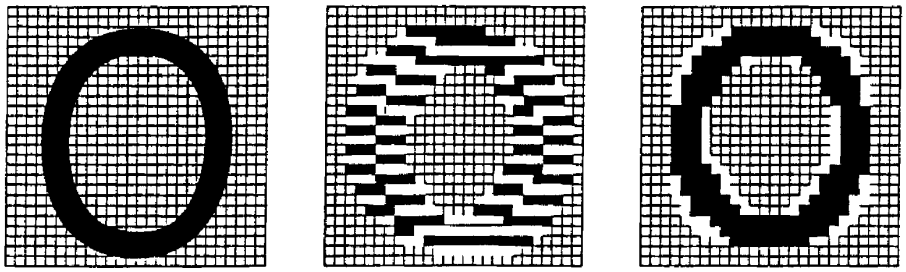


Figure 3-21. Effects of movement. (a) Character moving horizontally, (b) serration that occurs with an interlace system, and (c) output of a progressively scanned array. An image can still be smeared with progressive scanning but it won't be serrated.

Because an entire frame is captured, progressive scan devices do not suffer from same image motion effects seen with interlaced systems. Thus, progressive scan cameras are said to have improved vertical resolution over interlaced systems. Full frame and frame transfer devices inherently provide progressive scan readout. Although early interline transfer architecture was designed for interlace scanning, some current devices also provide progressive scan output.

Although the imagery is collected in a sequential method, camera electronics convert progressively scanned data into a standard video format (discussed in Section 5.2.2., *Broadcast/Non-Broadcast Design*). This allows the progressively scanned camera output to be viewed on any standard interlaced display. For scientific and industrial applications, the progressive output is captured by a frame grabber. Once in the computer, algorithms automatically reformat the data into the format required by the monitor. The camera pixel layout and array timing do not need to fit a specified format for these applications.

3.3.6. TIME DELAY and INTEGRATION

Time delay and integration (TDI) is analogous to taking multiple exposures of the same object and adding them[12]. The addition takes place automatically in the charge well and the array timing produces the multiple images. Figure 3-22 illustrates a typical TDI application. A simple camera lens inverts the image so the image moves in the opposite direction from the object. As the image is swept across the array, the charge packets are clocked at the same rate. The relative motion between the image and the target can be achieved in many ways. In airborne reconnaissance, the forward motion of the aircraft provides the motion with respect to the ground. With objects on a conveyor belt, the camera is stationary and the objects move. In a document flat bed scanner, the document is stationary but either the camera moves or a scan mirror moves.

Figure 3-23 illustrates four detectors operating in TDI mode. The charge increases linearly with the number of detectors in TDI. Shot noise also increases, but as the square root of the number of TDI elements, N_{TDI}. Theoretically, this results in an SNR improvement of $\sqrt{N_{TDI}}$. The well capacity limits the maximum number of TDI elements that can be used.

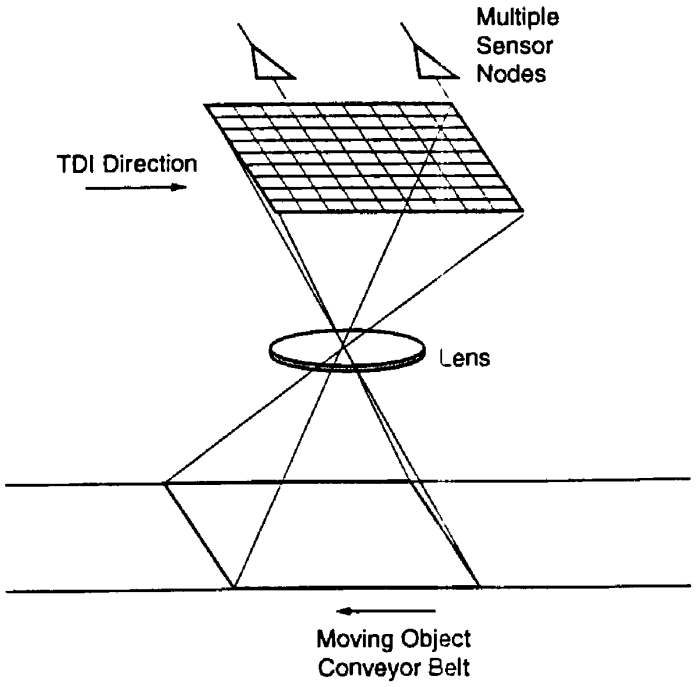


Figure 3-22. Typical TDI operation. The pixel clock rate must be matched to the image velocity.

For this concept to work, the charge packet must always be in synch with the moving image. If there is a mismatch between the image scan velocity and pixel clock rate, the output is smeared and this adversely affects the in-scan MTF (discussed in Section 10.3.3., *TDI*). The accuracy to which the image velocity is known limits the number of useful TDI stages.

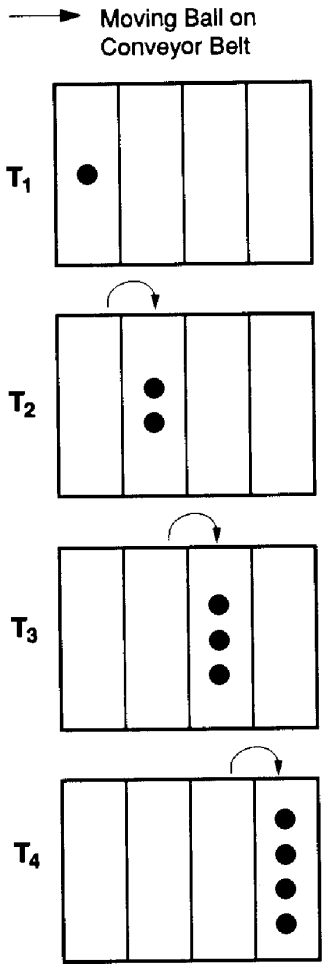


Figure 3-23. TDI concept. At time T_1, the image is focused onto the first detector element and creates a charge packet. At T_2 the image has moved to the next detector. Simultaneously, the charge packet is clocked down to the next pixel site. Here, the image creates additional charge that is added to the stored packet (created by the first detector). After four stages, the signal increases fourfold.

Although Figure 3-22 illustrates two readout registers, an array may have multiple readout registers. Array sizes may be as large as 2048 by 32 TDI elements. Additional readouts are required to avoid charge well saturation. The multiple readout outputs may be summed in electronics external to the TDI device or may be placed in a horizontal serial register for summing (Figure 3-24).

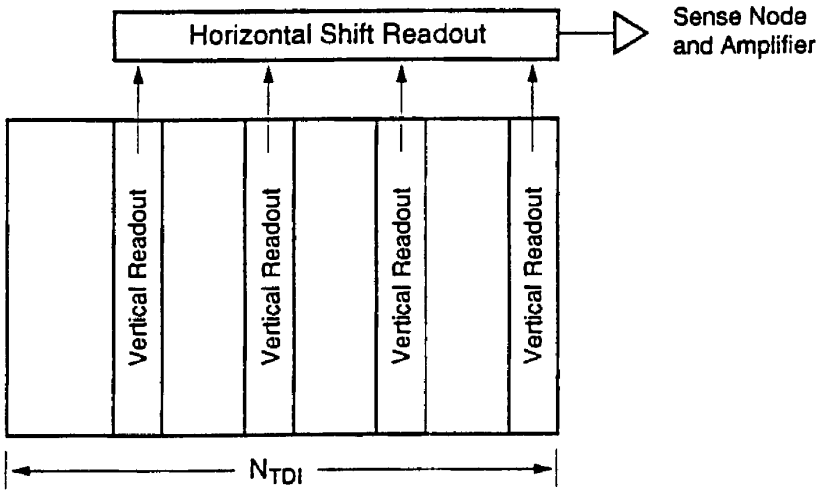


Figure 3-24. The array height must match the image height. To avoid saturation, multiple vertical register readouts may be used.

The vertical readout register must clock out the data before the next line is loaded into the register. The amplifier bandwidth or analog-to-digital conversion time limits the pixel rate. For example, if the amplifier can support 10^7 pixels/s and the register serves 500 vertical pixels, then the maximum (in-scan) line rate is 20,000 lines/s. If the amplifier can only handle 2×10^6 pixels/s and the line rate is maintained at 20,000 lines/s, then the vertical transfer register must be divided into five registers - each connected to 100 pixels. These registers and associated outputs operate in parallel (Figure 3-25).

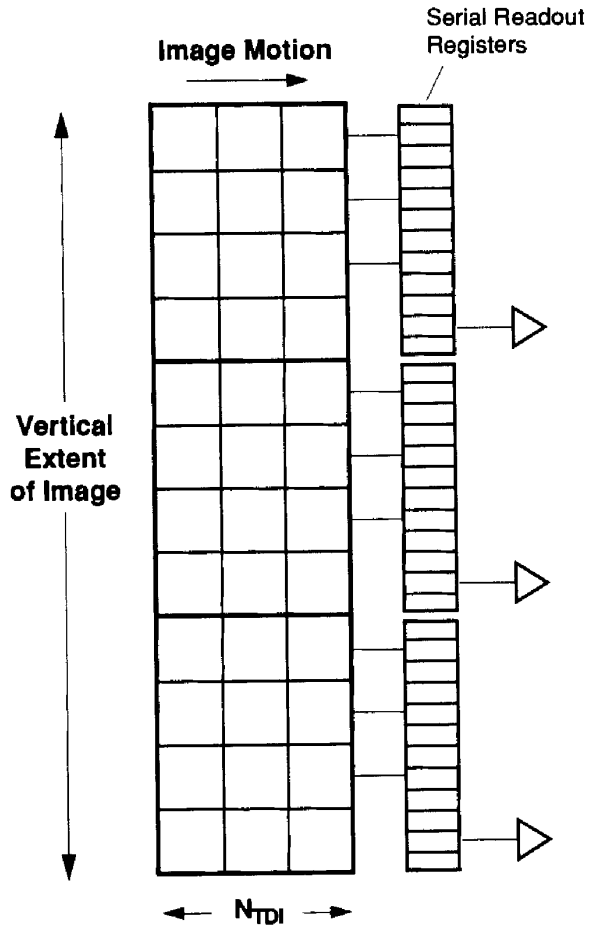


Figure 3-25. The vertical direction may be divided into subarrays to increase the line rate. The transfer register typically is a three-phase device.

TDI improves responsivity nonuniformity (discussed in Section 4.2.6., *Pattern Noise*). Variations in individual detector responsivities in the TDI direction are averaged by $1/N_{TDI}$. Multiple outputs are used to increase the effective pixel rate. Each output is amplified by a separate amplifier that has unique gain characteristics. If the gains are poorly matched, the image serviced by one amplifier will have a higher contrast than the remaining image. In TDI devices, streaking occurs when the average responsivity changes from column-to-column.[13] Careful selection of arrays will minimize these nonuniformities. They can also be minimized though processing techniques employed external to the device.

Example 3-3
TDI LINE RATE

The pixels in a TDI are 15 μm square. The object is moving at 2 m/s and the object detail of interest is 150 μm. What is the lens magnification and what is the pixel clock rate?

Each pixel must view 150 μm on the target. Because the pixel size is 15 μm, the lens magnification is $M_{OPTICS} = 15/150 = 1/10$. The TDI pixel clock rate is (2 m/s)/150 μm = 133 Khz.

3.4. CHARGE TRANSFER EFFICIENCY

The early CCDs transferred electrons in channels that were at the surface. Surface defects interfere with the transfer and create poor charge transfer efficiency. These were SCCD or surface channel CCDs. By burying the channel (BCCD), the charge was no longer affected by surface defects and this improved the CTE significantly. Nearly all CCDs use buried channel technology today.

As the charge packet moves from storage site to storage site, a few electrons are left behind. The ability to transfer all the charge is given by the CTE. As the number of transfers increases, the charge transfer efficiency must also increase to maintain signal strength.

The number of transfers across the full array is the number of pixels multiplied by the number of gates. For example, for an array that is 1000 × 1000, the charge packet farthest from the sense node must travel 2000 pixels. If four gates (four-phase device) are used to minimize cross talk, the farthest charge packet must pass through 8000 wells (neglecting isolation pixels). The net efficiency varies with the target location. If the target is in the center of the array, then it only experiences one-half of the maximum number of transfers on the array. If the target is at the leading edge, it is read out immediately with virtually no loss of information. The loss of information is described by the CTE MTF (discussed in Section 10.3.2., *Charge Transfer Efficiency*).

If many transfers exist (e.g., 8000) the transfer efficiency must be high (e.g., 0.999995) so that the net efficiency is reasonable ($0.999995^{8000} = 0.96$). Arrays for consumer applications typically have charge transfer efficiencies greater than 0.9999 and CTEs approach 0.999999 for scientific grade devices.

A fraction of the charge, as specified by the charge *in*efficiency, is left behind. After the first transfer, ϵ (ϵ is the CTE) remains in the leading well and (1-ϵ) enters the first trailing well. After the second transfer, the leading well transfers ϵ of the previous transfer and loses (1-ϵ) to the trailing well. The trailing well gains the loss from the first well and adds it to the charge transferred into the trailing well in the last go-around. Charge is not lost, just rearranged. The fractional values follow a binomial probability distribution:

$$P_R = \binom{N}{R} \epsilon^R (1 - \epsilon)^{N-R} , \tag{3-2}$$

where N is the number of transfers. For the first well, R = N. For the second well, R = N - 1 and so on.

Figure 3-26 illustrates the output when a large number of pixels are illuminated. The leading edge loses charge and decreases in value. For pixels near the end of the pulse, the charge lost to trailing wells is replaced by the charge acquired from leading wells. Here, the signal strength is maintained. Finally, charge is lost to wells after the signal and the pulse width is stretched.

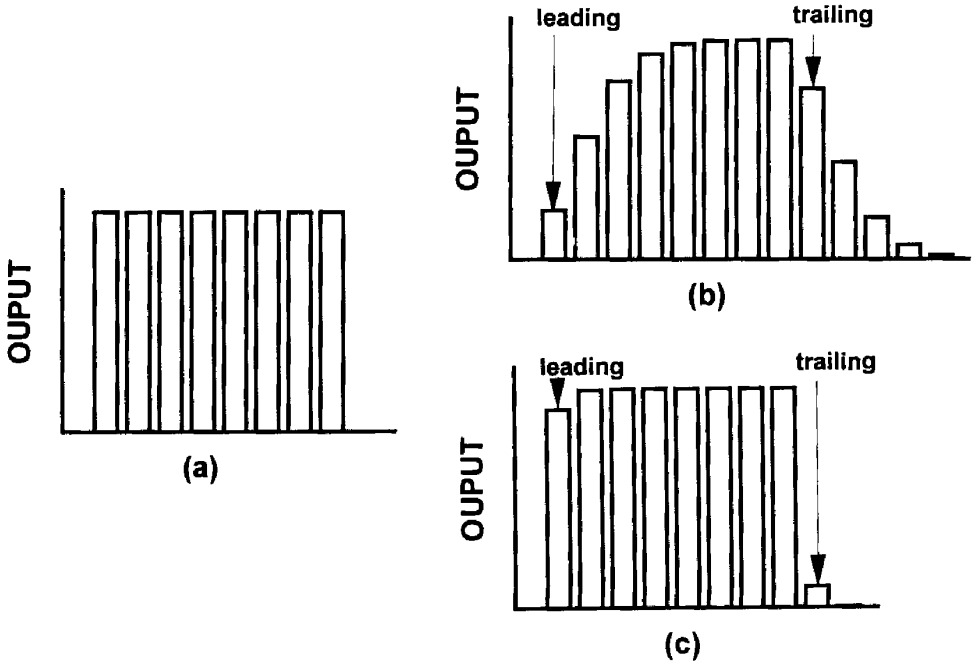


Figure 3-26. Input and output signals after many transfers. (a) Initially generated charge, (b) charge distribution with low CTE, and (c) charge distribution with high CTE.

Consider a very small spot of light that illuminates just one pixel and creates n_o electrons. A well, N transfers away, will contain n_N electrons. The fractional amount of charge left is

$$\frac{n_N}{n_o} = \epsilon^N . \tag{3-3}$$

The fractional amount of charge appearing in the first trailing well after N transfers is

$$\frac{n_{(first\ trailing\ well)-N}}{n_o} = N\epsilon^{N-1}(1-\epsilon) . \tag{3-4}$$

The fractional signal strength, n_N/n_o, is plotted in Figure 3-27. The first trailing well fractional strength, $n_{first\ trailing\ well\text{-}N}/n_o$, is plotted in Figure 3-28. Most of the electrons lost from the first well appear in the second and third wells. For high CTE arrays, a negligible amount appears in successive wells.

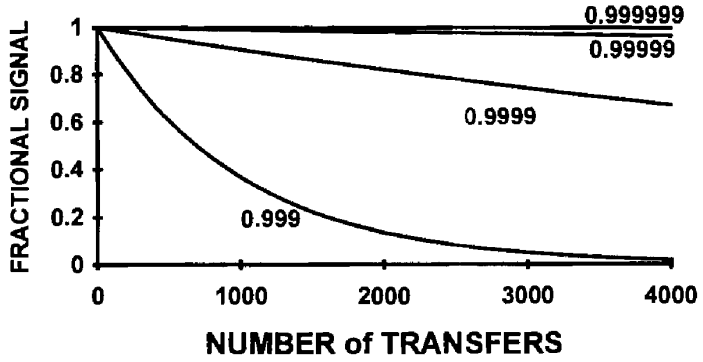


Figure 3-27. Fractional signal as a function of transfer efficiency and number of transfers.

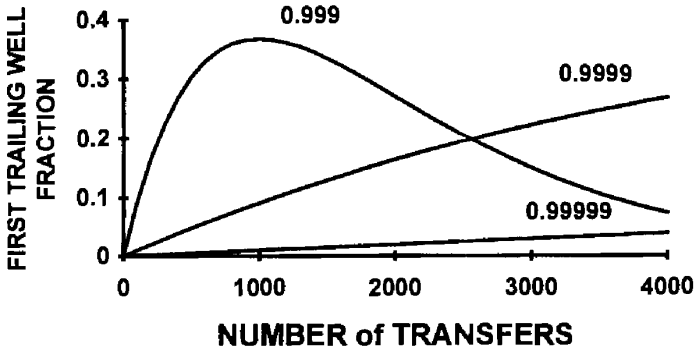


Figure 3-28. Fractional signal for the first trailing charge well. With low CTEs, as the number of transfers increases, more charge spills into the second trailing well. The charge in the first trailing well decreases.

CTE is not a constant value but depends upon the charge packet size. For very low charge packets, the CTE decreases due to surface state interactions. This is particularly bothersome when the signal-to-noise ratio is low and the array is very large (typical of astronomical applications). The CTE also decreases near saturation due to charge spill effects.

The fraction of charge left behind also depends upon the clocking frequency. At high frequencies, efficiency is limited by the electron mobility rate. That is, it takes time for the electrons to move from one storage site to the next. Thus, there is a tradeoff between frame rate (dictated by clock frequency) and image quality (affected by CTE). Using smaller pixels partially overcomes the limitation imposed by the electron mobility rate. However, a smaller pixel has a smaller charge well capacity.

If the surface states significantly affect CTE, then the fat zero technique helps. Fat zero puts a known amount of electrons into the well. These electrons will fill the interface states and thereby improve the CTE for the photoelectrons. Because the fat zero electrons partially fill the charge well, the remaining well capacity for the photoelectrons is reduced.

CTE effects in large linear arrays can be minimized by using alternate readouts. In Figure 3-29, the alternate readouts reduce the number of transfers by a factor of 2. Adjacent pixels experience the same number of transfers so that the signal is preserved at any particular location.

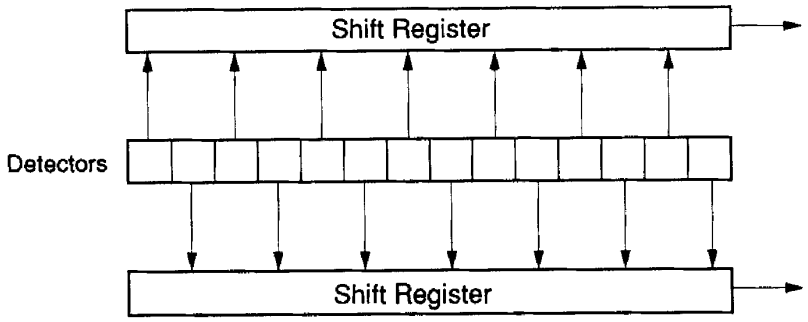


Figure 3-29. For long arrays, the MTF can be increased by alternating the readouts or by reading out subarrays (see Figure 3-14, page 61).

There are three methods to measure CTE: current, optical, and x-ray injection. Because most devices do not have current injection terminals, the optical and x-ray injection methods are used more often. With the optical technique, either a row of detectors or a single detector is illuminated. The ratio of the output of the first illuminated pixel to the average value of trailing pixels is measured. The CTE is found using Equation 3-3. The optical technique requires a spot[14] whose diameter is less than a pixel width. This can only be achieved with carefully designed optics that are critically aligned. But x-rays[1] generate a known number of electrons in a localized area that is much smaller than a pixel. The x-ray technique probably provides the highest accuracy.

3.5. CHARGE CONVERSION (OUTPUT STRUCTURE)

Charge is converted to a voltage by a floating diode or floating diffusion. Figure 3-30 illustrates the last two gates of a four-phase system. The low voltage gate allows charge transfer only when gate 4 goes to zero. The diode, acting as a capacitor, is precharged at a reference level. The capacitance, or sense node, is partially discharged by the amount of charge transferred. The difference in voltage between the final status of the diode and its precharged value is linearly proportional to the number of electrons, n_e. The signal voltage after the source follower is

$$V_{SIGNAL} = V_{RESET} - V_{OUT} = n_e \frac{Gq}{C} . \qquad (3\text{-}5)$$

The gain, G, of a source follower amplifier is approximately 1 and q is the electronic charge (1.6×10^{-19} coul). The charge conversion is q/C. The output gain conversion or OGC is Gq/C. It typically ranges from $0.1\,\mu V/e^-$ to $10\,\mu V/e^-$. The signal is then amplified and processed by electronics external to the CCD sensor.

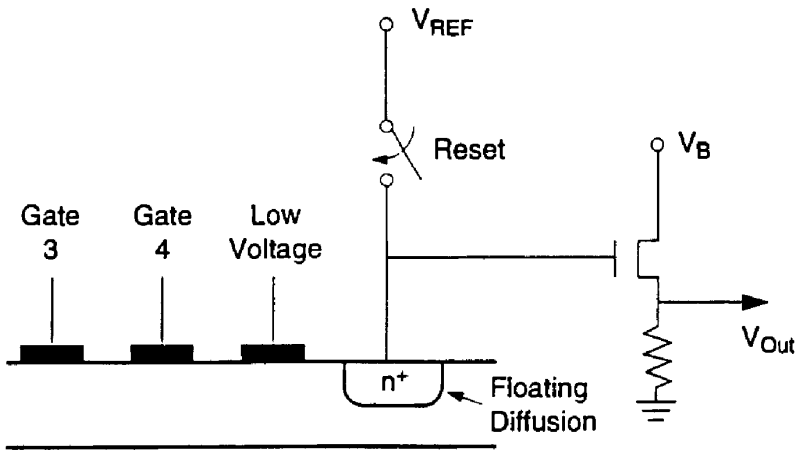


Figure 3-30. Output structure. The charge on the floating diffusion is converted to a voltage by the diffusion capacitance. The low voltage gate, which operates in a manner similar to a virtual well, allows charge transfer when the voltage on gate 4 is zero (see Figure 3-11, page 57).

3.6. DARK CURRENT

The CCD output is proportional to the exposure, $L_q(\lambda)t_{INT}$. The output can be increased by increasing the integration time and long integration times are generally used for low light level operation. However, this approach is ultimately limited by dark current leakage that is integrated along with the photocurrent. With a large pixel (24 μm square), a dark current density of 1000 pA/cm^2 produces 36,000 electrons/pixel/s. If the device has a well capacity of 360,000 electrons, the well fills in 10 s. The dark current is only appreciable when t_{INT} is long. It is not usually a problem for consumer applications but is a concern for scientific applications.

A critical design parameter is dark current noise reduction. There are three main sources of dark current: (1) thermal generation in the depletion region, (2) thermal generation and diffusion in the neutral bulk material, and (3) thermal generation due to surface states. Dark current densities vary significantly among manufacturers with values ranging from 0.1 nA/cm^2 to 10 nA/cm^2 in silicon CCDs. Dark current due to thermally generated electrons can be reduced by cooling the device. Surface state dark current is minimized with multi-phase pinning[15,16] (MPP).

The number of thermally generated dark current electrons is

$$n_{DARK} = \frac{J_D A_D t_{INT}}{q}, \tag{3-6}$$

where J_D is the dark current density. For thermal generation in the depletion region, It is proportional to

$$J_D \propto T^2 e^{-\frac{(E_G - E_T)}{kT}}, \tag{3-7}$$

where T is the absolute temperature, E_G is the band gap, and E_T is the impurity energy gap. With TDI, the pixels in a TDI column are summed and the dark current increases:

$$n_{DARK} = \frac{J_D A_D t_{INT} N_{TDI}}{q}. \tag{3-8}$$

In principle, dark current density can be made negligible with sufficient cooling. The dark current density decreases approximately twofold for every 8 to 9°C drop in array temperature from ambient. Conversely, the dark current density increases by a factor of 2 for every 8 to 9°C increase in array temperature. Because the temperature is in the exponent of Equation 3-7, the doubling temperature decreases as the array temperature decreases. At low temperatures, a 1°C change in temperature changes the dark current by a significant amount. This means that if cooling is desired, the temperature must be maintained with high precision. Table 3-1 provides the dark current for Texas Instruments chip TC271 using experimentally[17] obtained values of $E_G - E_T \approx 0.58$ eV and $J_D = 100\,pA/cm^2$ at 27°C.

The most common cooler is a thermoelectric cooler (TEC or TE cooler). Thermoelectric coolers are Peltier devices driven by an electric current that pumps heat from the CCD to a heat sink. The heat sink is cooled by passive air, forced air, or forced liquid (usually water). The final array temperature depends upon the amount of heat generated in the array, the cooling capacity of the thermoelectric device, and the temperature of the TEC heat sink. Peltier devices can cool to about -60°C. Thermoelectric coolers can be integrated into the same package with the array (Figure 3-31). Cooling probably is only worthwhile for scientific applications. However, many devices contain TE coolers to stabilize the temperature so that the dark current does not vary with ambient temperature changes.

Table 3-1
DARK CURRENT VALUES for TI TC271
(Normalized to 100 pA/cm^2 at 27°C)

TEMPERATURE (°C)	DARK CURRENT (pA/cm^2)	PERCENT CHANGE for 1° C	DOUBLING TEMPERATURE
60	1136	6.9	10.8
40	276	7.7	9.5
20	55.8	8.9	8.4
0	9.02	10.2	7.2
-20	1.11	11.9	6.2
-40	9.58×10^{-2}	14.1	5.3
-60	5.33×10^{-3}	17.0	4.4
-80	1.66×10^{-4}	20.9	3.6

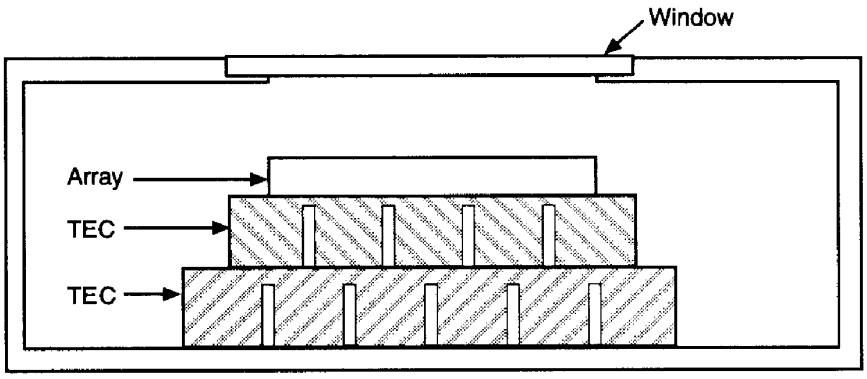


Figure 3-31. Cross section of a two stage TEC integrated into a package.

Although liquid nitrogen (LN, LN2, or LN_2) is at -200°C, the typical operating temperature is -120°C to -60°C because the CTE and quantum efficiency drop at very low temperatures. Condensation is a problem and the arrays must be placed in an evacuated chamber or a chamber that is filled with a dry atmosphere. Dark current can approach[18] 3.5 electrons/pixel/s at -60°C and 0.02 electrons/pixel/h at -120°C. Various cooling techniques and fabrication concepts are provided in Reference 19.

Multi-pinned phasing technology CCDs can operate at room temperature with reduced dark current.[15,16] MPP devices have dark current density levels as low as 2 pA/cm^2 with a high value of 1 nA/cm^2. Typically, MPP devices have charge wells that are two to three times smaller than conventional devices and these devices are more likely to saturate. Some devices operate in either mode. MPP is the most common architecture used in scientific and medical applications.

The output amplifier constantly dissipates power. This results in local heating of the silicon chip. Because dark current is dependent upon temperature, a small variation in the device temperature profile produces a corresponding profile in the dark current. To minimize this effect, the output amplifier is often separated by several isolation pixels to move the amplifier away from the active sensors.

Example 3-4
DARK CURRENT

A CCD array has a well size of 150,000 electrons, dark current density of 10 pA/cm^2, and detector size 8 μm square. The advertised dynamic range is 80 dB. Is the dark current noise significant? Assume that the integration time is 1/60 s (16.67 ms).

Using Equation 3-6, the number of dark electrons is

$$n_{DARK} = \frac{\left(10\times10^{-9}\frac{A}{cm^2}\right)(0.0167s)\,(8\times10^{-4}cm)^2}{1.6\times10^{-19}\frac{coul}{electron}} = 668\ e^- . \qquad (3\text{-}9)$$

Assuming Poisson statistics, the dark current shot noise is $\sqrt{668}$ or 26 electrons rms. The dynamic range is the charge well capacity divided by the noise floor. With a dynamic range of 10,000:1, the noise floor is 15 electrons. Because the noise variances add, the total noise is:

$$\langle n_{SYS}\rangle = \sqrt{26^2 + 15^2} = 30\ \ e^-\ rms . \qquad (3\text{-}10)$$

Therefore, the dark current will affect the measured SNR at low levels. The dark current will saturate the well in 3.75 s.

Example 3-5
ARRAY COOLING

The dark current density decreases by a factor of 2 for every 8°C drop in temperature. What should the array temperature be so that the dark current noise is 5 electrons rms for the array described in Example 3-4?

The dark current noise must be reduced by a factor of 5/26 = 0.192 and the dark current must be reduced by $(0.192)^2$ or 0.0369. The doubling factor approximately provides

$$\frac{n_{DARK\text{-}COOL}}{n_{DARK\text{-}AMBIENT}} = 2^{\left(-\frac{T_{AMBIENT} - T_{COOL}}{8}\right)}. \qquad (3\text{-}11)$$

Then, $T_{AMBIENT} - T_{COOL} = 38.1°C$. That is, the array temperature must be 38.1°C below the temperature at which the dark current density was originally measured. Because the dark current is reduced by 0.0369, the time to saturation increased by 1/0/0369 or 27.1 times to 102 s.

Although this varies by manufacturer, many use $T_{AMBIENT} = 20°C$. Note that this is an approximation only and Equation 3-7 should be used to determine the required temperature. In reality, the user does not precisely select the temperature but, if possible, cools the array well below the desired temperature. The lowest possible temperature is limited by the cooling device.

3.7. DARK PIXELS

Many arrays have "extra" photosites at the end of the array. These shielded photosites are used to establish a reference dark current level (or dark signal). The number of dark elements varies with device and manufacturer and ranges from a few to 25. The average value of the dark current pixels is subtracted from the active pixels leaving only photogenerated signal. For example, if the output of the dark pixels is 5 mV, then 5 mV is subtracted from the signal level of each active pixel.

Figure 3-32a illustrates the output from a single charge well. Light leakage may occur at the edge of the shield (see Example 3-1, page 62) and partially fill a few wells. Because of this light leakage, a few pixels (called dummy or

isolation pixels) are added to the array. Figure 3-32b illustrates the output of three dark reference detectors, three isolation detectors, and three active pixels. The average value of the three dark pixels is subtracted from every active pixel value.

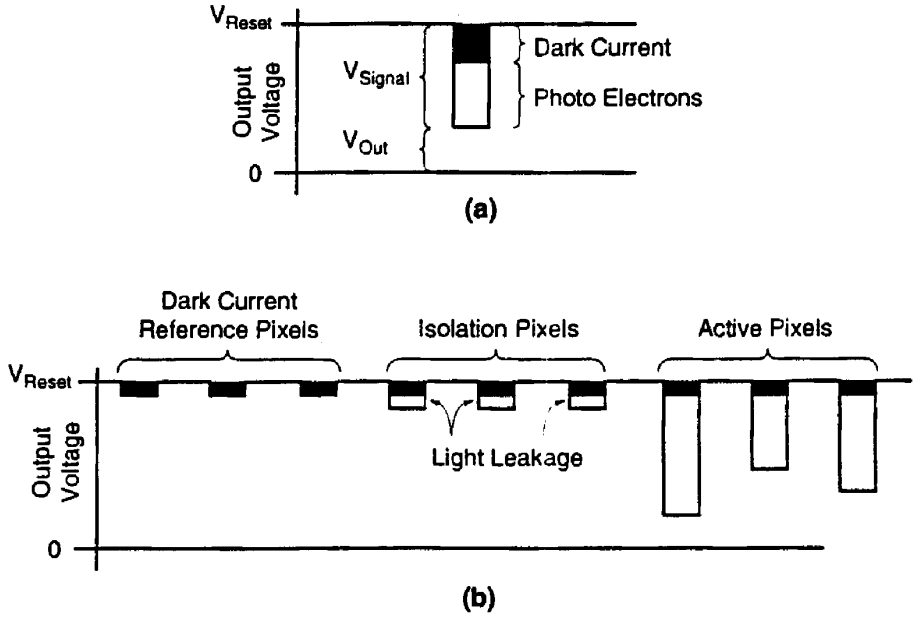


Figure 3-32. Typical output. (a) Single pixel and (b) active line with isolation and dark pixels. The varying voltage on the active pixels is proportional to the scene intensity. The dark pixels are covered with an opaque mask. Light can leak around the mask and partially fill the isolation pixel wells.

While this process is satisfactory for general imagery and machine vision use, it may be unacceptable for scientific applications. Dark pixels have slightly different dark current than the active pixels. Furthermore, the dark current value varies from pixel to pixel. This variation appears as fixed pattern noise (discussed in Section 4.2.6., *Pattern Noise*). Removing the average value does not remove the variability.

In critical scientific applications, only the dark value from a pixel may be removed from that pixel. That is, the entire array is covered (mechanical shutter in place) and the individual pixel values are stored in a matrix. Then the shutter is removed and the stored values are subtracted, pixel by pixel, as a matrix subtraction. This method ensures that the precise dark voltage is subtracted from each pixel. This, of course, increases computational complexity. Removal of dark current values allows maximum use of the analog-to-digital converter

dynamic range. This method cannot remove the dark current shot noise. Dark current shot noise is reduced by cooling.

Additional isolation pixels may exist between the readout register and the sense node amplifier. These pixels reduce any possible interaction between the amplifier temperature and first column pixel dark current. They also reduce amplifier noise interactions.

3.8. ANTIBLOOM DRAIN

When a well fills, charge spills over into adjacent pixels in the same column resulting in an undesirable overload effect called blooming. Channel stops prevent spill over onto adjacent columns. Overflow drains or antibloom drains prevent spill over. The drain can be attached to every pixel or may only operate on a column of pixels. Any photoelectron that is swept into the drain is instantly removed. Thus, the location of the drain is important.

If the drain is buried, the long wavelength quantum efficiency is reduced because long wavelength charge is generated below the wells and near the buried drain. A buried drain is also called a vertical overflow drain (VOD). Here, vertical refers to the *depth* of the device whereas the horizontal and vertical *directions* define the pixel size. If the drain is next to the detector, it is a lateral antibloom drain (Figure 3-33). This takes up real estate and lowers the fill-factor.

Figure 3-34 illustrates the potential well created by a lateral drain. When the charge well fills over the drain barrier, charge flows into the drain. The barrier height can be controlled by an external voltage so that variable integration times are possible. Here, the antibloom drain is used for exposure control. The exposure control can work at any speed. The drain, acting as an electronic shutter, may be used synchronously or asynchronously. Asynchronous shuttering is important for use in processes where the motion of objects does not match the array frame timing or in high light level applications. The charge well is drained, reset, and then photoelectrons are integrated for the desired time.

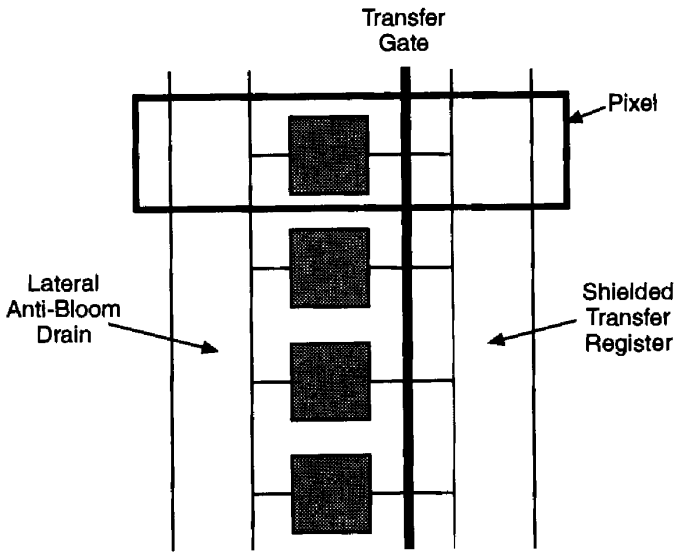


Figure 3-33. Lateral antibloom drain. The transfer gate controls the desired integration time.

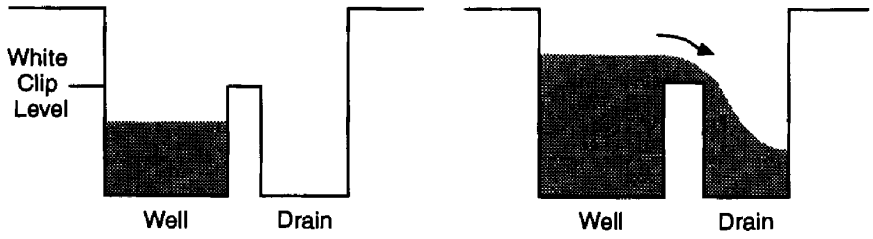


Figure 3-34. Lateral overflow drain. When the number of stored electrons exceeds the saddlepoint, the excess electrons flow into the drain

In a perfect system, the output is linearly related to the input up to the antibloom drain limit. In real arrays, because of imperfect drain operation, a knee is created[20] (Figure 3-35). The response above the knee is called knee slope or knee gain. While scientific cameras operate in a linear fashion, there is no requirement to do so with consumer cameras. The knee is a selling feature in the consumer marketplace. The advantage of the knee is that it provides some

response above the white clipping level. Each CCD manufacturer claims various competitive methods of handling wide scene contrasts. These methods usually involve manipulating the drain potential.

Interline transfer devices may have the drain at the top of a vertical shift register. The excess charge cannot be drained while image information is in the vertical shift registers (Figure 3-36). This limits the range of integration times available. Figure 3-37 illustrates the variable integration afforded by the drain.

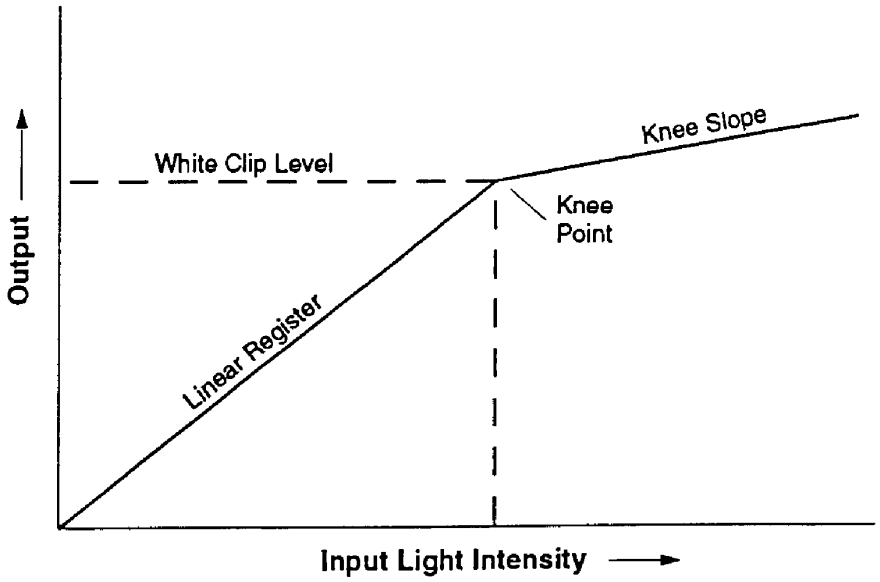


Figure 3-35. Characteristic knee created by an overflow drain.

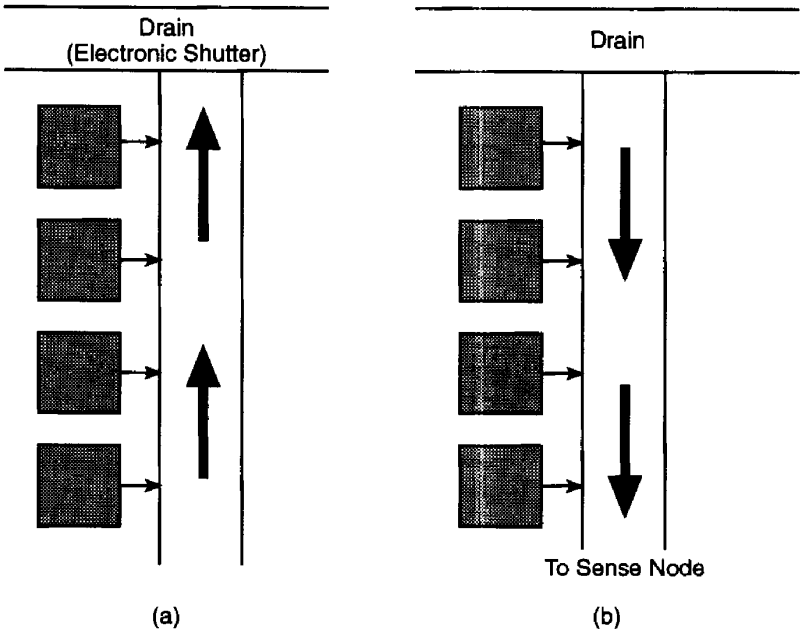


Figure 3-36. Interline transfer device where the drain is at the top of the vertical shift register. (a) Unwanted charge is sent to the drain and (b) desired charge is read out.

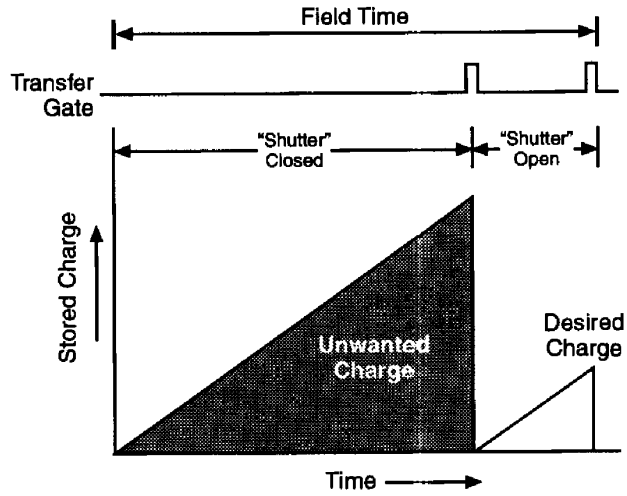


Figure 3-37. By judiciously activating the transfer gate, any integration time can be achieved. A variable integration time is equivalent to a variable electronic shutter.

3.9. CID

A charge injection device consists of two overlapping MOS capacitors sharing the same row and column electrode. Figure 3-38 illustrates the pixel architecture. Physically, the capacitors are orthogonal. Charge is stored under the horizontally or vertically oriented capacitor. The nearly contiguous pixel layout provides a fill-factor of 80% or greater.

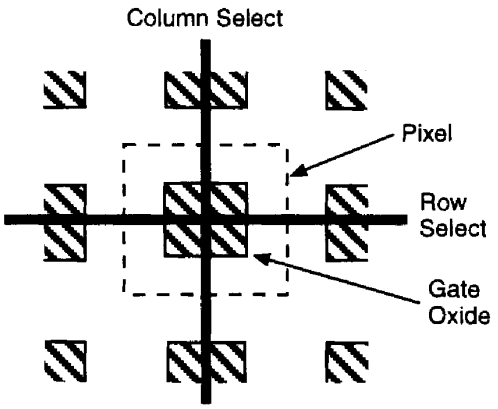


Figure 3-38. CID pixel architecture.

Although the capacitors are physically orthogonal, it is easier to understand their operation by placing them side-by-side. Figure 3-39 illustrates a functional diagram of an array and Figure 3-40 illustrates the pixel operation. In Figure 3-40a, a large voltage is applied to the columns and photogenerated carriers (usually holes) are stored under the column gate. If the column voltage is brought to zero, the charge transfers to the row gate (Figure 3-40b). The change in charge causes a change in the row gate potential which is then amplified and outputted. If V_1 is reapplied to the columns, the charge transfers back to the column gate. This is non-destructive readout and no charge is lost. Now additional charge integration is possible. Reset occurs by momentarily setting the row and column electrodes to ground. This *injects* the charge into the substrate (Figure 3-40c).

The conversion of charge into voltage depends upon the pixel, readout line, and amplifier capacitance. The capacitance is high because all the pixels on a given row are tied in parallel. Therefore, when compared to a CCD, the charge conversion is small, yielding a small signal-to-noise ratio. Because the readout is nondestructive, it can be repeated numerous times. The multiple reads are averaged together to improve the signal-to-noise ratio.

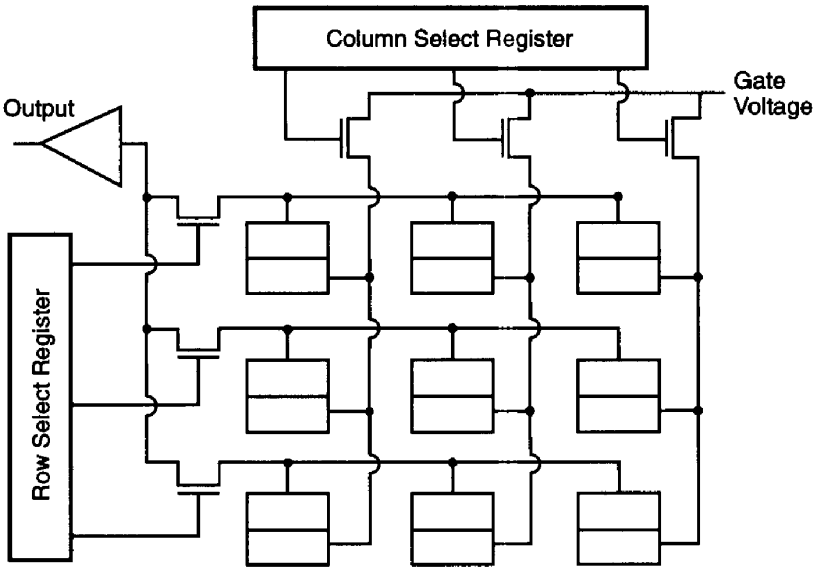


Figure 3-39. Functional layout of a 3 × 3 CID array. The row and column select registers are also called decoders. The select registers and readout electronics can be fabricated with CMOS technology.

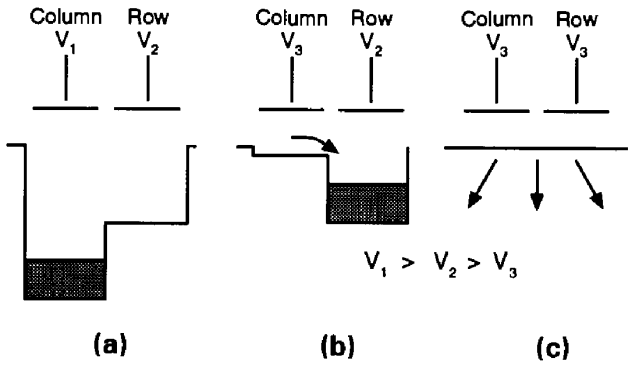


Figure 3-40. CID pixel operation. (a) Integration, (b) readout, and (c) injection.

Because each pixel sees a different capacitance, CIDs tend to have higher pattern noise compared to CCDs. However, off-chip algorithms can reduce the amount of pattern noise. With no charge transfer, CIDs are not sensitive to CTE effects. Without multiple gates, CIDs have larger well capacities than comparably sized CCDs. CIDs inherently have antibloom capability. Because charge is limited to a single pixel, it cannot overflow into neighboring pixels. Perhaps the greatest advantage of CIDs is random access to any pixel or pixel cluster. Subframes and binned pixels can be read out at high frame rates.

3.10. CMOS

The main advantage of CMOS imagers is that they are compatible with mainstream silicon chip technology. Because transistors are made by this technology, on-chip processing is possible.[21] An active pixel sensor (APS) has one or more active transistors integrated into the pixel (Figure 3-41).

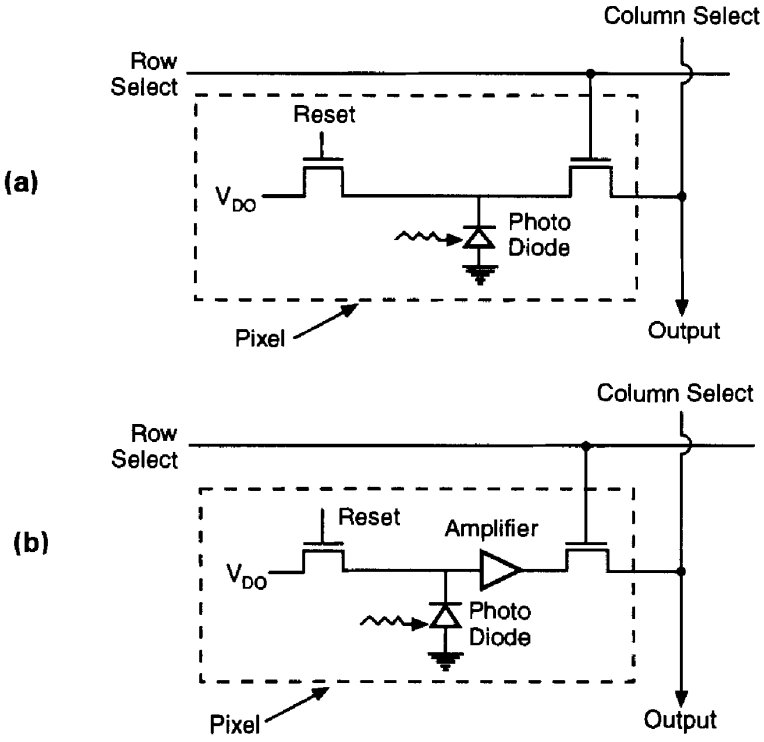


Figure 3-41. (a) Passive pixel device and (b) active pixel sensor. CCDs and CIDs are regarded as passive pixel sensors. CIDs use photogates, CCDs use either photogates or photodiodes, and CMOS devices typically use photodiodes.

With the APS approach, highly integrated image sensors are possible.[22] By placing processing on the chip, a CMOS camera is typically physically smaller than a CCD camera which requires clocks, image reformatting, and signal processing in separate hardware. A sophisticated APS array could create[23] a "camera-on-a-chip." It is possible to build a frame transfer device where pixels can be binned to enhance the SNR and provide variable resolution imaging.[24]

In 1993, Fossum[25] described state-of-the-art active pixel concepts. At that time they were the double-gate floating surface transistor, charge modulation device, bulk charge modulation device, based-stored image sensor, and static induction transistor. That review continued[23] in 1997.

The APS contains a photodiode, row-select transistor, and a reset transistor. As shown in Figure 3-41, by activating a row, the data from the pixels in that row are simultaneously copied into the columns. Each column will have a load transistor, column select switch, and a sampling switch. The chip may also have an analog-to-digital converter and provide correlated double sampling. The pixels are then reset and a new integration is started. The APS does not rely upon charge transfer. Rather the photodiode drives a capacitance line. The total capacitance limits the chip speed. APSs can be fully addressable and subarrays can be read out at high frame rates just like CIDs.

CMOS devices tend to have higher dark currents due to the highly doped silicon used. As such it does not appear that CMOS sensors will replace CCDs in low noise scientific applications. Because the active devices often take up real estate, the area for the photosensor is reduced. This leads to reduced sensitivity that can be partially offset by a microlens. Because each pixel has its own amplifier, pattern noise is larger. However, more logic can be added to each pixel and it seems possible to use on-chip signal processing that suppresses FPN.[26] With charge limited to a single pixel, it cannot overflow into neighboring pixels and create blooming as seen with CCDs.

While more integration can lead to the camera-on-a chip, production yield will probably decrease as the number of transistors increase. Consider an array that contains 640 × 480 pixels (307,200 pixels). With a CCD, there are 307,200 elements on the chip (neglecting dark pixels and the readout structure). With an APS that has a photodiode and three transistors per pixels there are four times more elements (1,228,800 total). If any one of the four elements fails, that pixel is dead.

A further advantage is their low power consumption. APSs operate from 5-volt supply or less (compared to 10 V to 15 V for a CCD). This is a very

attractive feature for man-portable, battery-operated devices. It appears at this time, CMOS will compete with CCDs in the general video marketplace where weight, size, and power consumption are factors.

3.11. PHYSICAL PARAMETERS

All detector arrays are fabricated for specific applications. Microlenses are used to increase the optical fill factor. Color filter arrays employ filters that are placed over the detectors to create specific spectral responses that lend themselves to color imagery. For general video applications, the number of detectors is matched to the video standard to maximize bandwidth and image sharpness. The overall array size follows the convention used with vidicons.

3.11.1. MICROLENSES

Optical fill factor may be less than 100% due to manufacturing constraints in full transfer devices. In interline devices, the shielded vertical transfer register can reduce the fill factor to less than 20%. Microlens assemblies (also called microlenticular arrays or lenslet arrays) increase the effective optical fill-factor (Figure 3-42). But it may not reach 100% due to slight misalignment of the microlens assembly, imperfections in the microlens itself, nonsymmetric shielded areas, and transmission losses. As shown by the camera formula (Equation 2-16, page 35), the output is directly proportional to the detector area. Increasing the optical fill factor with a microlens assembly increases the effective detector size and, therefore, the output voltage.

The photosensitive area is below the gate structure and the ability to collect the light depends upon gate thickness. The cone of light reaching the microlens depends upon the f-number of the primary camera lens. Figure 3-42 illustrates nearly parallel rays falling on the microlens. This case is encountered with high f-number lens systems. Low f-number primary camera lenses increase the cone angle and the effective fill-factor decreases with decreasing f-number.[27] Microlenses are optimized for most practical f-numbers. As the array size grows, off-axis detectors do not obtain the same benefit as on-axis detectors.[28]

Hyper-HAD is a Sony trademark which indicates the presence of a microlens assembly over a hole accumulation diode. While many camera manufacturers use the Hyper-HAD detectors, they do not identify the detector by Sony's trademark. This leads the user to believe that there are many different detectors and hence many different cameras on the market.

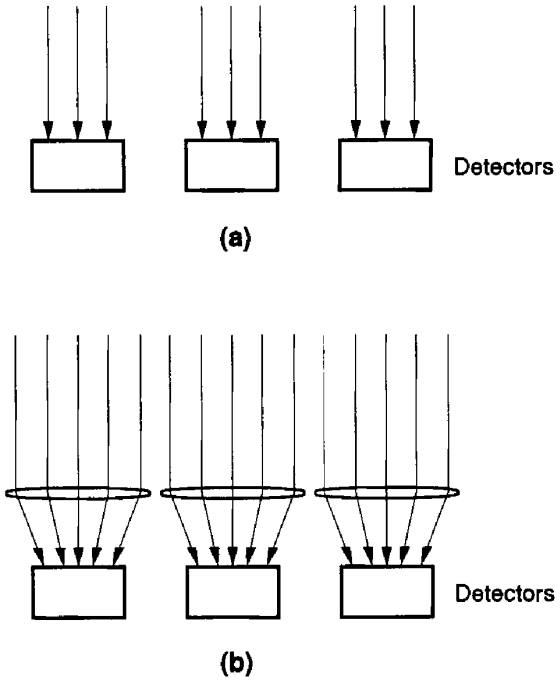


Figure 3-42. Optical effect of a microlens assembly. (a) With no microlens, a significant amount of photon flux is not detected. (b) The microlens assembly can image nearly all the flux onto the detector when a high f-number lens is used. These lenslets can either be grown on the array during the fabrication process or manufactured out of a material such as quartz and placed on the array surface during packaging.

3.11.2. COLOR FILTER ARRAYS

The subjective sensation of color can be created from three primary colors. By adjusting the intensity of each primary (additive mixing), a full gamut (rainbow) of colors is experienced. This approach is used on all color displays. They have red, green, and blue phosphors that, when appropriately excited, produce a wide spectrum of perceived colors. The CIE committee standardized a color perception model for the human observer in 1931. The literature[29] is rich with visual data that form the basis for color camera design.

The "color" signals sent to the display must be generated by three detectors, each sensitive to a primary or its complement. The primary additive colors are red, green, and blue (R, G, B) and their complementary colors are yellow, cyan and magenta (Ye, Cy, Mg). For high quality color imagery, three separate detectors (discussed in Section 5.3.3., *Color Correction*) are used whereas for consumer applications, a single array is used. The detectors are covered with different filters that, with the detector response, can approximate the primaries or their complements (Figure 3-43). A single array with filters is called a color filter array (CFA).

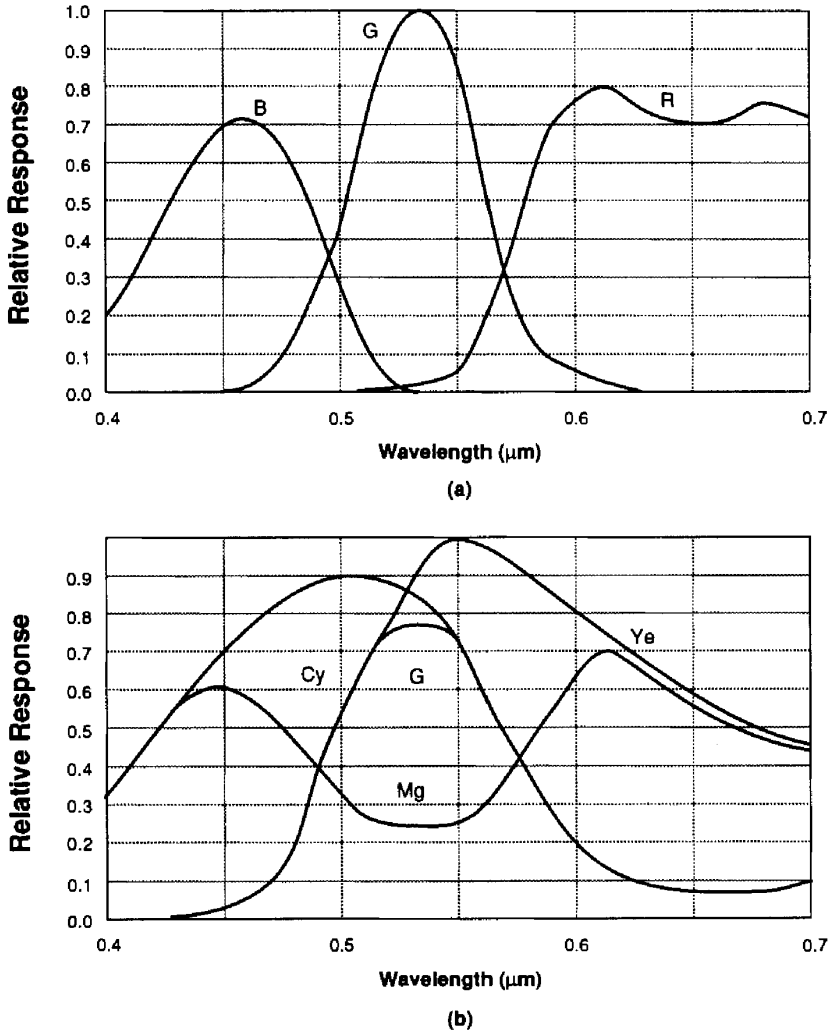


Figure 3-43. Desired spectral response for the three primaries and their complements. (a) The primaries and (b) their complements.

While CFAs can have filters with the appropriate spectral transmittance to create the primaries, it is more efficient to create the complementary colors. Complementary filters have higher transmittances than the primary filters. The luminance channel is identical to the green channel and is often labeled Y. "White" (no color filter) is represented by W = R + G + B.

A linear set of equations relates the primaries to their complements. These equations are employed (called matrixing) in cameras to provide either or both output formats. Matrixing can convert RGB into other color coordinates:

$$\begin{aligned} Ye &= R + G = W - B \\ Mg &= R + B = W - G \\ Cy &= G + B = W - R \,. \end{aligned} \tag{3-12}$$

The arrangement of the color filters for a single array system is either a stripe or a mosaic pattern (Figure 3-44). The precise layout of the mosaic varies by manufacturer. One basic CFA patent[30] was granted to Bryce E. Bayer at Eastman Kodak in 1976.

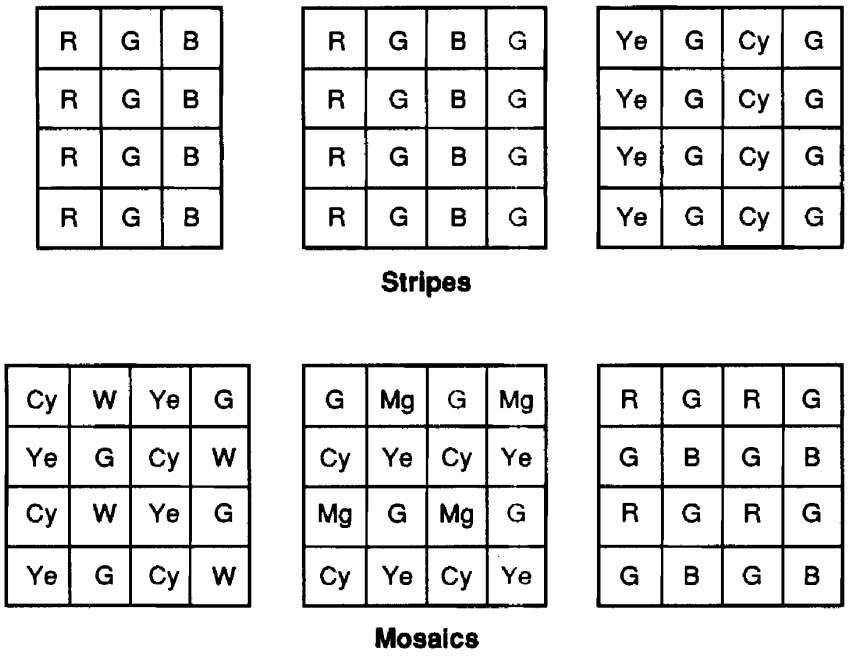


Figure 3-44. Representative stripe and mosaic arrays. Although shown as a full frame device for clarity, they typically are interline transfer devices. The layout depends upon the manufacturer's philosophy and cleverness in reducing color aliasing.

In many sensors, the number of detectors devoted to each color is different. The basic reason is that the human visual system (HVS) derives its detail information primarily from the green portion of the spectrum. That is, luminance differences are associated with green whereas color perception is associated with red and blue. The HVS requires only moderate amounts of red and blue to perceive color. Thus, many sensors have twice as many green as either red or blue detector elements. An array that has 768 horizontal elements may devote 384 to green, 192 to red, and 192 to blue. This results in an unequal sampling of the colors. A birefringent crystal (discussed in Section 10.3.4., *Optical Anti-alias Filter*), inserted between the lens and the array, accommodates the different sampling rates (discussed in Section 8.3.2., *Detector Array Nyquist Frequency*). The video signal from the CFA is embedded in the architecture of the CFA. The color video from a single chip CFA must be decoded (unscrambled) to produce usable R, G, and B signals.

3.11.3. NUMBER OF DETECTORS

Each detector array is designed for a specific application (discussed in Section 5.2.2., *Broadcast/Non-Broadcast Design*) The EIA 170 video standard supports 485 lines (discussed in Section 5.2.1., *Video Timing*). However, one line is split between the even and odd fields so that there are only 484 continuous lines. Thus detector arrays designed for EIA 170 compatibility tend to have 484 detectors in the vertical direction. For convenience, this has been reduced to 480 detectors. Image processing algorithms are more efficient with square pixels. With a 4:3 aspect ratio, the desired number of detectors is 640 × 480. Less expensive arrays will have a submultiple (for easy interpolation) such as 320 × 240.

For video applications, several rows or columns are devoted to dark current and for light leakage. Therefore an array may be 650 × 492 but the light sensitive part may be 640 × 480. It is manufacturer dependent whether to specify the array size by the number of active pixels or the total number of pixels (which includes the dark pixels).

Beat frequencies are very obvious in color images. To avoid beat frequencies, the color pixel rate should be a multiple of the chrominance subcarrier frequency (3.579545 MHz). This results in arrays that contain 384, 576, or 768 horizontal detectors. While CFAs are designed for NTSC operation, the same chip can be used for monochrome video without the CFA. Therefore, many monochrome arrays also contain 384, 576, or 768 horizontal detectors. These arrays do not have square pixels. But, from a manufacturing point-of-view, this reduces the inventory of arrays offered.

Scientific array size tends to a power of 2 (e.g., 512 × 512, 1024 × 1024) for easy image processing. There is a perception that "bigger is better" both in terms of array size and dynamic range. Arrays may reach 8192 × 8192 with a dynamic range of 16 bits. This array requires (8192)(8192)(16) or 1.07 Gbits of storage for each image. Image compression schemes may be required if storage space is limited. The user of these arrays must decide which images are significant and through data reduction algorithms, store only those that have value. Otherwise, he will be overwhelmed with mountains of data.

While large format arrays offer the highest resolution, their use is hampered by readout rate limitations. For example, consumer camcorder systems operating at 30 frames/s have a data rate of about 10 Mpixels/s. An array with 5120 × 5120 elements operating at 30 frames/s has a data rate of about 768 Mpixels/s. Large arrays can reduce readout rates by having multiple parallel ports servicing subarrays. Each subarray requires separate vertical and horizontal clock signals. The tradeoff is frame rate (speed) versus number of parallel ports (complexity of CCD design) and interfacing with downstream electronics. Because each subarray is serviced by different on-chip and off-chip amplifiers, the displayed image of the subarrays may vary in contrast and level. This is due to differences in amplifier gains and level adjustments.

3.11.4. VIDEO CHIP SIZE

Vidicon vacuum tubes were originally used for professional television applications. These were specified by the tube diameter. To minimize distortion and nonuniformities within the tube, the recommended[31] image size was considerably less than the overall tube diameter. When CCDs replaced the tubes, the CCD industry maintained the image sizes but continued to use the tube format nomenclature (Table 3-2).

Table 3-2
ARRAY SIZE for STANDARD FORMATS

CAMERA FORMAT	STANDARDIZED ARRAY SIZE (H × V)	ARRAY DIAGONAL
1 inch	12.8 mm × 9.6 mm	16 mm
2/3 inch	8.8 mm × 6.6 mm	11 mm
1/2 inch	6.4 mm × 4.8 mm	8 mm
1/3 inch	4.8 mm × 3.6 mm	6 mm
1/4 inch	3.2 mm × 2.4 mm	4 mm

Although each manufacturer supplies a slightly different array size and pixel size, nominal sizes for a 768 × 480 array are given in Table 3-3. With interline transfer devices, approximately one-half of the pixel width is devoted to the shielded vertical transfer register. That is, the detector active width is one-half of the pixel width. Thus the active area of the pixel is rectangular in interline transfer devices. This asymmetry does not appear to affect image quality in consumer video products significantly.

Table 3-3
NOMINAL PIXEL SIZE for a 768 × 480 ARRAY
Sizes vary by manufacturer. Detector sizes are smaller.

CAMERA FORMAT	NOMINAL PIXEL SIZE (H × V)
1 inch	16.7 μm × 20 μm
2/3 inch	11.4 μm × 13.8 μm
1/2 inch	8.33 μm × 10 μm
1/3 inch	6.25 μm × 7.5 μm
1/4 inch	4.17 μm × 5 μm

The decrease in optical format is related to cost. The price of CCD arrays is mainly determined by the cost of processing semiconductor wafers. As the chip size decreases, more devices can be put on a single wafer and this lowers the price of each individual device. The trend of going to smaller devices will probably continue as long as the optical and electrical performance of the imagers does not change. However, smaller pixels reduce the charge well size. For a fixed flux level and lens f-number, the smaller arrays have reduced sensitivity.

Smaller chips make for smaller cameras. However, to maintain resolution, pixels can only be made so small. Here, the tradeoff is among pixel size, optical focal length, and overall chip size. Further unless the lens f-number is reduced as the chip size is reduced, the system will move from being detector-limited to optically-limited (discussed in Section 10.4., *Optical-Detector Subsystem*). As this happens, the system MTF will change and smaller detectors will provide a less sharp image.

3.12. REFERENCES

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4

ARRAY PERFORMANCE

The most common array performance measures are read noise, charge well capacity, and responsivity. From these the minimum signal, maximum signal, signal-to-noise ratio, and dynamic range can be calculated. Full characterization includes quantifying the various noise sources, charge transfer efficiency, spectral quantum efficiency, linearity, and pixel nonuniformity. These additional metrics are necessary for the most critical scientific applications.

Because the array is the basic building block of the camera, camera terminology is often used for array specifications. Additional performance measures exist at the system level. These include the noise equivalent irradiance (NEI) and noise equivalent differential reflectance (NE$\Delta\rho$) and are discussed in Chapter 6, *Camera Performance*.

The magnitude of each noise component must be quantified and its effect on system performance must be understood. Noise sources may be a function of the detector temperature. Predicted system performance may deviate significantly from actual performance if significant 1/f noise or other noise is present. There are a myriad of factors involved in system optimization. It is essential to understand what limits the system performance so that intelligent improvements can be made.

Janesick[1] uses three methods to characterize CCD performance: (1) photon transfer, (2) x-ray transfer, and (3) photon standard. The photon transfer technique (described in this chapter) appears to be the most valuable in calibrating, characterizing, and optimizing arrays for general video and industrial applications. Additional information, necessary for characterizing scientific arrays, is obtained from the x-ray transfer and photon standard methods.

Soft x-ray photons produce a known number of electron-hole pairs in a localized area of the CCD. Because the number and location of electron hole-pairs are known precisely, it is easy to determine the charge transfer efficiency. With the photon standard technique, the CCD array views a source with a known spectral distribution. Using calibrated spectral filters or a monochrometer, the spectral quantum efficiency is determined.

The symbols used in this book are summarized in the *Symbol List* (page xviii) which appears after the *Table of Contents*.

4.1. SIGNAL

Device specifications depend, in part, upon the application. Arrays for general video applications may have responsivity expressed in units of V/lux. For scientific applications, the units may be in V/(J-cm^{-2}) or, if a digital output is available, DN/(J-cm^{-2}) where DN refers to a digital number. For example, in an 8-bit system the digital numbers range from zero to 255. These units are incomplete descriptors unless the device spectral response and source spectral characteristics are furnished.

The maximum output occurs when the charge wells are filled. The exposure that produces this value is the saturation equivalent exposure (SEE). With this definition, it is assumed that the dark current produces an insignificant number of electrons so that only photoelectrons fill the well.

Sensitivity suggests something about the lowest signal that can be detected. It is usually defined as the input signal that produces a signal-to-noise ratio of one. This exposure is the noise equivalent exposure (NEE). The minimum signal is typically given as equivalent electrons rms. It is only one of many performance parameters used to describe system noise performance.

Figure 4-1 illustrates a signal transfer diagram. The shutter represents the integration time, t_{INT}. The detector converts the incident photons, $n_{DETECTOR}$, into electrons at a rate determined by the quantum efficiency. A voltage is created when the electrons are transferred to the sense node capacitance. The signal after the source follower amplifier is

$$V_{SIGNAL} = n_e \frac{G\,q}{C} \quad , \tag{4-1}$$

where n_e is the total number of electrons in the charge packet. It includes both photoelectrons and dark current electrons. The output gain conversion, Gq/C, is typically 0.1 μV/e$^-$ to 10 μV/e$^-$. The source follower amplifier gain, G, is near unity and, therefore, it is sometimes omitted from radiometric equations. Amplifiers, external to the CCD device, amplify the signal to a useful voltage. These amplifiers are said to be off-sensor or off-chip.

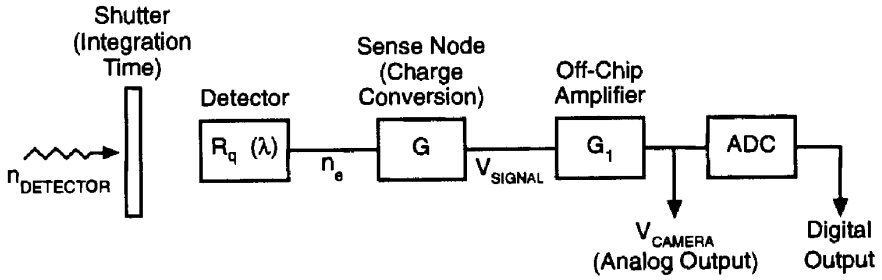


Figure 4-1. Representative signal transfer diagram. Many systems do not have a shutter, but it represents t_{INT}. The output may be specified as the number of electrons, output voltage of the source follower amplifier, or output of the off-chip amplifier. Some devices provide a digital output. V_{SIGNAL}, V_{CAMERA}, and DN can be measured whereas n_e is calculated.

4.1.1. SPECTRAL RESPONSE

For an ideal material, when the photon energy is greater than the semiconductor band gap energy, each photon produces one electron-hole pair (quantum efficiency is one). However, the absorption coefficient in silicon is wavelength dependent (Figure 4-2). Long wavelength photons are absorbed deeper into the substrate than short wavelengths. Very long wavelength photons may pass through the CCD and not be absorbed. Beyond 1.1 μm, the absorption is essentially zero because the photon energy is less than the band gap energy. For a doping concentration of $10^{17}cm^{-3}$, the depth at which 90% of the incident photons are absorbed is given in Table 4-1. Because of reflections, the photon incidance is higher. The values in Table 4-1 apply only to those photons that enter the material.

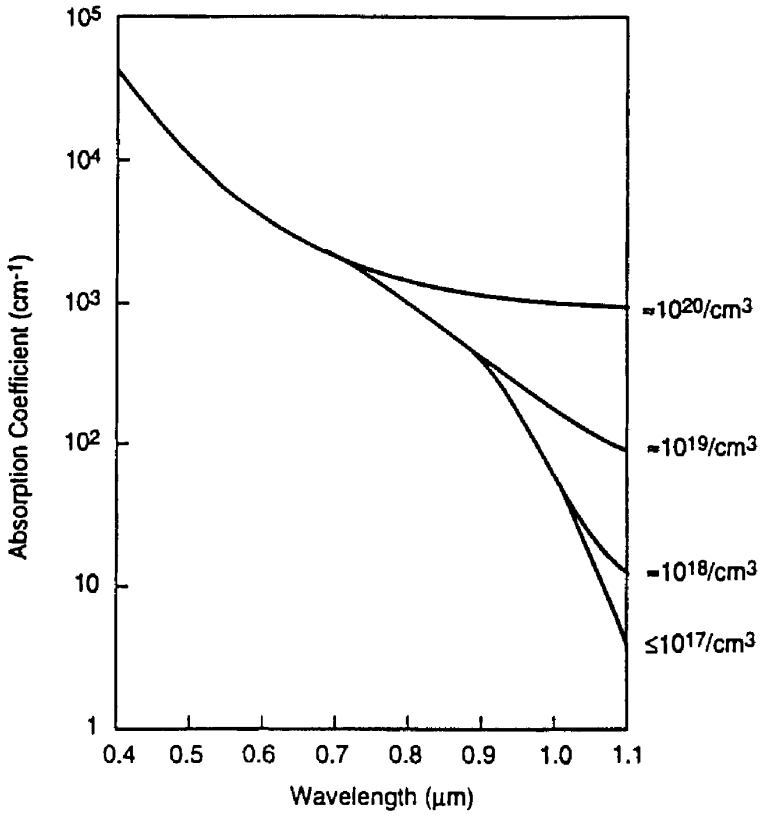


Figure 4-2. Silicon absorption coefficient as a function of wavelength and doping concentration at 25°C. Detectors typically have doping concentrations less than $10^{17}/cm^3$. (From Reference 2).

Any photon absorbed within the depletion will yield a quantum efficiency near unity. However, the depletion region size is finite and long wavelength photons will be absorbed within the bulk material. An electron generated in the substrate will experience a three-dimensional random walk until it recombines or reaches the edge of a depletion region where the electric field exists. If the diffusion length is zero, all electrons created within the bulk material will recombine immediately and the quantum efficiency approaches zero for these photons. As the diffusion length approaches infinity, the electrons eventually reach a charge well and are stored. Here, the quantum efficiency approaches one.

Table 4-1
REPRESENTATIVE 90% ABSORPTION DEPTH

Wavelength (μm)	Depth (μm)
0.40	0.19
0.45	1.0
0.50	2.3
0.55	3.3
0.60	5.0
0.65	7.6
0.70	8.5
0.75	16
0.80	23
0.85	46
0.90	62
0.95	150
1.00	470
1.05	1500
1.10	7600

Doping controls the diffusion length and the quantum efficiency is somewhere between these two extremes (Figure 4-3). The quantum efficiency is dependent upon the gate voltage (low voltages produce small depletion regions) and the material thickness (long wavelength photons will pass through thin substrates). Diffusion creates a responsivity that overlaps pixels (Figure 4-4). The maximum signal and other performance parameters defined in this chapter are for large area illumination. That is, a large number of detectors are illuminated and the average output is used. As the image size decreases, diffusion effects becomes more apparent. Diffusion effects are described by an MTF (discussed in Section 10.3.1., *Diffusion MTF*).

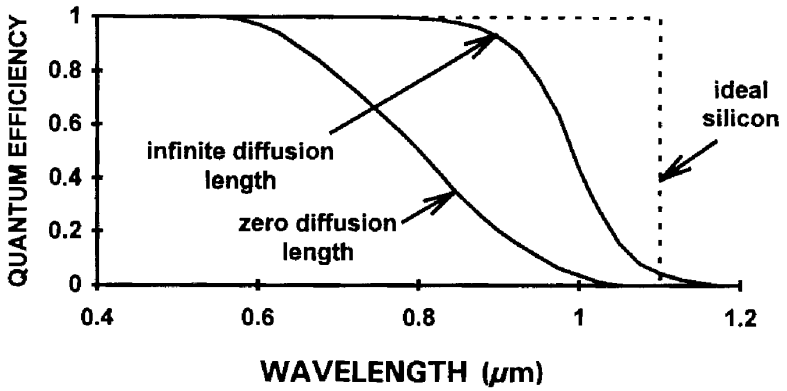


Figure 4-3. Theoretical internal quantum efficiency for silicon photosensors 250 μm thick. The long wavelength quantum efficiency depends upon the thickness of the substrate and the diffusion length. Most arrays have a relatively large diffusion length so that the quantum efficiency tends to be near the infinite diffusion length curve. (From Reference 3).

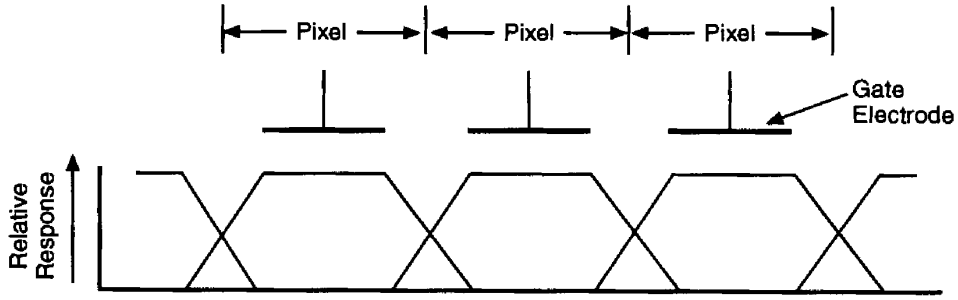


Figure 4-4. Idealized relative spatial response to long wavelength photons.

For front illuminated devices with photogates, the spectral responsivity deviates from the ideal spectral response due to the polysilicon gate electrodes (see Figure 3-2, page 48). The transmittance of polysilicon starts to decrease below 0.6 μm and becomes opaque at 0.4 μm (Figure 4-5). The transmittance depends upon the gate thickness and material.[4] The gate structure is a thin film and therefore interference effects will cause variation in quantum efficiency that is wavelength dependent. Interference effects can be minimized through choice of material and film thickness. Because different manufacturing techniques are used for each array type, the spectral response varies with manufacturer. If a manufacturer uses different processes, then the spectral response will vary within his product line.

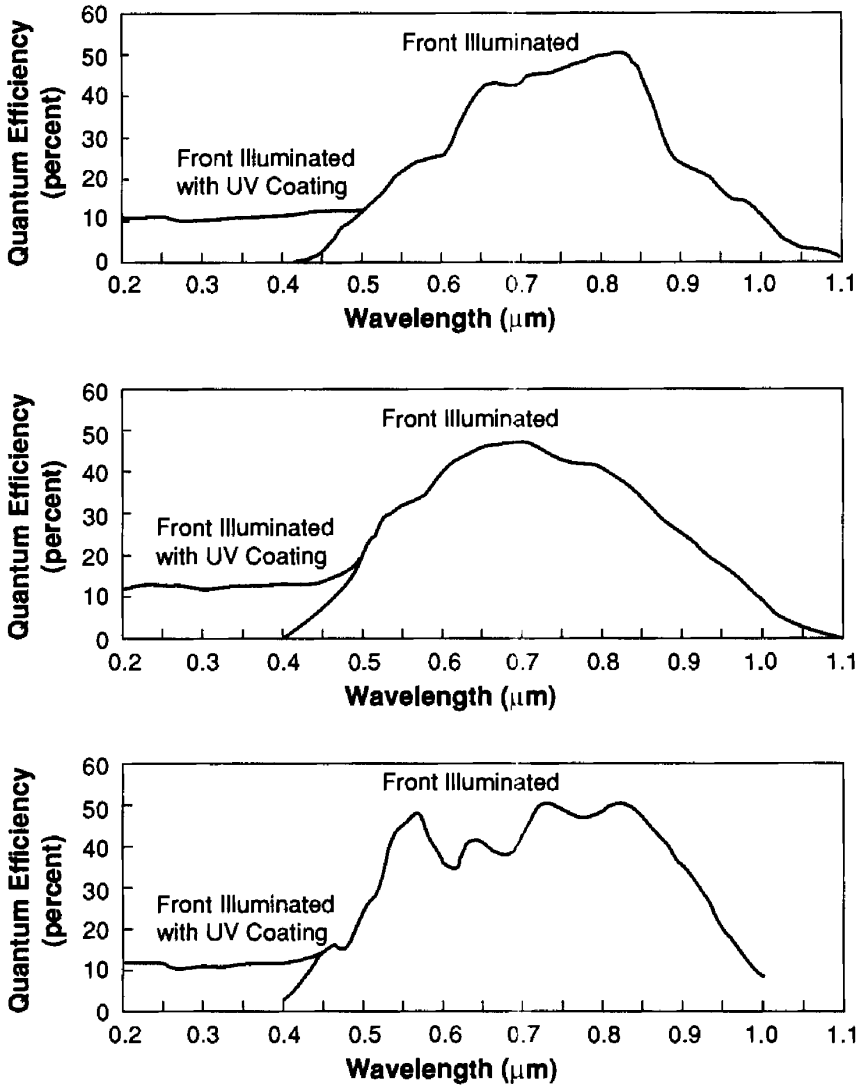


Figure 4-5. Typical response curves provided by different manufacturers. Above 0.8 μm, the quantum efficiency drops because the electron-hole pairs, generated deep in the array, may recombine before reaching a storage site. Below 0.6 μm, the polysilicon overcoat starts to become opaque. The variation in spectral response may not be a concern for many applications. Organic phosphors convert UV photons into visible photons and thereby extend the device's spectral response. The ripples in the responsivity are caused by interference effects.

Photodiodes, as used in most interline transfer devices, do not have polysilicon gates. Therefore these devices tend to have a response that approaches the ideal silicon spectral response. That is, there are no interference effects and the blue region response is restored. With virtual phase devices, one polysilicon electrode is replaced by a shallow highly doped layer. Because there is no electrode over this layer, higher quantum efficiency occurs in the blue region (see Figure 3-11, page 57). CIDs consist of two overlapping MOS capacitors sharing the same row and column electrode. Because the electrode only covers a part of the pixel, the area-averaged spectral response is higher the CCDs (see Figure 3-38, page 89).

Devices with vertical antibloom drains have reduced red response. The buried drain is in close proximity to where long photon absorption occurs. Any electron that enters the drain is instantly removed.

Even with no polysilicon overcoat, UV photons are absorbed at the surface. These electrons recombine before they reach a storage site. Hence the quantum efficiency is very low in the UV. The UV response can be enhanced with a UV fluorescent phosphor. These phosphors are deposited directly onto the array and they emit light at approximately 0.54 to 058 μm when excited by 0.12 to 0.45 μm light. Phosphors radiate in all directions and only the light fluorescing toward the array is absorbed. Lumogen, which is one of many available organic phosphors, has an effective quantum efficiency of about 15%. It does not degrade the quantum efficiency in the visible region because it is transparent at these wavelengths. The coating does not change the spectral response of the detector elements. Rather, it converts out-of-band photons into in-band photons. Therefore, the detector with the coating appears to have a spectral response from 0.12 to 1.1 μm.

Illuminating the array from the back side avoids the polysilicon problem and increases the quantum efficiency below 0.6 μm (Figure 4-6). Photons entering the back side are absorbed in the silicon and diffuse to the depletion region. However, short wavelength photons are absorbed near the surface and these electron-hole pairs recombine before reaching a storage site in a thick wafer (see Table 4-1). Therefore, the wafer is thinned to about 10 μm to maintain good spectral responsivity (Figure 4-7). In back-side thinned devices, the incident photon flux does not have to penetrate the polysilicon gate sandwich structure and interference effects are much easier to control. With a proper anti-reflection coating, a quantum efficiency of approximately 85% is possible. However, silicon has an index of refraction that varies with wavelength making it somewhat difficult to manufacture an anti-reflection coating that is effective across the entire spectrum. Coatings that optimize the response in the near IR

have reduced effectiveness in the visible (Figure 4-8). Lumogen reduces the effectiveness of the anti-reflection coating. New anti-reflection coatings overcome this problem and some offer UV response without the use of lumogen.[6]

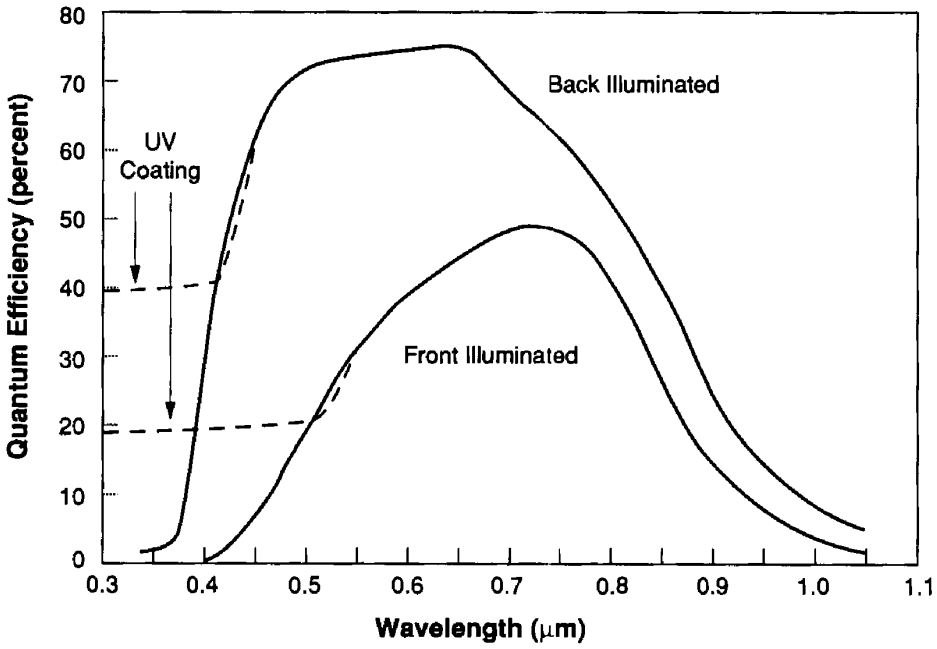


Figure 4-6. Representative spectral response of front illuminated and back illuminated CCD arrays. The spectral response depends upon the process used to manufacture each device.

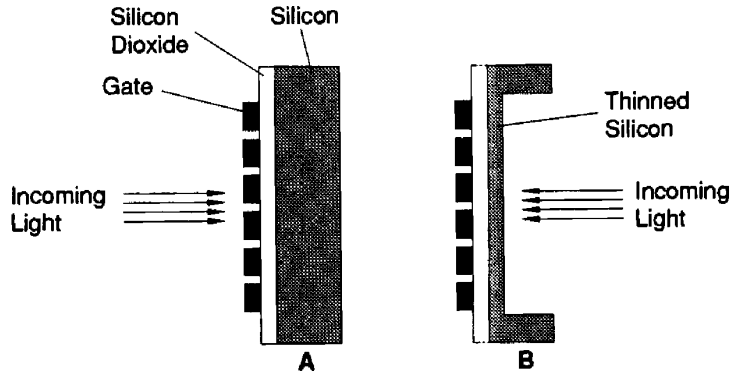


Figure 4-7. (a) Front illuminated and (b) back illuminated arrays. Owing to their extremely complex and fragile design, back illuminated devices are usually limited to scientific applications that require high quantum efficiency.

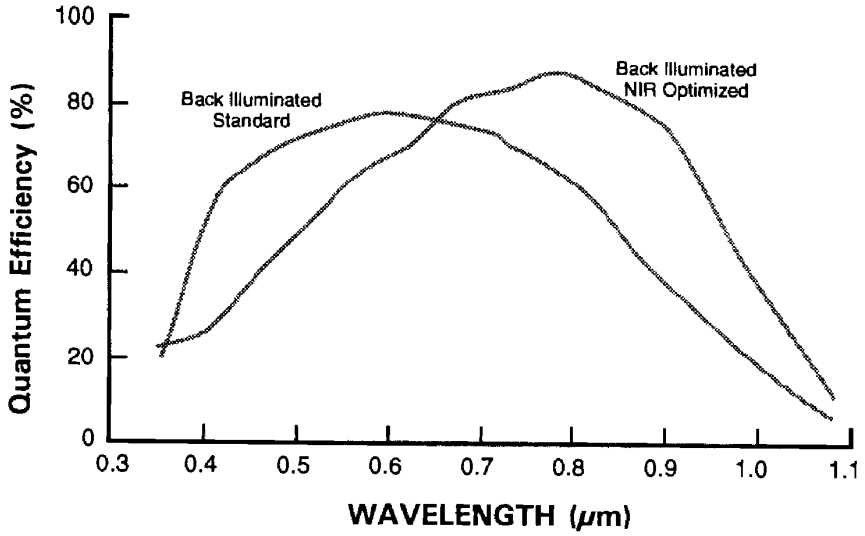


Figure 4-8. Effect of different anti-reflection coatings on back illuminated CCDs. (From Reference 5).

As the wavelength increases, the silicon becomes more transparent. With thin back illuminated devices, the rear surface and silicon oxide layer create an optical etalon. This creates constructive and destructive interference that appear to modulate the spectral responsivity.[5] At 0.8 μm, the modulation occurs approximately every 5 nm. This is bothersome in spectroscopic applications. For other applications, the wave band is sufficiently wide to cover several etalon fringe cycles and this averages out the effect.

CCD arrays for general and industrial applications are within a sealed environment for protection. Light must pass though a window (may be glass or quartz) to reach the array. In addition to reflection losses at all wavelengths, the glass transmittance decreases for wavelengths below 0.4 μm. For scientific applications requiring high sensitivity, the glass can be coated with a broad band anti-reflection coating. For UV applications, a quartz UV transmitting window can be used.

4.1.2. RESPONSIVITY

The spectral quantum efficiency is important to the scientific and military communities. When the array is placed into a general video or industrial camera, it is convenient to specify the output as a function of incident flux density or energy density averaged over the spectral response of the array.

Assume that the array is at a distance of R_1 from an ideal source whose area is A_S. This radiometric setup is similar to that described in Section 2.5., *Camera Formula*, page 33, except no lens is present. For convenience, radiant quantities are used rather than photon flux. Assuming a Lambertian source,

$$n_{pe} = \frac{1}{q}\frac{A_S A_D}{R_1^2}\int_{\lambda_1}^{\lambda_2}\frac{M_e(\lambda)}{\pi}R_e(\lambda)t_{INT}\,d\lambda\ , \tag{4-2}$$

where $R_e(\lambda)$ is the spectral response expressed in units of A/W. Note that the detector incidance is $E_e(\lambda) = M_e(\lambda)A_S/R_1^2$. Then

$$n_{pe} = \frac{A_D}{q}\int_{\lambda_1}^{\lambda_2}\frac{E_e(\lambda)}{\pi}R_e(\lambda)t_{INT}\,d\lambda\ . \tag{4-3}$$

The array output voltage (after the source follow amplifier) is $(G\,q\,n_{pe})/C$:

$$V_{SIGNAL} = \frac{G}{C}\frac{A_S A_D}{R_1^2}\int_{\lambda_1}^{\lambda_2}\frac{M_e(\lambda)}{\pi}R_e(\lambda)t_{INT}\,d\lambda \tag{4-4}$$

or

$$V_{SIGNAL} = \frac{G}{C}A_D\int_{\lambda_1}^{\lambda_2}\frac{E_e(\lambda)}{\pi}R_e(\lambda)t_{INT}\,d\lambda\ . \tag{4-5}$$

It is desirable to express the responsivity in the form

$$V_{SIGNAL} = R_{AVE}\left(\frac{1}{A_D}\frac{A_S A_D}{R_1^2}\int_{\lambda_1}^{\lambda_2}\frac{M_e(\lambda)}{\pi}t_{INT}\,d\lambda\right). \tag{4-6}$$

The value R_{AVE} is an average response that has units of $V/(J\text{-}cm^{-2})$ and the quantity in the brackets has units of J/cm^2.

Combining the two equations provides

$$R_{AVE} = \frac{G}{C} A_D \frac{\int_{\lambda_1}^{\lambda_2} M_e(\lambda)\, R_e(\lambda)\, d\lambda}{\int_{\lambda_1}^{\lambda_2} M_e(\lambda)\, d\lambda} \quad \frac{V}{J/cm^2} . \tag{4-7}$$

Note that R_q and R_{AVE} are the for array package. R_q or R_{AVE} is the detector responsivity multiplied by the window transmittance. Usually the manufacturer includes the window transmittance in the quoted responsivity.

Experimentally, the most popular approach to measure R_{AVE} is to vary the exposure (e.g., the integration time). The value R_{AVE} is the slope of the output/input transformation (Figure 4-9). The bracketed term in Equation 4-6 is the input. By placing a calibrated radiometer next to the array (at distance R_1 from the source), the incidance, E_e, can be measured, Multiplying by the integration time provides J/cm^2. These equations are valid over the region that the array output/input transformation is linear. The incidance can also be changed by moving the source (varying R_1).

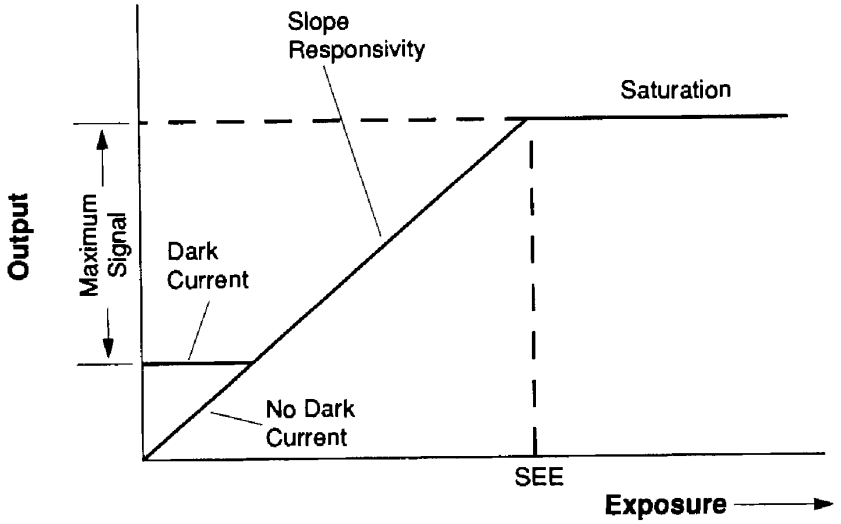


Figure 4-9. The average responsivity is the slope of the output-input transformation. The maximum input or the saturation equivalent exposure (SEE) is the input that fills the charge wells. SEE is used to define the dynamic range. Dark current limits the available signal strength. Cooling can reduce the dark current to a negligible level.

It is imperative that the source color temperature remains constant. Assuming an incandescent bulb is used, reducing the bulb voltage will reduce the output but this changes the color temperature. Changing the source temperature changes the integrals and this leads to incompatible results (see Section 2.7., *Normalization Issues*, page 39). The incidance can only be varied by inserting neutral density filters.

The value R_{AVE} is an average type responsivity that depends upon the source characteristics and the spectral quantum efficiency. While the source can be standardized (e.g., CIE illuminant A or illuminant D_{6500}), the spectral quantum efficiency varies by device (see Figure 4-5, page 108). Therefore extreme care must be exercised when comparing devices solely by the average responsivity.

Both $M_e(\lambda)$ and $R_e(\lambda)$ are functions of wavelength. If a very small wavelength increment is selected, $M_e(\lambda)$ and $R_e(\lambda)$ may be considered as constants. Equation 4-7 can be approximated as

$$R_{AVE} \approx \frac{G}{C} A_D \frac{M_e(\lambda_o) R_e(\lambda_o) \Delta\lambda}{M_e(\lambda_o) \Delta\lambda} \approx \frac{G}{C} A_D R_e(\lambda_o) \ . \qquad (4\text{-}8)$$

The responsivity (with units of A/W) is related to the quantum efficiency R_q by $R_e = (q\lambda/hc)\, R_q$. If the wavelength is measured in micrometers, then $R_e = (\lambda/1.24)\, R_q$. At a specific wavelength

$$R_{SIGNAL}(\lambda_o) = \frac{Gq}{C} \frac{\lambda_o}{hc} A_D R_q(\lambda_o) \quad \frac{v}{J/cm^2} = \frac{G}{C} A_D R_e(\lambda_o) \qquad (4\text{-}9)$$

or

$$R_{SIGNAL}(\lambda_o) = \frac{G}{C} \frac{\lambda_o}{1.24} A_D R_q(\lambda_o) \quad \frac{v}{J/cm^2} \ . \qquad (4\text{-}10)$$

Here, the detector area is measured in square centimeters. Typically $R_q(\lambda_o)$ is evaluated at that wavelength which provides the peak quantum efficiency: $R_q(\lambda_p)$. The symbol η is often used for the quantum efficiency.

If the device has a digital output, the number of counts (integer value) is

$$DN = int\left[V_{CAMERA}\frac{2^N}{V_{MAX}}\right], \tag{4-11}$$

where N is the number of bits provided by the analog-to-digital converter and *int* represents the integer value of the bracketed term. The value N is usually 8 for general video applications but may be as high as 16 for scientific cameras. The value V_{MAX} is the maximum output that corresponds to a full well, N_{WELL}:

$$V_{MAX} = G_1\frac{G\,q}{C}N_{WELL}\,. \tag{4-12}$$

The responsivity at the peak wavelength is approximated by

$$R_{AVE} \approx \left[\frac{2^N}{N_{WELL}}\frac{\lambda_P}{1.24}A_D\,R_q(\lambda_P)\right]\ \frac{DN}{J/cm^2}\,. \tag{4-13}$$

This assumes that the analog-to-digital converter input dynamic range exactly matches V_{MAX}. This may not be the case in real systems. If an antibloom drain is present, then the responsivity is defined up to the knee point (see Figure 3-35, page 87) and Equation 4-11 is modified accordingly.

When using arrays for general video, the output is normalized to photometric units (see Section 2.3.1., *Units*, page 25). It is convenient to express the array average response as

$$V_{SIGNAL} = R_{PHOTOMETRIC}\left(683\frac{1}{A_D}\int_{0.38}^{0.75\,\mu m} M_p(\lambda)\,V(\lambda)\,d\lambda\right), \tag{4-14}$$

where $R_{PHOTOMETRIC}$ has units of V/lux and the bracketed term has units of lux. Combining Equations 4-4 and 4-14 yields

$$R_{PHOTOMETRIC} = \frac{\dfrac{G}{C}\dfrac{A_S A_D}{R_1^2}\displaystyle\int_{\lambda_1}^{\lambda_2} L_e(\lambda)\,R_e(\lambda)\,t_{INT}\,d\lambda}{683\dfrac{1}{A_D}\displaystyle\int_{0.38}^{0.75\,\mu m} M_p(\lambda)\,V(\lambda)\,d\lambda}\ \frac{V}{lux}\,. \tag{4-15}$$

Because $M_P(\lambda)/A_D = E_e(\lambda)$, for a Lambertian source,

$$R_{PHOTOMETRIC} = \frac{\frac{G}{C} A_D \int_{\lambda_1}^{\lambda_2} E_e(\lambda)\, R_e(\lambda)\, t_{INT}\, d\lambda}{683 \int_{0.38}^{0.75\,\mu m} E_e(\lambda)\, V(\lambda)\, d\lambda} \quad \frac{V}{lux} . \qquad (4\text{-}16)$$

$R_{PHOTOMETRIC}$ depends on the integration time and is either 1/60 or 1/30 s depending on the architecture for EIA 170 or NTSC video standards (see Section 3.3.4., *Interline Transfer*, page 63). Experimentally, the photometric illuminance is measured with a calibrated sensor. The input intensity levels are changed either by moving the source (changing R_1) or by inserting neutral density filters between the source and the array.

The responsivity depends on the spectral response and the spectral content of the illumination. The apparent variation in output with different light sources was discussed in Section 2.7., *Normalization Issues*, page 39. Selecting an array based on the responsivity is appropriate if the anticipated scene illumination has the same color temperature as the calibration temperature. That is, if the photometric responsivity is measured with a CIE illuminant A and the scene color temperature is near 2856 K, then selecting an array with the highest photometric responsivity is appropriate. Otherwise, the average photometric responsivity is used for informational purposes only.

Five numerical examples follow. Additional examples can be found in Chapter 6.

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Example 4-1
MAXIMUM OUTPUT

A device provides a output gain conversion of 6 μV/e$^-$. The well size is 70,000 electrons. What is the maximum output?

The maximum output is the OGC multiplied by the well capacity or 420 mV. If the dark current creates 5,000 electrons, then the maximum signal voltage is reduced to (70,000−5,000)(0.006mV)= 390 mV. This signal may be amplified by an off-chip amplifier.

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Example 4-2
DIGITAL RESPONSIVITY

A device with a well capacity of 50,000 electrons has its output digitized with a 12-bit analog-to-digital converter (ADC). What is the digital step-size (digital responsivity)?

The step size is the well capacity divided by the number of digital steps. $50{,}000/2^{12} = 12.2$ electrons/DN. Equation 4-2 (page 112) provides the number of electrons as a function of input exposure. The relationship between the ADC maximum value and charge well capacity assumes an exact match between V_{MAX} and the ADC input range. If these do not match, an additional amplifier must be inserted just before the ADC.

Example 4-3
RESPONSIVITY

A 2/3-inch format interline transfer device provides an output gain conversion of 6 μV/e$^-$. If the quantum efficiency is 0.8 at 0.6 μm, what is the responsivity in units of V/μJ-cm^{-2} ?

From Table 3-3 (page 99), a 2/3-inch format pixel is approximately 11.4 μm $\times$ 13.8 μm. If the interline transfer device has a 50% fill factor, then $A_D = 7.87 \times 10^{-7}$ cm^2. The constant hc is 1.99×10^{-25} J-m/photon. Using Equation 4-9,

$$R_{SIGNAL}(\lambda_o) = (6 \times 10^{-6})\left(\frac{0.6 \times 10^{-6}}{1.99 \times 10^{-25}}\right)(7.87 \times 10^{-7})\,(0.8) = 11.4 \times 10^{6} \quad (4\text{-}17)$$

$$\frac{V}{J\text{-}cm^{-2}} = \left(\frac{V}{e^-}\right)\left(\frac{m}{(J\text{-}m)/photon}\right)(cm^2)\left(\frac{electrons}{photons}\right)$$

or $R_{SIGNAL}(\lambda_o) = 11.4$ V/μJ-cm^{-2}.

Example 4-4
PHOTOMETRIC OUTPUT

An array designed for video applications has a sensitivity of 250 μV/lux when measured with CIE illuminant A. What is the expected output if the input is 1000 lux?

If the color temperature does not change and only the intensity changes, then the output is (250 μV)(1000) = 250 mV. However, if the color temperature changes, the output changes in a nonlinear manner. Similarly, two sources may produce the same illuminance but V_{SIGNAL} may be quite different. The color temperature must always be specified when $R_{PHOTOMETRIC}$ is quoted.

Implicit in this calculation is that the integration time remains constant. Because photometric units are used for general video applications, it is reasonable to assume that t_{INT} is either 1/60 or 1/30 s for EIA 170 compatibility.

Example 4-5
PHOTOMETRIC CONVERSION

An array designed for video applications has a sensitivity of 20 V/μJ-cm^{-2}. What is the estimated photometric response? The relative spectral response of $R_{SIGNAL}(\lambda)$ is illustrated in Figure 4-10.

Substituting Equation 4-9 into Equation 4-16 provides

$$R_{PHOTOMETRIC} = t_{INT} R_{SIGNAL-MAX} \left[\frac{\int_{\lambda_1}^{\lambda_2} E_e(\lambda) R_{SIGNAL-RELATIVE}(\lambda) d\lambda}{683 \int_{0.38}^{0.75\,\mu m} E_e(\lambda) V(\lambda) d\lambda} \right] \frac{V}{lux} . \quad (4\text{-}18)$$

Two different spectral responsivities are considered: one as shown in Figure 4-10 and the other has an additional infrared blocking filter that cuts off at 0.7 μm. Numerical integration provides the value of the bracketed term (Table 4-2). As the color temperature increases, the bracketed value may either increase or decrease depending upon the spectral response. With $R_{SIGNAL-MAX}$ = 2000 V/J-m^{-2} (note change in units), t_{INT} = 1/60 s, $R_{PHOTOMETRIC}$ is given in Table 4-3.

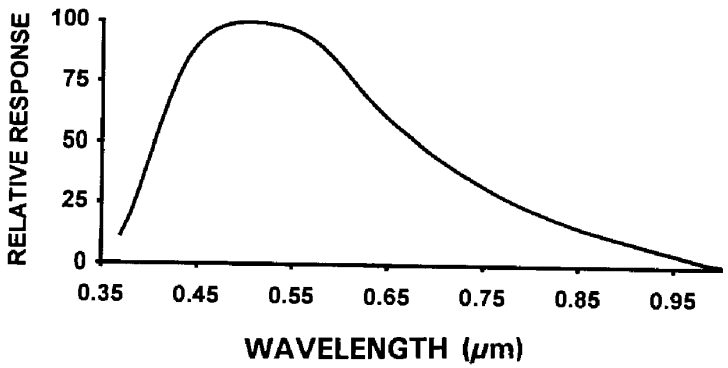


Figure 4-10. Relative spectral responsivity of $R_{SIGNAL}(\lambda)$.

Table 4-2
EQUATION 4-18 BRACKETED TERM

COLOR TEMPERATURE	NO INFRARED FILTER	WITH INFRARED FILTER
2856 K	0.00473	0.00319
6500 K	0.00391	0.00353

Table 4-3
PHOTOMETRIC RESPONSIVITY (V/lux)

COLOR TEMPERATURE	NO INFRARED FILTER	WITH INFRARED FILTER
2856 K	0.158	0.106
6500 K	0.130	0.117

4.1.3. MINIMUM SIGNAL

The noise equivalent exposure (NEE) is an excellent diagnostic tool for production testing to verify noise performance. NEE is a poor array-to-array comparison parameter and should be used cautiously when comparing arrays with different architectures. This is so because it depends on array spectral

responsivity and noise. The NEE is the exposure that produces a signal-to-noise ratio of one. If the measured rms noise on the analog output is V_{NOISE}, then the NEE is calculated from the radiometric calibration:

$$NEE = \frac{V_{NOISE}}{R_{AVE}} \quad \frac{J}{cm^2} \; rms. \tag{4-19}$$

When equated to electrons, NEE is simply the noise value in rms electrons. The absolute minimum noise level is the noise floor and this value is used most often for the NEE. Noise sources are discussed in Section 4.2., *Noise*. Although noise is a rms value, the notation *rms* is often omitted. When divided by the average quantum efficiency, the noise equivalent signal (NES) is obtained:

$$NES = \frac{NEE}{R_{q\text{-}AVE}} \quad photons. \tag{4-20}$$

4.1.4. MAXIMUM SIGNAL

The maximum signal is that input signal that saturates the charge well and is called the saturation equivalent exposure (SEE). It is

$$SEE = \frac{V_{MAX}}{R_{AVE}} \quad \frac{J}{cm^2} \; . \tag{4-21}$$

The well size varies with architecture, number of phases, and pixel size. The well size is approximately proportional to pixel area (Table 4-4). Small pixels have small wells. If an antibloom drain is present, the maximum level is taken as the white clip level (see Figure 3-35, page 87). The maximum value of V_{MAX} is

$$V_{MAX} = G_1 \frac{G\,q}{C} (N_{WELL} - n_{DARK}) \; . \tag{4-22}$$

For back-of-the-envelope calculations, the dark current is considered negligible (i.e., the device is cooled or MPP is implemented). Then $n_{DARK} \approx 0$.

Table 4-4
NOMINAL WELL CAPACITY for
TEXAS INSTRUMENTS FRAME TRANSFER DEVICES
(Varies by manufacturer and device type)

FORMAT	WELL CAPACITY (electrons)
2/3 inch	200,000
1/2 inch	80,000
1/3 inch	30,000

4.1.5. DYNAMIC RANGE

Dynamic range defined as the maximum signal (peak) divided by the rms noise. If an antibloom drain is present, the knee value is used as the maximum (See Figure 3-35, page 87). Expressed as a ratio, the dynamic range is

$$DR_{ARRAY} = \frac{SEE}{NEE} = \frac{V_{MAX}}{V_{NOISE}} \qquad (4\text{-}23)$$

and when expressed in decibels,

$$DR_{ARRAY} = 20\log\left(\frac{SEE}{NEE}\right) \quad dB \ . \qquad (4\text{-}24)$$

When equated to electrons,

$$DR_{ARRAY} = \frac{N_{WELL} - n_{DARK}}{\langle n_{SYS} \rangle} \ , \qquad (4\text{-}25)$$

where $<n_{SYS}>$ is the system noise measured in electrons rms. The effects of $<n_{SYS}>$ on dynamic range is further discussed in Section 4.3., *Array Signal-to-Noise Ratio*. Often, only the noise floor is considered in $<n_{SYS}>$. The noise is dependent upon amplifier design and is not related to charge well capacity.

While larger arrays have larger well capacities, this does not necessary mean that the dynamic range increases by the same amount. As the pixel rate increases, the amplifier bandwidth increases. Simultaneously, the amplifier noise increases and the dynamic range decreases.

Sometimes the manufacturer will specify dynamic range by the peak signal divided by the peak-to-peak noise. This peak-to-peak value includes any noise spikes and, as such, may be more useful in determining the lowest detectable signal in some applications. If the noise is purely Gaussian, the peak-to-peak is assumed to be four to six times the rms value. This multiplicative factor is author dependent.

If the system noise is less than the ADC's least significant bit (LSB), then the quantization noise limits the system dynamic range. The rms quantization noise, $<n_{ADC}>$, is $V_{LSB}/\sqrt{12}$ where V_{LSB} is the voltage step corresponding to the least significant bit. The dynamic range is $2^N \sqrt{12}$. For a 12-bit ADC, the dynamic range is 14,189:1 or 83 dB. An 8-bit system cannot have a dynamic range greater than 887:1 or 59 dB.

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Example 4-6
ARRAY PARAMETERS

An array has a dynamic range of 3000:1, average responsivity of 2 V/(μJ/cm^2), and a saturation equivalent exposure of 150 nJ/cm^2. These values apply only at λ_P. What are the remaining design parameters?

Maximum output:

The maximum output is R_{AVE} SEE = 300 mV.

Noise level:

The noise floor rms value is equal to the maximum output divided by the dynamic range or 100 μV rms.

Analog-to-digital Converter:

For a digital output, the ADC must have 12 bits (2^{12} = 4096 levels) to span the array's full dynamic range. The responsivity in DN is 2^{12}/SEE = 27.3 DN/(nJ/cm^2) at λ_P.

4.2. NOISE

Many books and articles[7-13] have been written on noise sources. The level of detail used in noise modeling depends on the application. Shot noise is due to the discrete nature of electrons. It occurs when photoelectrons are created and when dark current electrons are present. Additional noise is added when reading the charge (reset noise) and introduced by the amplifier (1/f noise and white noise). If the output is digitized, the inclusion of quantization noise may be necessary. Switching transients that are coupled though the clock signals also appear as noise. It can minimized by good circuit design.

Figure 4-1 (page 104) illustrated the signal transfer diagram. The noise transfer diagram is somewhat different (Figure 4-11). With different transfer functions, both the optical and electronic subsystems must be considered to maximize the system signal-to-noise ratio.

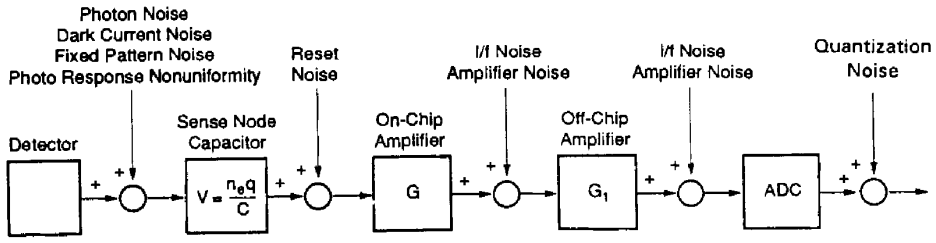


Figure 4-11. The various subsystems are considered as ideal elements with the noise introduced at appropriate locations.

Although the origins of the noise sources are different, they all appear as variations in the image intensity. Figure 4-12a illustrates the ideal output of the on-chip amplifier before correlated double sampling. The array is viewing a uniform source and the output of each pixel is identical. Photon shot noise produces a temporal variation in the output signal that is proportional to the square root of the signal level in electrons. Each pixel output will have a slightly different value (Figure 4-12b).

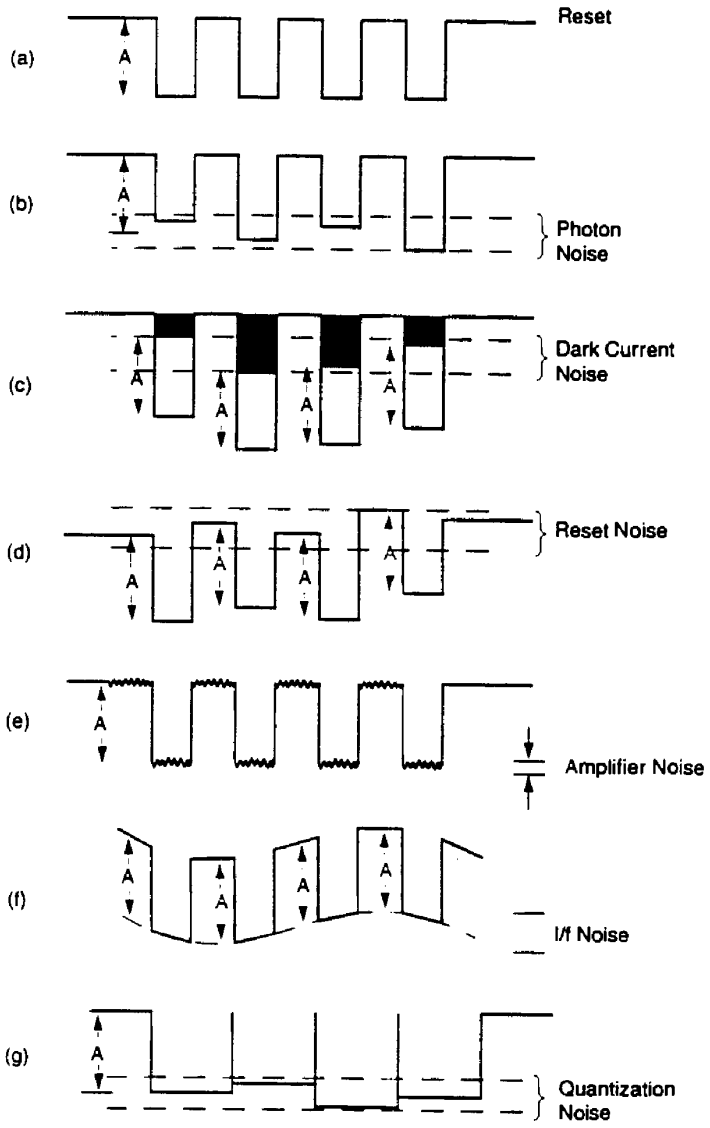


Figure 4-12. Noise sources affect the output differently. (a) though (f) represent the output after the on-chip amplifier. (g) is the output after the sample-and-hold circuitry. The array is viewing a uniform source that produces identical outputs (amplitude = A) for each pixel. (a) ideal output, (b) photon shot noise, (c), dark current shot noise, (d) reset noise, (e) amplifier noise, (f) amplifier 1/f noise, and (g) quantization noise. These values change from frame-to-frame. Pattern noise is not shown but is a variation that does not change significantly each frame. All these processes occur simultaneously.

Under ideal conditions, each pixel would have the same dark current and this value is subtracted from all pixels leaving the desired signal (see Section 3.6., *Dark Current*, page 79). However, dark current also exhibits fluctuations. Even after subtracting the average value, these fluctuations remain and create fixed pattern noise (Figure 4-12c). The output capacitor is reset after each charge is read. Errors in the reset voltage appear as output signal fluctuations (Figure 4-12d). The amplifier adds white noise (Figure 4-12e) and 1/f noise (Figure 4-12f). Amplifier noise affects both the active video and reset levels. The analog-to-digital converter introduces quantization noise (Figure 4-12g). Quantization noise is apparent after image reconstruction. Only photon shot noise and amplifier noise affect the amplitude of the signal. With the other noise sources listed, the signal amplitude, A, remains constant. However, the value of the output fluctuates with all the noise sources. Because this value is presented on the display, the processes appear as displayed noise. These noise patterns change from pixel-to-pixel and on the same pixel from frame-to-frame.

Pattern noise refers to any spatial pattern that does not change significantly from frame-to-frame. Dark current varies from pixel-to-pixel and this variation is called fixed pattern noise (FPN). FPN is due to differences in detector size, doping density, and foreign matter getting trapped during fabrication. Photoresponse nonuniformity (PRNU) is the variation in pixel responsivity and is seen when the device is illuminated. This noise is due to differences in detector size, spectral response, and thickness in coatings. These "noises" are not noise in the usual sense. PRNU occurs when each pixel has a different average value. This variation appears as spatial noise to the observer. Frame averaging will reduce all the noise sources except FPN and PRNU. Although FPN and PRNU are different, they are sometimes collectively called scene noise, pixel noise, pixel nonuniformity, or simply pattern noise.

It is customary to specify all noise sources in units of equivalent electrons at the detector output. Amplifier noise is reduced by the amplifier gain. When quoting noise levels, it is understood that the noise magnitude is the rms of the random process producing the noise. Noise powers are considered additive.

Equivalently, the noise sources are RSSed (root sum of the squares) or added in quadrature:

$$\langle n_{SYS} \rangle = \sqrt{\langle n_{SHOT}^2 \rangle + \langle n_{PATTERN}^2 \rangle + \langle n_{RESET}^2 \rangle + \langle n_{ON\text{-}CHIP}^2 \rangle + \langle n_{OFF\text{-}CHIP}^2 \rangle + \langle n_{ADC}^2 \rangle} \quad (4\text{-}26)$$

where $\langle n_i^2 \rangle$ is the noise variance for source i and $\sqrt{\langle n_i^2 \rangle} = \langle n_i \rangle$ is the standard deviation measured in rms units.

For system analysis, it may be sufficient to consider only the on-chip amplifier noise. The array manufacturer usually provides this value and may call it readout noise, mux noise, noise equivalent electrons, or the noise floor. The value varies by device and manufacturer. Reset noise can be reduced to a negligible level with CDS (discussed in Section 4.4., *Correlated Double Sampling*). CDS can also reduce the source follower 1/f noise. The off-chip amplifier is usually a low noise amplifier such that its noise is small compared to the on-chip amplifier noise. Although always present, quantization noise is reduced by selecting the appropriated sized analog-to-digital converter (e.g., selecting an ADC with many quantization levels). The simplified noise model is

$$\langle n_{SYS} \rangle \approx \sqrt{\langle n_{SHOT}^2 \rangle + \langle n_{FLOOR}^2 \rangle + \langle n_{PATTERN}^2 \rangle} \; . \quad (4\text{-}27)$$

The noise model does not include effects such as banding and streaking which are forms of pattern noise found in linear and TDI arrays. Banding can occur with arrays that have multiple outputs serviced by different nonlinear amplifiers (see Figure 3-14, page 61). Streaking occurs when the average responsivity changes from column to column in TDI devices.[14] These effects are incorporated in the three-dimensional noise model (discussed in Section 12.2., *Three-dimensional Noise Model*) and are used to predict the performance of military systems. Only a complete signal-to-noise ratio analysis can determine which noise source dominates (discussed in Section 4.3., *Array Signal-to-noise Ratio*).

4.2.1. SHOT NOISE

Both photoelectrons and dark current contribute to shot noise. Using Poisson statistics, the variance is equal to the mean:

$$\left\langle n_{SHOT}^2 \right\rangle = \left\langle n_{PE}^2 \right\rangle + \left\langle n_{DARK}^2 \right\rangle = n_{PE} + n_{DARK} . \quad (4\text{-}28)$$

The number of photoelectrons was given by Equation 4-2, page 112, and the number of dark current electrons was given by Equation 3-6, page 80. These values should be modified by the CTE:

$$\left\langle n_{SHOT}^2 \right\rangle = \left\langle n_{pe}^2 \right\rangle + \left\langle n_{DARK}^2 \right\rangle = (CTE)^N n_{pe} + (CTE)^N n_{DARK} . \quad (4\text{-}29)$$

Because the CTE is high ($CTE^N \approx 1$), it is usually omitted from most equations. However, CTE should be included for very large arrays. With TDI, the number of photoelectrons and dark current electrons increases with the number of TDI elements, N_{TDI}:

$$\left\langle n_{SHOT}^2 \right\rangle = N_{TDI} n_{pe} + N_{TDI} n_{DARK} . \quad (4\text{-}30)$$

While the dark current average value can be subtracted from the output to provide only the signal due to photoelectrons, the dark current shot noise cannot. Cooling the array can reduce the dark current to a negligible value and thereby reduce dark current shot noise to a negligible level (see Section 3.6., *Dark Current*, page 79).

4.2.2. RESET NOISE

The noise associated with resetting the sense node capacitor is often called kTC noise. This is due to thermal noise generated by the resistance, R, within the resetting FET. The Johnson noise current variance is

$$\left\langle i_n^2 \right\rangle = \frac{4kT}{R} \Delta f . \quad (4\text{-}31)$$

Because the resistance is in parallel with the sense node capacitor, the noise equivalent bandwidth is $\Delta f = RC/4$. Then

$$\left\langle i_n^2 \right\rangle = kTC \ . \tag{4-32}$$

When expressed as equivalent electrons, the rms noise is

$$\left\langle n_{RESET} \right\rangle = \frac{\sqrt{kTC}}{q} \quad e^- \ rms \ . \tag{4-33}$$

The value $\langle n_{RESET} \rangle$ represents the uncertainty in the amount of charge remaining on the capacitor following reset.

For a 0.01 pF capacitor at room temperature, kTC noise is about 40 electrons rms and a 0.2 pf capacitor produces about 126 e^- rms. Reducing the capacitance reduces the noise. This has an added benefit that the device output gain conversion, Gq/C, increases. kTC noise may be significantly reduced with correlated double sampling. While cooling reduces this noise source, cooling is used primarily to reduce dark current. That is, cooling reduces dark current noise exponentially whereas reset noise is reduced only by $\sqrt{T}$.

4.2.3. ON-CHIP AMPLIFIER NOISE

Amplifier noise consists of two components: 1/f noise and white noise. If f_{KNEE} is the frequency at which the 1/f noise equals the white noise, then the amplifier noise density is

$$V_{ON\text{-}CHIP} = V_{AMP\text{-}NOISE}\left(1 + \frac{f_{KNEE}}{f}\right) \quad \frac{rms \ volts}{\sqrt{Hz}} \ . \tag{4-34}$$

The 1/f noise can be minimized through correlated double sampling.

When discussing individual noise sources, noise is usually normalized to unit bandwidth. When modified by electronic subsystems, the total system noise power is

$$\sigma^2_{SYS} = \int_0^\infty S(f_{elec})\,|H_{sys}(f_{elec})|^2\,df_{elec} \quad volts\ , \tag{4-35}$$

where $S(f_{elec})$ is the total noise power spectral density from all sources. The subscript *elec* is used to emphasize that this is electrical frequency (Hz). $H_{sys}(f_{elec})$ is the frequency response of the system electronics. The variable $H(f_{elec})$ is used by electronic circuitry designers and its magnitude is identical to the MTF. The noise equivalent bandwidth is that bandwidth with unity value that provides the same total noise power. Assuming the noise is white over the spectral region of interest [$S(f_{elec}) = S_o$], Δf_{elec} is

$$\Delta f_{elec} = \frac{\int_0^\infty S(f_{elec})\,|H_{sys}(f_{elec})|^2\,df_{elec}}{S_o}\ . \tag{4-36}$$

The bandwidth Δf_{elec} applies only to those noise sources that are white and cannot be applied to 1/f noise. Although common usage has resulted in calling Δf_{elec} the noise *bandwidth*, it is understood that it is a power equivalency.

If t_{CLOCK} is the time between pixels, the bandwidth for an *ideal* sampled-data system is

$$\Delta f_{elec} = \frac{1}{2\,t_{CLOCK}} = \frac{f_{CLOCK}}{2}\ . \tag{4-37}$$

When equated to electrons,

$$\langle n_{ON\text{-}CHIP} \rangle = \frac{C}{G\,q} V_{ON\text{-}CHIP\text{-}AMP\text{-}NOISE} \sqrt{\Delta f_{elec}} \quad e^- rms\ . \tag{4-38}$$

As the clock frequency increases (for faster readout), $< n_{ON\text{-}CHIP} >$ increases.

4.2.4. OFF-CHIP AMPLIFIER NOISE

The off-chip amplifier noise is identical in form to the on-chip amplifier noise (Equation 4-34). The 1/f knee value may be different for the two amplifiers. If f_{KNEE} is small, the equivalent number of noise electrons is

$$\langle n_{OFF\text{-}CHIP} \rangle = \frac{C}{G G_1 q} V_{OFF\text{-}CHIP\text{-}AMP\text{-}NOISE} \sqrt{\Delta f_{elec}} \quad e^- \ rms \ . \quad (4\text{-}39)$$

4.2.5. QUANTIZATION NOISE

The analog-to-digital converter produces discrete output levels. A range of analog inputs can produce the same output. This uncertainty, or error, produces an effective noise given by

$$V_{NOISE} = \frac{V_{LSB}}{\sqrt{12}} \quad V \ rms \ , \quad (4\text{-}40)$$

where V_{LSB} is the voltage associated with the least significant bit. For an ADC with N bits, $V_{LSB} = V_{MAX}/2^N$. When expressed in equivalent electrons,

$$\langle n_{ADC} \rangle = \frac{C}{G G_1 q} \frac{LSB}{\sqrt{12}} \quad e^- \ rms \ . \quad (4\text{-}41)$$

When the ADC is matched to the amplifier output, V_{MAX} corresponds to the full well. Then

$$\langle n_{ADC} \rangle = \frac{N_{WELL}}{2^N \sqrt{12}} \ . \quad (4\text{-}42)$$

Ideally, $\langle n_{ADC} \rangle$ is less than the noise floor. This is achieved by selecting a high resolution ADC (large N).

Example 4-7
TOTAL NOISE

An array has a noise floor of 20 electrons rms, well capacity of 50,000 electrons, and an 8-bit analog-to-digital converter. Neglecting shot noise and pattern noise, what is the total noise?

The LSB represents $50{,}000/2^8 = 195$ electrons. The quantization noise is $195/\sqrt{12}$ or 56.3 electrons rms. The total noise is

$$\langle n_{SYS} \rangle = \sqrt{\langle n_{FLOOR}^2 \rangle + \langle n_{ADC}^2 \rangle} + \sqrt{20^2 + 56.3^2} \approx 59.7\ e^- rms\ . \quad (4\text{-}43)$$

The array dynamic is range 2500:1 and the ADC only has 256 levels. Here, the ADC noise dominates the array noise. If a 12-bit ADC is used (4096 levels), the LSB represents 12.2 electrons and $\langle n_{ADC} \rangle = 3.5$ electrons rms. The total noise in electrons is

$$\langle n_{SYS} \rangle = \sqrt{\langle n_{FLOOR}^2 \rangle + \langle n_{ADC}^2 \rangle} = \sqrt{20^2 + 3.52^2} \approx 20.3\ e^- rms\ . \quad (4\text{-}44)$$

4.2.6. PATTERN NOISE

Fixed pattern noise (FPN) refers to the pixel-to-pixel variation[15,16] that occurs when the array is in the dark. It is primarily due to dark current differences. Significant FPN can be caused by synchronous timing effects at high data rates. It is a signal-independent noise and is additive to the other noise powers. PRNU is due to differences in responsivity (when light is applied). It is a signal-dependent noise and is a multiplicative factor of the photoelectron number.

PRNU be either be specified as a peak-to-peak value or a rms value referenced to an average value. This average value may either be full well or one-half full well value. That is, the array is uniformly illuminated and a histogram of responses is created. The PRNU can either be the rms of the histogram divided by the average value or the peak-to-peak value divided by the average value. This definition varies by manufacturer so that the test conditions must be understood when comparing arrays. For this text, the rms value is used.

Because dark current becomes negligible by efficiently cooling the array, PRNU is the dominate pattern component for most arrays. As a multiplicative noise, PRNU is traditionally expressed as a fraction of the total number of charge carriers. This approach assumes that the detectors are operating in a linear region with the only difference being responsivity differences. If U is the fixed pattern ratio or nonuniformity, then

$$\langle n_{PATTERN} \rangle \approx \langle n_{PRNU} \rangle = U n_{pe} . \tag{4-45}$$

As with shot noise, CTE^N should be added to the equation. Because $CTE^N \approx 1$ for modest sized arrays, it is omitted from most equations. CTE should be included for very large arrays. TDI devices, through their inherent averaging, reduces PRNU by $1/N_{TDI}$. PRNU is usually supplied by the manufacturer. Off-chip gain/level correction algorithms can minimize FPN and PRNU. For system analysis, the corrected pattern noise value is used.

In principle, FPN and the noise floor can be reduced so that the system is photon shot noise limited. This provides the theoretical limit:

$$\langle n_{SYS} \rangle_{MIN} = \sqrt{n_{pe}} . \tag{4-46}$$

However, all systems have some pattern noise. The plot of SNR versus nonuniformity suggests a desired maximum level of acceptable nonuniformity.[17] In Figure 4-13, the noise floor is considered negligible:

$$\langle n_{SYS} \rangle = \sqrt{n_{pe} + (U n_{pe})^2} . \tag{4-47}$$

The total noise value $\langle n_{SYS} \rangle$ increases when PRNU is excessive. Typically an array is selected that has small PRNU. This value can be further reduced by off-chip electronics. The final value should be sufficiently small so that it does not contribute to the overall noise. Because cost increases as the PRNU decreases, the optimum PRNU occurs at the knee of the curve. This occurs when the photon shot noise is approximately equal to PRNU or $U \approx 1/\sqrt{n_{pe}}$. For worst case analysis, the charge well capacity should be used for n_{pe}.

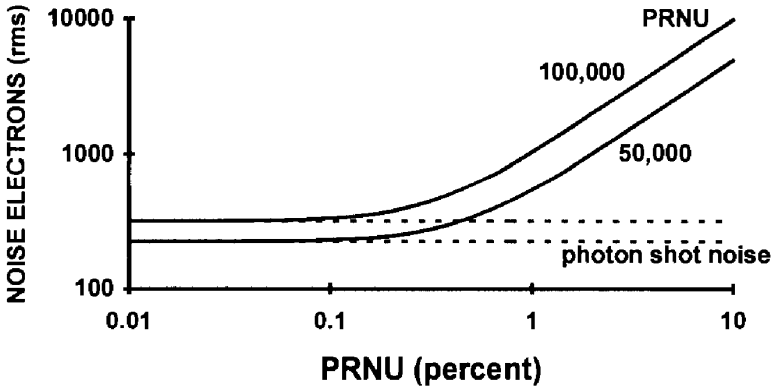


Figure 4-13. System noise as a function of PRNU for two signal levels. The noise floor is considered negligible. The noise floor will increase $\langle n_{SYS} \rangle$ and the location of the knee. Shot noise is independent of PRNU (horizontal dashed lines). The value $1/\sqrt{n_{pe}}$ is 0.4% and 0.3% when n_{pe} is 50,000 and 100,000, respectively. These values represent the "knee" in the curve.

4.2.7. PHOTON TRANSFER

Although various noise sources exist, for many applications it is sufficient to consider photon shot noise, noise floor, and PRNU. Here, the total array noise is

$$\langle n_{SYS} \rangle = \sqrt{\langle n_{SHOT}^2 \rangle + \langle n_{FLOOR}^2 \rangle + \langle n_{PRNU}^2 \rangle} \tag{4-48}$$

or

$$\langle n_{SYS} \rangle = \sqrt{n_{pe} + \langle n_{FLOOR}^2 \rangle + (U n_{pe})^2} \ . \tag{4-49}$$

Either the rms noise or noise variance can be plotted as a function of signal level. The graphs are called the photon transfer curve and the mean-variance curve, respectively. Both graphs convey the same information. They provide[18,19] array noise and saturation level from which the dynamic range can be calculated.

For very low photon fluxes, the noise floor dominates. As the incident flux increases, the photon shot noise dominates. Finally, for very high flux levels, the noise may be dominated by PRNU. As the signal approaches well saturation, the noise plateaus and then drops abruptly at saturation (Figure 4-14). As the charge well reaches saturation, electrons are more likely to spill into adjoining wells (blooming) and, if present, into the overflow drain. As a result, the number of noise electrons starts to decrease. Figure 4-15 illustrates the rms noise as a function of photoelectrons when the dynamic range is 60 dB. Here dynamic range is defined as $N_{WELL}/<n_{FLOOR}>$. With large signals and small PRNU, the total noise is dominated by photon shot noise. When PRNU is large, the array noise is dominated by U at high signal levels.

Dark current shot noise only affects those applications where the signal-to-noise ratio is low (Figure 4-16). At high illumination levels, either photon shot noise or pattern noise dominate. Because many scientific applications operate in a low signal environment, cooling will improve performance. General video and industrial cameras tend to operate in high signal environments and cooling will have little effect on performance. A full SNR analysis is required before selecting a cooled camera.

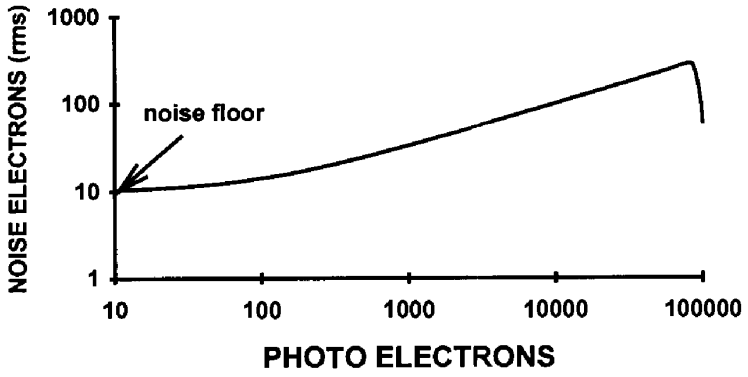
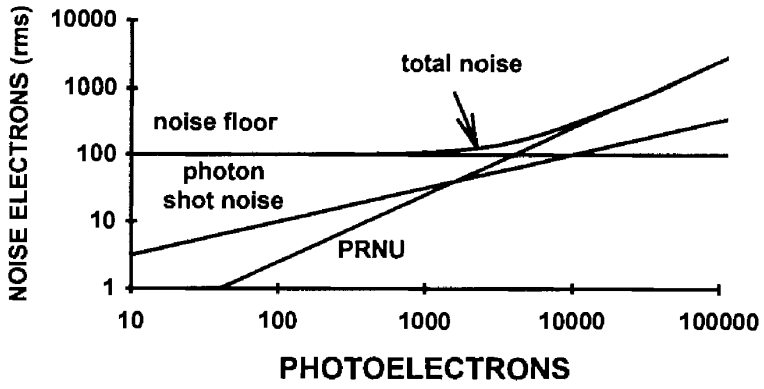
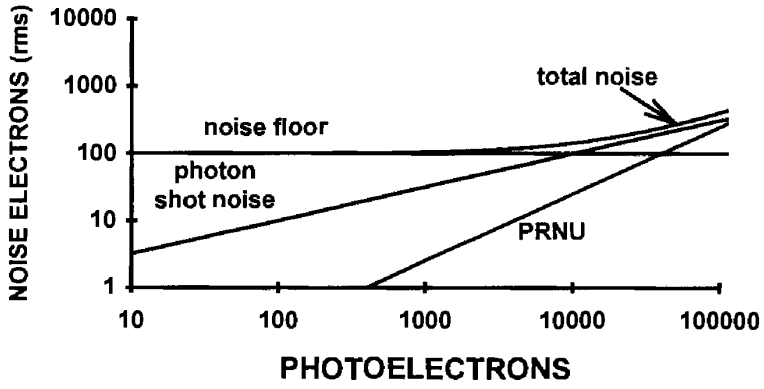


Figure 4-14. Photon transfer curve. At low input signals, the device noise is dominated by the noise floor. As the signal increases, the noise increases due to photon shot noise and pattern noise. As the well reaches saturation, there is a drop in noise electrons due to spill over and well capacity limitation.

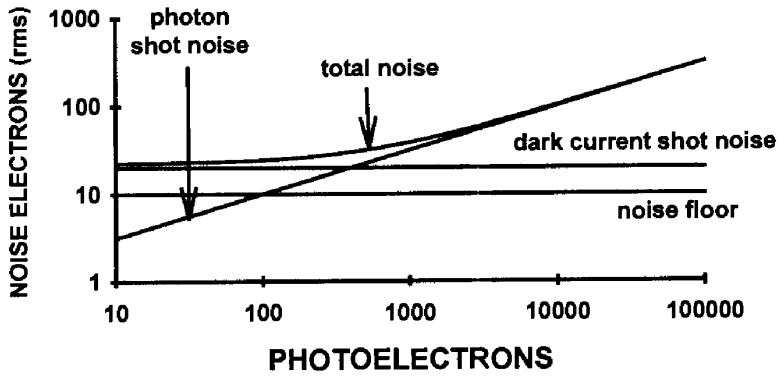


(a)

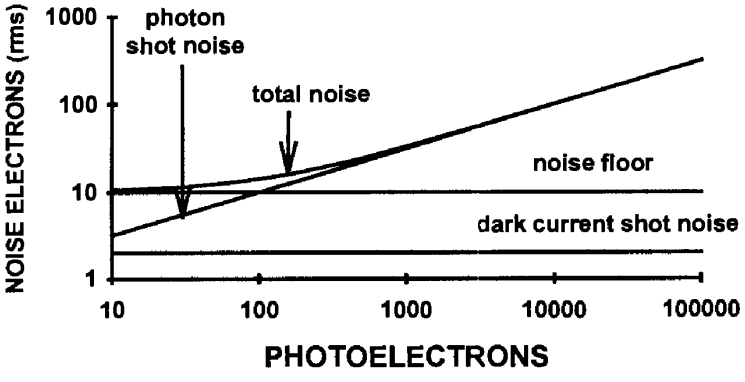


(b)

Figure 4-15. Photon transfer curves for (a) U = 2.5% and (b) U = 0.25%. The charge well capacity is 100,000 electrons and the noise floor is 100 e^- rms to produce a dynamic range of 60 dB. The noise floor, photon shot noise, and PRNU have slopes of 0, 0.5, and 1, respectively. Dark noise is considered negligible. The drop at saturation is not shown (see Figure 4-14).



(a)



(b)

Figure 4-16. Dark current shot noise effects. The noise floor is 10 electrons rms and PRNU is zero. (a) Dark current shot noise is $20e^-$ rms and (b) dark current shot noise is $2e^-$ rms. For large signals, photon shot noise dominates the array noise. The drop at saturation is not shown (Figure 4-14).

Figure 4-17 illustrates the mean-variance technique. In the shot noise limited region,

$$V_{SIGNAL} = \frac{G\,q}{C}\,n_{PE} \tag{4-50}$$

and

$$V_{NOISE}^2 = \left(\frac{G\,q}{C}\right)^2 n_{PE}\,. \tag{4-51}$$

Then the output gain conversion is

$$\frac{G\,q}{C} = \frac{V_{NOISE}^2}{V_{SIGNAL}} \tag{4-52}$$

or the OGC is equal to the noise variance divided by the mean value. It is simply the slope of the shot noise in Figure 4-17.

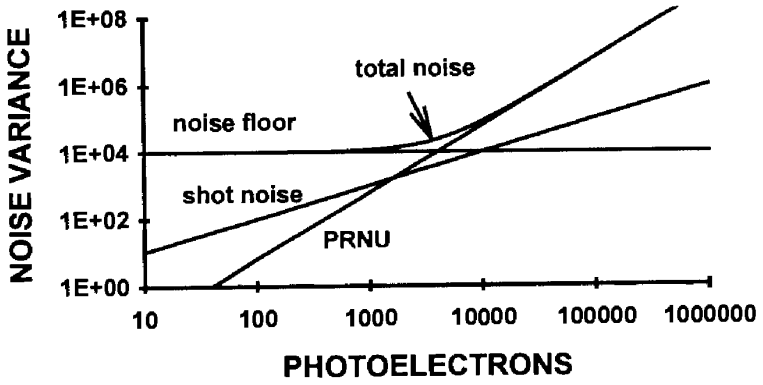


Figure 4-17a. Mean-variance plot which corresponds to Figure 4-15a. The slopes for noise floor, photon shot noise, and PRNU are 0, 1, and 2, respectively.

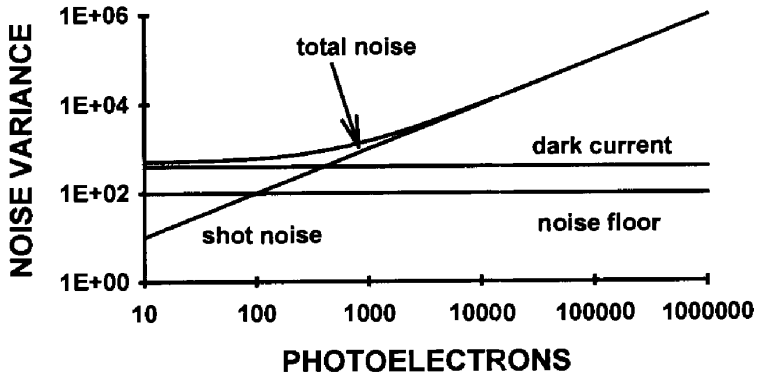


Figure 4-17b. Mean-variance plots which corresponds to Figure 4-16a. The slopes for noise floor, photon shot noise, and PRNU are 0, 1, and 2, respectively.

If both signal and noise are measured after the on-chip amplifier, the measured photogenerated signal is $V_{SIGNAL} = G\,q\,n_{pe}/C$ and the noise is

$$V_{NOISE} = \frac{G\,q}{C}\langle n_{SYS}\rangle \,. \tag{4-53}$$

When $V_{NOISE} = 1$, the signal is C/Gq. The shot noise intercept on the photon transfer curve is 1/OGC (Figure 4-18). The OGC has units of μV/electrons. Similarly, if the values are collected after the ADC, when the shot noise is one, the shot noise signal provides the output gain conversion in units of DN/electrons.

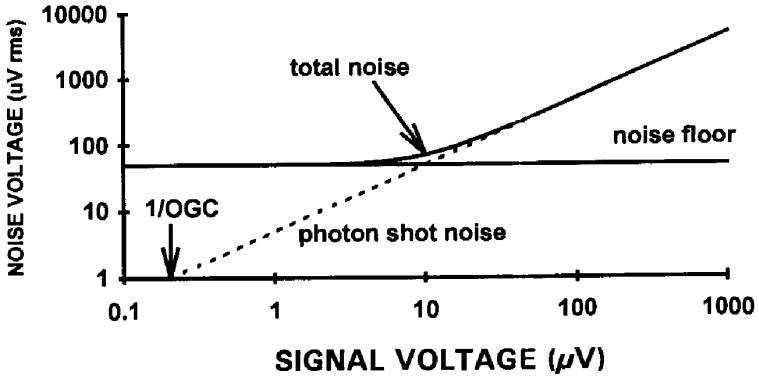


Figure 4-18. Photon transfer curve. The noise floor is 250 e^- and the OGC is 5 μV/e^-. When the photon shot noise is one, the signal is 1/OGC. The drop at saturation is not shown (Figure 4-14).

4.3. ARRAY SIGNAL-TO-NOISE RATIO

The array signal-to-noise ratio is

$$SNR = \frac{n_{pe}}{\sqrt{\langle n_{SHOT}^2 \rangle + \langle n_{FLOOR}^2 \rangle + \langle n_{PATTERN}^2 \rangle}} . \qquad (4\text{-}54)$$

With negligible dark current shot noise,

$$SNR = \frac{n_{pe}}{\sqrt{n_{pe} + \langle n_{FLOOR}^2 \rangle + (Un_{pe})^2}} . \qquad (4\text{-}55)$$

The charge transfer efficiency factor, CTE^N, should be added to n_{pe} in both the numerator and denominator. For buried channel devices (the most popular) CTE^N is near one and is typically is omitted. Equation 4-55 suggests that the maximum SNR occurs when n_{PE} is a maximum. This occurs when the charge wells are filled. However, as the charge wells fill, electrons can get close to the surface even for buried channel devices. Thus as n_{PE} approaches N_{WELL}, CTE can decrease. The best performance is a compromise between high SNR and high CTE. High CTE is generally only a concern with large devices.

The SNR plots are similar to the photon transfer curves. At low flux levels, the SNR increases with the signal (noise floor is constant). At moderate levels, photon shot noise limits the SNR and at high levels, the SNR approaches 1/U. In Figure 4-19, the SNR is expressed as a power ratio (in dB) which is 20 log(SNR). While the array may have a finite PRNU, it can be minimized off-chip through an appropriate algorithm.

When photon shot noise dominates, the SNR depends only on the photon flux level ($SNR = \sqrt{n_{pe}}$). In Figure 4-19, dynamic range is defined as $N_{WELL}/<n_{FLOOR}>$. The instantaneous dynamic range, which includes all noise sources, is the SNR. The theoretical maximum SNR is $\sqrt{N_{WELL}}$. The SNR is equal to the dynamic range only when the system is noise floor limited. This occurs only for low signal values and small wells (less than about 10,000 electrons). For large well capacity arrays, the actual SNR can never reach the value suggested by the dynamic range. Dynamic range is used to select an appropriate analog-to-digital converter resolution (number of bits). This assures that low contrast targets can be seen.

The array signal-to-noise ratio was derived for a large target that covers many pixels. The noise rides on the signal. The camera SNR, which includes all the noise sources, is provided in Section 6.2.1., *Camera SNR*. In Chapter 12, *Minimum Resolvable Contrast*, the average noise associated with the target and the background is considered.

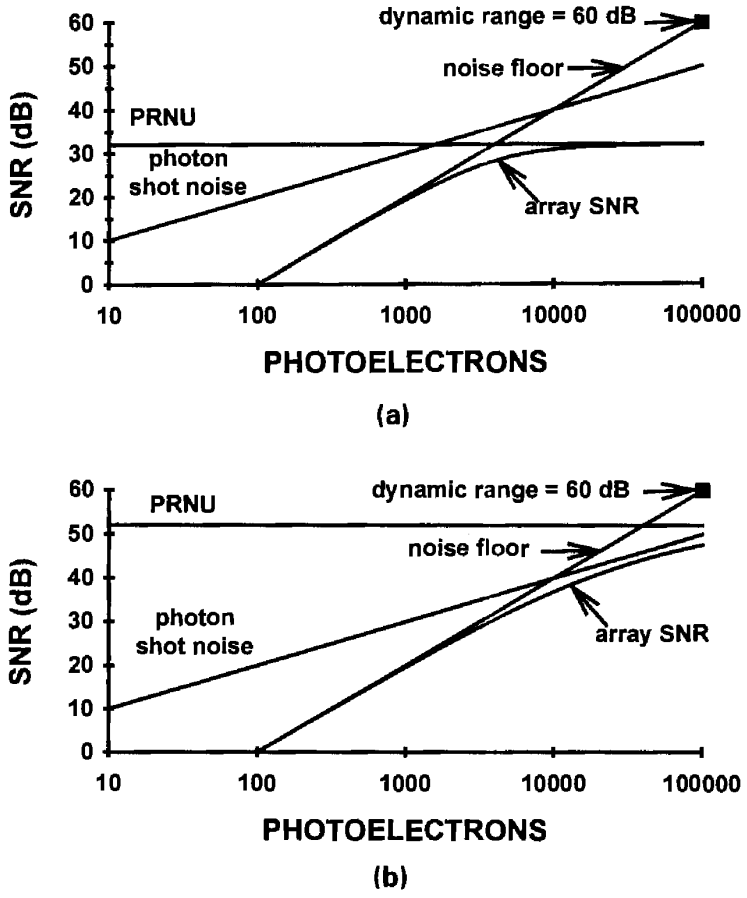


Figure 4-19. SNR as a function of noise for (a) U = 2.5% and (b) U = 0.25%. PRNU, photon shot noise, and the noise floor have slopes of 0, 10, and 20, respectively. Dark current shot noise is considered negligible.

4.4. CORRELATED DOUBLE SAMPLING

After a charge packet is read, the floating diffusion capacitor is reset before the next charge packet arrives. The uncertainty in the amount of charge remaining on the capacitor following reset appears as a voltage fluctuation (see Section 4.2.2., *Reset Noise*, page 127).

Correlated double sampling (CDS) assumes that the same voltage fluctuation is present on both the video and reset levels. That is, the reset and video signals are correlated in that both have the same fluctuation. The CDS circuitry may be integrated into the array package and this makes processing easier for the end user. For this reason it is included in this chapter.

CDS may be performed[20,21] in the analog domain by a clamping circuit with a delay-line processor or by the circuit illustrated in Figure 4-20. When done in the digital domain, a high speed ADC is required that operates much faster than the pixel clock. Limitations of the ADC may restrict the use of CDS in some applications. The digitized video and reset pulses are subtracted and then clocked out at the pixel clock rate.

The operation of the circuit is understood by examining the timing signals (Figure 4-21). When the valid reset pulse is high, the reset switch closes and the signal (reset voltage) is stored on capacitor C_R. When the valid video pulse is high, the valid video switch closes and the signal (video voltage) is stored on capacitor C_V. The reset voltage is subtracted from the video voltage in a summing amplifier to leave the CDS corrected signal. CDS also reduces amplifier 1/f noise.

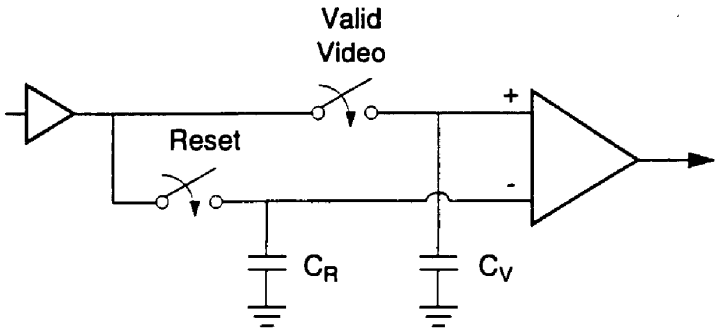


Figure 4-20. Correlated double sampling circuitry. The switches close according to the timing shown in Figure 4-21. (After Reference 20).

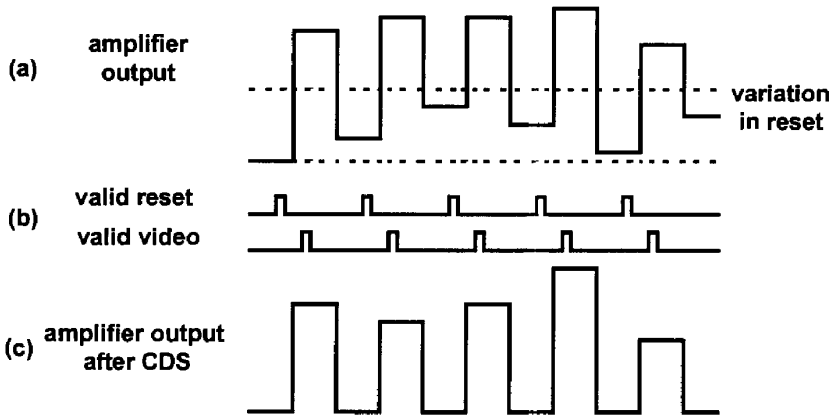


Figure 4-21. Correlated double sampling. (a) Amplifier output signal before CDS, (b) timing to measure video and reset levels, and (c) the difference between the video and reset levels after CDS. The dashed lines indicate the variation in the reset level. The signal level has been inverted compared to Figure 4-12 (page 124).

4.5. FRAME RATES

For a fixed output clock rate, the time to read an array increases as the array size increases. Very large arrays cannot be read in real time. Let the active array size be m × n pixels. Let there be an additional N_{READ} pixels before the sense node. Suppose the clock operates at f_{CLOCK} pixels/s. The minimum time to clock out the array is

$$t_{ARRAY} = \left[\frac{mn + N_{READ}}{f_{CLOCK}} \right] \tag{4-56}$$

and the theoretical frame rate (Figure 4-22) is

$$F_{ARRAY} = \frac{1}{t_{ARRAY}} . \tag{4-57}$$

The maximum frame rate is limited by N_{READ}. The actual frame rate may be less due to electron mobility, on-chip amplifier bandwidth, or clock rate limitations. For some CCDs and all CIDs and CMOS devices, subarrays (also called windows) can be read out. As the subarray size decreases, the frame rate increases, With increased frame rates, the integration time decreases and then more illumination is required to maintain a specific signal-to-noise ratio.

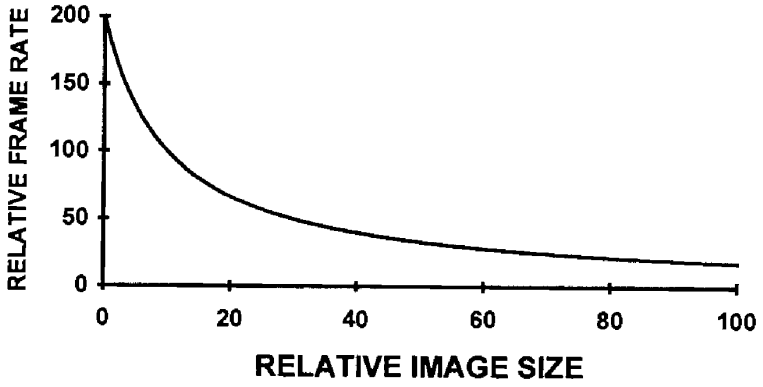


Figure 4-22. Frame rate a function of array size.

4.6. DEFECTS

Large arrays sometimes contain defects. Table 4-5 provides representative definitions. These definitions vary by manufacturer. Arrays with a few defects are more expensive than arrays with a large number. Depending upon the application, the location of the defects may be important. For example, the center ("sweet spot") must be fully operational with increasing defects allowed as the periphery is approached.

Defects are regions of reduced sensitivity. They can also be regions of increased dark current. For scientific application such as spectroscopy, the variation in dark current can affect results - particularly if long integration times are used. These pixels may be labeled as "hot" or "warm." Hot and warm detectors do not follow the same cooling curve as "normal" detectors.[22]

Table 4-5
ARRAY DEFECTS

DEFECTS	REPRESENTATIVE DEFINITION
Point defect	A pixel whose output deviates by more than 6% compared to adjacent pixels when illuminated to 70% saturation.
Hot point defects	Pixels with extremely high output voltages. Typically a pixel whose dark current is 10 times higher than the average dark current.
Dead pixels	Pixels with low output voltage and/or poor responsivity. Typically a pixel whose output is one-half of the others when the background nearly fills the wells.
Pixel traps	A trap interferes with the charge transfer process and results in either a partial or whole bad column (either all white or all dark).
Column defect	Many (typically 10 or more) point defects in a single column. May be caused by pixel traps.
Cluster defect	A cluster (grouping) of pixels with point defects.

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5

CAMERAS

Solid state camera terminology is a mix of photographic, sensor, image processing, and television terminology. As solid state cameras enter emerging technologies, camera manufacturers adopt the marketplace terminology and add it to their specifications.

Many specifications include the known problems associated with vacuum image tubes such as image burn-in, distortion, or microphonics. These effects are not present in solid state devices. References to these vacuum tube disadvantages probably will disappear in the future as these tubes disappear.

Video standards were originally developed for televisions applications. The purpose of a standard is to ensure that devices offered by different manufacturers will operate together. The standards apply only to the transmission of video signals. It is the camera manufacturer's responsibility to create an output signal that is compatible with the standards. Similarly, it is the display manufacturer's responsibility to ensure that the display can recreate an adequate image.

Some agencies involved with standards include the Institute of Electrical and Electronic Engineers (IEEE), Electronics Industry Association (EIA), EIA-Japan (EIAJ), Joint Electron Devices Engineering Council (JEDEC), Society of Motion Picture and Television Engineers (SMPTE), International Electrotechnical Commission (IEC), Technical Center of the European Broadcast Union (EBU), Advanced Television Systems Committee (ATSC), Comite Consultatif International des Radiocommunications (CCIR) (now ITU-R), and International Telecommunications Union-Radiocommunications (ITU-R). Major manufacturers such as Panasonic, Sony, and JVC influence the standards.

There is no industry wide definition of low light level imaging. To some, it is simply a solid state camera that can provide a usable image when the lighting conditions are about 1 lux. Lower illumination values may be possible by cooling the device. To others it refers to an intensified camera. Intensified cameras are sometimes called low light level television (LLLTV) systems.

Because solid state devices are designed for specific applications, the array and camera use the same terminology: progressive scan chips are used in

progressive scan cameras, TDI arrays are used in TDI cameras, etc. Through appropriate clocking, progressive scan cameras can also provide composite video and be used with consumer displays. Scientific cameras can have both analog and digital outputs. The corresponding sections in Chapter 3, *Solid State Arrays*, should be read with the specific cameras listed here.

In this chapter, camera designs are separated into consumer/broadcast and industrial/scientific applications. The major features of each design are listed in the appropriate sections. However, as technology matures, the distinctions blur. That is, the same camera may be used for a variety of applications. New cameras offer variable frame rates and data rates that can be selected by the user. Therefore, the reader must review all sections before selecting a specific design. Chapter 6, *Camera Performance*, discusses minimum signal, maximum signal, dynamic range, and signal-to-noise ratio.

Both monochrome and color cameras are quite complex as evidenced by the 1478-page *Television Engineering Handbook*, K. B. Benson, ed., McGraw-Hill, New York (1986). This chapter is an overview of solid state camera operation. It highlights those features and specifications that are most often reported in camera data sheets. Together with the preceding chapters, it provides the necessary information to compare and analyze camera systems.

Selecting the right camera to meet specific requirements may be difficult. For consumer video, cost is very important. For broadcast systems, image quality and color are important. Scientific cameras offer low noise and high resolution. Issues not addressed include environmental conditions such as temperature, humidity, altitude, shock, vibration, the "-ilities" (e.g., reliability, maintainability, etc.) and physical attributes (e.g., weight and size).

The symbols used in this book are summarized in the *Symbol List* (page xviii) which appears after the *Table of Contents*.

5.1. CAMERA OPERATION

Figure 5-1 illustrates a generic solid state camera. The lens assembly images the light onto the detector array. General purpose consumer cameras typically have an infrared blocking filter to limit the camera's spectral response to the visible spectral band. Depending upon the application (military, industrial, or scientific), the camera may or may not have this filter. Color cameras have a spectral response limited to the visible region. Cameras may provide digital image processing and these cameras have an internal ADC. Analog cameras will not have an internal ADC. However, they still spatially sample the scene.

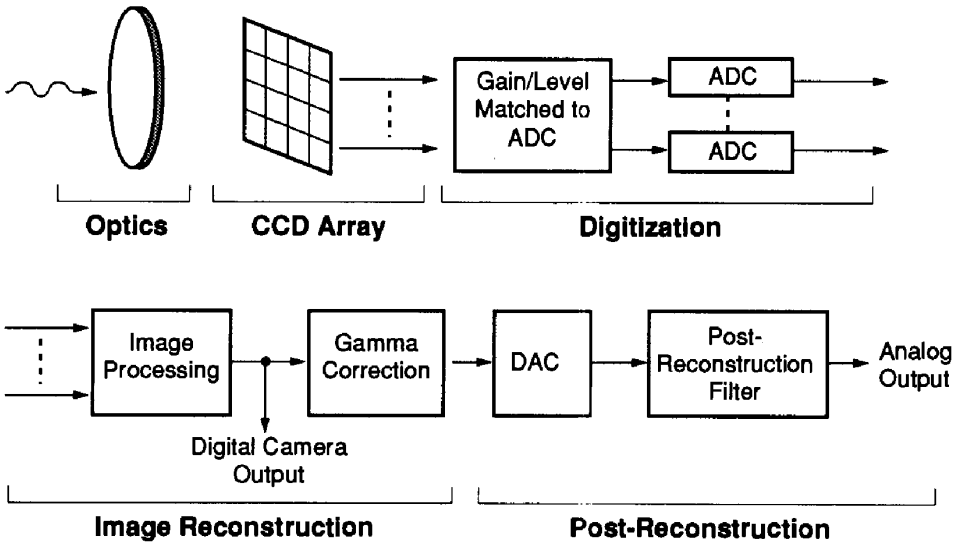


Figure 5-1. Generic functional block diagram. Not all components exist in every camera. The gamma correction circuitry is appropriate when the video is to be viewed on a CRT-based display. Analog cameras will not have an internal ADC.

A single chip color camera typically has an unequal number of red, green, and blue detectors resulting in different sampling frequencies for the different colors (discussed in Section 8.3.2., *Detector Array Nyquist Frequency*). Because the detectors are at discrete locations, target edges and the associated ambiguities are different for each color. A black-to-white edge will appear to have colors at the transition and monochrome periodic imagery may appear to have color. Aliasing is extremely annoying in color systems. A birefringent filter placed between the lens and the array reduces aliasing (discussed in Section 10.3.4., *Optical Anti-Alias Filter*). Any method to reduce aliasing generally reduces the overall MTF.

While aliasing is never considered desirable, it is accepted in scientific and military monochrome applications where the MTF must be maintained. Aliasing is reduced to an acceptable level in consumer color sensors. For specific applications such as medical imaging, it may be considered unacceptable. In medical imagery, an aliased signal may be misinterpreted as a medical abnormality requiring medication, hospitalization, or surgery.

Correlated double sampling reduces reset noise and minimizes 1/f noise. CDS circuitry may be integrated into the array package and this makes processing easier for the end user.

Image processing or image reconstruction reformats the data into signals and timing that are consistent with transmission and display requirements. The advantage of a digital camera is that the output can be directly fed into an image processor, machine vision system, or digital data capture system. If using an analog output camera for machine vision, the video signal must pass through an external analog-to-digital converter. These multiple conversions may modify the imagery (discussed in Section 8.4., *Aliasing in Frame Grabbers and Displays*). Thus, staying within the digital domain ensures maximum image fidelity.

To present a linear transformation from a scene to an observer, a gamma correction (discussed in Section 5.3.3., *Gamma Compensation*) algorithm provides compensation for the monitor's nonlinear response. The concern with gamma should be limited to applications where cathode ray tube (CRT) based displays are used. As the display industry moves from CRTs to flat panel displays, gamma correction is not required. However, gamma provides some image enhancement and therefore will probably be used with flat-panel displays. Gamma correction is generally not preferred for machine vision or scientific applications.

The digital-to-analog converter (DAC) and sample-and-hold circuitry converts the digital data into an analog stair-step signal. The post-reconstruction filter removes the stair-step appearance and creates a smooth analog signal. After the post-reconstruction filter, the spatial scene sampling by the detectors is barely noticeable.

5.2. VIDEO FORMATS

In 1941, the Federal Trade Commission (FCC) adopted the 525-line, 30-Hz frame standard for broadcast television that was proposed by the NTSC (National Television Systems Committee). The standard still exists today with only minor modifications. Although originally a monochrome standard, it has been modified for color transmission. Amazingly, color video fits within the video electronic bandwidth originally set aside for black-and-white television. NTSC initially selected a 60-Hz field rate. It was later changed to 59.94 Hz for color systems to avoid interactions (beat frequencies) between the audio and color subcarrier frequencies. The monochrome standard is often called EIA 170 (originally called RS 170) and the color format is simply known as NTSC

(originally called EIA 170A or RS 170A). The timing for these two standards is nearly the same.[1]

Worldwide, three color broadcast standards exist: NTSC, PAL, and SECAM. NTSC is used in the United States, Canada, Central America, some of South America, and Japan. The phase alteration line (PAL) system was standardized in most European countries in 1967 and is also found in China. Many of the PAL standards were written by the CCIR. As a result, PAL is sometimes called CCIR. In 1967, France introduced SECAM (Sequentiel colour avec mémoire). SECAM is used in France, Russia, and the former Soviet bloc nations. Reference 2 provides a complete worldwide listing. These standards are incompatible for a variety of reasons.

Video transmission bandwidth restrictions and the perception of good imagery on a display dictated the standard formats. That is, camera design is based upon the perception of displayed information. The interlace and scan times were selected to minimize electronic bandwidth and still provide a cosmetically pleasing image to the viewer with no flicker effects. Two fields are interwoven on the display. The eye's persistence time combined with the CRT phosphor persistence blends the two separate images into a perceived full image.

In the NTSC and EIA 170 standards, a frame is composed of 525 scan lines separated into two sequential fields (even and odd). Because time is required for vertical retrace, only 485 lines are displayed. There are 242.5 active lines per field. Because field 1 ends in a half-line, it is called the odd field. Figure 5-2 illustrates how the information is presented on a display. For commercial television, the aspect ratio (horizontal to vertical extent) is 4:3.

When a camera is designed to be compatible with a transmission standard, the manufacturer uses the broadcast terminology as part of the camera specifications. Similarly, consumer display manufacturers use the same terminology.

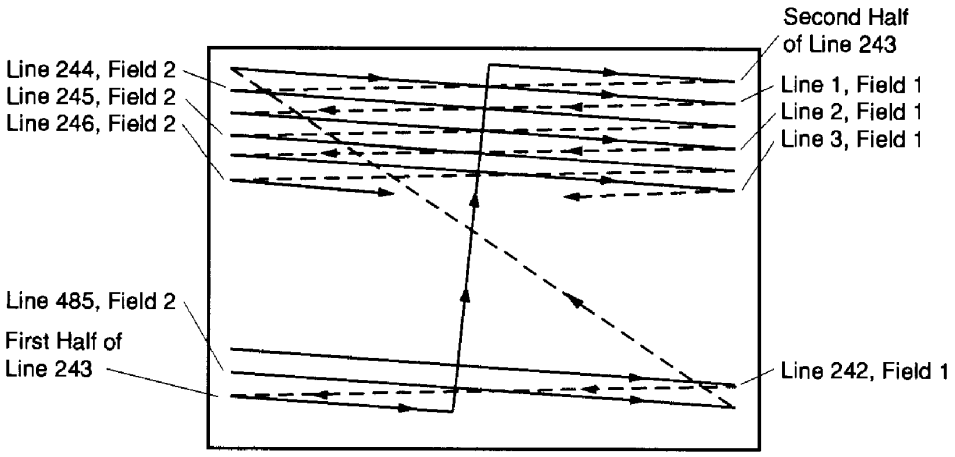


Figure 5-2. Presentation of EIA 170 video on a display. Standard timing is defined for video transmission only. Solid state arrays may not read out data in this precise order. The camera image processing algorithm formats the data into a serial stream that is consistent with the video standard.

5.2.1. VIDEO TIMING

Table 5-1 provides the relevant parameters for the monochrome and color video standards. The standards specify the line frequency and blanking period. The scanning frequency is the frame rate multiplied by the number of lines. The total line time is calculated from the line frequency (e.g., $1/15{,}750 = 63.492\,\mu s$) and the active line time is the total line time minus the horizontal blanking period. The blanking period has a tolerance of about $\pm 0.25\%$ so that the active time line also varies slightly. Table 5-1 provides the minimum active time line where the maximum blanking period has been selected.

Table 5-1
STANDARD VIDEO TIMING

FORMAT	FRAME RATE (Hz)	LINES PER FRAME	ACTIVE LINES	SCANNING FREQUENCY (kHz)	TOTAL LINE TIME (μs)	MINIMUM ACTIVE LINE TIME (μs)
EIA 170	30	525	485	15.750	63.492	52.092
NTSC	29.97	525	485	15.7343	63.555	52.456
PAL	25	625	575	15.625	64.0	51.7
SECAM	25	625	575	15.625	64.0	51.7

For the monochrome video transmission (See Section 5.2.2., *Broadcast/Non-broadcast Design*), the picture element was originally defined[3] as the smallest area being delineated by an electrical signal. Note that this is the definition of a resel (analog element) and it is referenced to an imaginary pixel. The impulse response to an ideal band-limited system is

$$A(t) = \frac{\sin(2\pi f_c t)}{2\pi f_c t} , \qquad (5\text{-}1)$$

where f_c is the video bandwidth cutoff frequency. The pixel length is defined as the minimum distance between two impulses such that the two are still discernible. This occurs when the maximum of one falls on the first minimum (zero) of the next. The separation of these two vertical lines in time is $\Delta t = 1/2f_c$. This is the smallest possible dimension in a linear system. For the video standard, the number of resels ("pixels") per line is

$$N = \frac{active\ line\ time}{\Delta t} = 2f_c(active\ line\ time) . \qquad (5\text{-}2)$$

The nominal[4] video bandwidths of NTSC, PAL, and SECAM are 4.2, 5.5, and 6 MHz, respectively. Table 5-2 lists the nominal number of horizontal elements per line. The quoted resolution (number of horizontal pixels) varies in the literature and depends upon the precise bandwidth and active line time selected by the author. Multiplying the pixel number by the number of active lines yields the elements per frame.

Table 5-2
NOMINAL NUMBER OF VIDEO RESELS ("PIXELS")
Based upon electrical transmission bandwidth only

FORMAT	NOMINAL BANDWIDTH (MHz)	ACTIVE LINE TIME (μs)	NUMBER of HORIZONTAL ELEMENTS	NUMBER of ACTIVE LINES	ELEMENTS PER FRAME
EIA 170	4.2	52.09	437	485	212,000
NTSC	4.2	52.45	440	485	213,000
PAL	5.5	51.7	569	575	327,000
SECAM	6.0	51.7	620	575	356,500

The full bandwidth is somewhat wider than the nominal value but high frequency components may be attenuated. For example, NTSC has a full bandwidth of approximately 4.5 MHz. The total bandwidth allocated for sound, chrominance, and luminance is 6, 8, and 8 MHz for NTSC, PAL, and SECAM, respectively. Using the allocated bandwidth, the maximum number of horizontal pixels is 625 for NTSC and 827 for PAL and SECAM.

Current camera design philosophy matches the number of detectors to the number of pixels supported by the video bandwidth. Based upon electrical bandwidth considerations, it appears that the number of horizontal detectors should range from 440 to 625 for NTSC, 560 to 827 for PAL, and 620 to 827 for SECAM compatible cameras.

The actual number of detector elements depends upon the manufacturer's philosophy. Image processing algorithm complexity is minimized when the spatial sampling frequency is equal in the horizontal and vertical directions. The 4:3 aspect ratio suggests that there should be 4/3 times more detectors in the horizontal direction compared to the vertical direction. If the number of elements in the vertical direction is simply equal to the number of active scan lines, then the number of horizontal detectors should be about 646 for NTSC, and 766 for PAL and SECAM.

The number of pixels per line is often chosen so that the horizontal clock rate is an integer multiple of the color subcarrier. For NTSC, 768 pixels equate to four times the NTSC color subcarrier (see Section 3.11.3., *Number of Detectors*, page 97).

This larger number provides more sampling for each color and reduces color aliasing. For single chip color cameras, resolution is more difficult to define. The primaries or their complements spatially sample the scene unequally (discussed in Section 8.3.2., *Detector Array Nyquist Frequency*). If the chip contains 768 detectors horizontally, then the number of green, red, and blue detectors is typically 384, 192, and 192, respectively. Because the eye is most sensitive to luminance values and the green component represents luminance, then the green resolution may be taken as the camera resolution. Most chips contain more green detectors and therefore the resolution is more than just one-third of an equivalent monochrome system. Through data interpolation, any number of output data points can be created. This number should not be confused with the camera spatial resolution. Single chip color cameras cannot provide the resolution listed in Table 5-2.

To reduce cost, a camera may contain fewer detector elements. Here, the full bandwidth of the video standard is not exploited. The imagery of these cameras will be poorer compared to those cameras that fully use the available bandwidth. Recall that the standard only specifies the timing requirements and a maximum bandwidth. The timing ensures that the camera output can be displayed on a standard display.

For the complete system, the horizontal resolution may be limited by the detector array, bandwidth of the video standard, or by the display. Display resolution is discussed in Section 7.5., *Resolution*. It is common for the display to limit the overall system resolution.

For NTSC and EIA 170 compatible arrays, it is common to have about 480 detectors in the vertical direction. The image formatting algorithm inserts blank lines (all black) to meet video standards (485 lines). Because many displays operate in an overscan mode, the blank (black) lines are not noticed.

Resolution is often expressed in TV lines. This visual psychophysical measure was developed to specify the resolution of monitors. Because of phasing effects, the number of individual horizontal lines that can be perceived, on the average, is less than the number of scan lines. The ratio of the average number to the total number is the Kell factor[5] and is assumed to be 0.7. Thus, the vertical resolution is 340 lines for NTSC and 402 lines for PAL and SECAM. This vertical resolution applies to the monitor capability and not the camera. However, the camera output must be displayed on a monitor so that the Kell factor is sometimes included in camera specifications.

For higher vertical resolution, more lines are required. EIA 343A (originally RS 343A) was created[6] for high resolution closed circuit television cameras (CCTV). Although the standard encompasses equipment that operates from 675 to 1023 lines, the recommended values are 675, 729, 875, 945, and 1023 lines per frame (Table 5-3). The military primarily uses 875 lines/frame but it requires "standards conversion" boxes that can record and present imagery on EIA 170 compatible equipment. EIA 343A is still a monochrome standard.

Table 5-3
RECOMMENDED EIA 343A VIDEO FORMATS

LINES/FRAME	ACTIVE LINES	SCANNING FREQUENCY (kHz)	LINE TIME μs	ACTIVE LINE TIME μs
675	624	20.25	49.38	42.38
729	674	21.87	45.72	38.72
875	809	26.25	38.09	31.09
945	874	28.35	35.27	28.27
1023	946	30.69	32.58	25.58

5.2.2. BROADCAST/NON-BROADCAST DESIGN

The EIA 170 standard was developed for the *broadcasting* of video signals over limited bandwidth channels. The FCC dictated that the bandwidth cannot exceed 6 MHz. To avoid flicker on the television receiver, a 2:1 interlace concept was adopted. The NTSC standard was constrained to the same bandwidth limitation.

For compatibility, all broadcast cameras and television receivers are designed to the timing and bandwidth of the broadcast standard. Using a wider bandwidth receiver does not improve image quality or resolution because it is limited by the 6 MHz bandwidth. An inexpensive receiver may have reduced bandwidth (as do many VHS recorders) and this reduces image quality. However, to function, this "lower quality" receiver still must operate under the *timing* requirements of the video standard.

Table 5-2 (page 153) listed the number of video resels supported by the video standard. If the camera has more pixels, then the received image resolution will be limited by the standard's bandwidth. If the camera has fewer

pixels, then the camera's resolution limits image quality. By using image compression, high definition television cameras can effectively transmit more resels than that suggested in Table 5-2. The number of transmitted resels remains the same (constrained by bandwidth). It is through coding (e.g., image compression) that the resels contain more information.

Because EIA 170 and NTSC are so pervasive, nearly all cameras are built to these video standards. This permits saving imagery on off-the-shelf video recorders and displaying it on just about any monitor. However, for non-broadcast operation, it is not necessary to adhere to the 6 Mhz bandwidth limitation. The only requirement is that the timing be identical to the standard timing. A high resolution monitor (wide bandwidth) can display the imagery from a camera that has more pixels and a wide bandwidth recorder can store that imagery.

Departure from the standard video timing requires special monitors and special recorders. Already digital recorder and digital monitors exist. Computer monitors now operate in the progressive scan mode. To avoid flicker, the frame rate exceeds 70 Hz. The frame rate is determined by the video drive electronics and is not generally user-selectable.

To see an image on a monitor, the camera's timing must be consistent with the monitor requirements. Because the video standards are popular, most cameras adhere to the appropriate timing. With progressive-scan cameras, the camera's internal electronics must reformat the data into an interlace mode. If the camera's output is fed directly into a computer, timing is no longer a concern. If digital data are transferred, only a sync signal is necessary to indicate the start of the data. If analog data are transferred, then the frame capture board should have a resolution that is greater than the camera's. That is, there should be more datels than pixels.

5.2.3. COMPONENT/COMPOSITE SIGNALS

The term composite is used to denote a video signal that encodes luminance, color, and timing information onto a single channel. It can be transmitted on a single wire such as cable television. NTSC, PAL, and SECAM are composite video signals. The signal must be decoded to create an image.

Component analog video (CAV) carries each part on a separate wire. RGB, or their complementary values are carried on three separate cables. It is common for the G to be a composite line and carry the sync signals. Component videos

do not require encoding and therefore there is less chance that there will be color or luminance cross coupling. This implies that component imagery will produce a higher quality image.

As equipment is miniaturized (e.g., hand-held video recorders) and resolution increased (e.g., HDTV), there seems to a proliferation of recommended standards.[7] Most standards deal with color encoding (chrominance encoding). The luminance channel is identical with the green channel and is labeled Y. The other signals are color and the exact composition depends upon the standard. SECAM uses the primaries whereas the other formats use the complements. The chrominance values are related through matrices but the signals are not compatible due to different line frequencies and sync signals. Because the eye is most sensitive to luminance, the luminance channel has the widest bandwidth and the chrominance channels have smaller bandwidths.

Matrixing can convert the RGB into any color coordinate system. With the ease of digital implementation, multiple outputs are available from many cameras. That is, a camera may offer RGB, NTSC, and Y/C outputs to provide flexibility to the user.

5.2.4. IRE UNITS

The Institute of Radio Engineers (IRE) assigned 140 IRE units to the peak-to-peak composite signal (Figure 5-3). This provides 100 IRE units for the active image signal and 40 IRE units for blanking. They assumed that the video is one volt peak-to-peak when terminated by 75 Ω. Thus, each IRE unit is equal to $1/140 = 7.14$ mV.

To avoid seeing the retrace, NTSC introduces a small setup. With most systems, the video is usually clamped at the blanking level and the video signal with setup does not contain a reference black signal. That is, the video does not contain a signal to indicate the black level. This voltage only occurs when there is a black object within the field-of-view. The blanking level (retrace) is sometimes called "blacker-than-black" because it is 7.5 IRE units below the black level. With the signal standardized to 1 V peak-to-peak, the setup reduces the active video to 0.66 v.

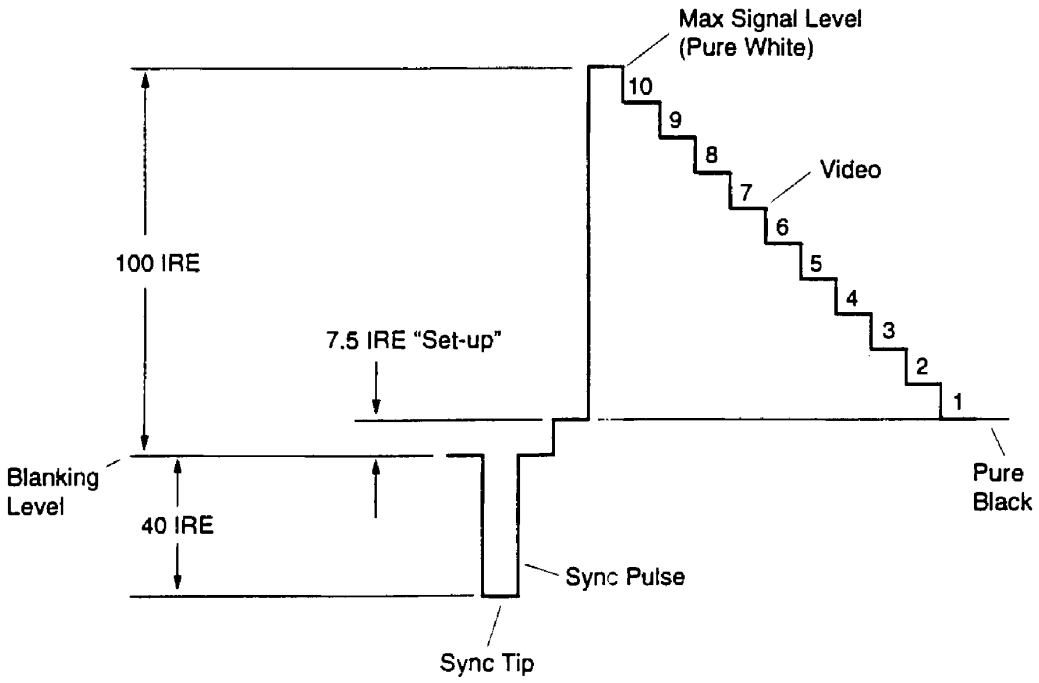


Figure 5-3. Definition of IRE units. The active video represents a gray scale divided into 10 equal steps. NTSC assigns 7.5 IRE units to setup.

By convention, the blanking level is assigned a value of O v so that the active video is positive while the sync pulse is negative. The peak-to-peak amplitude remains at 1 V. As new standards are introduced,[7] the voltage levels associated with IRE units change (Table 5-4). The composite signal with setup (NTSC) can introduce ambiguity in signal level because there is no fixed black reference. Without setup, radiometrically correct imagery is ensured and black-to-white measurements can be performed with higher accuracy. SMPTE and EBU have recommended the non-NTSC format for color component video.

When a video signal is expressed as a percentage, it is numerically equal to the IRE units. 80% video is the same at 80 IRE units. For example, 80% video is (0.8)(0.714) = 571 mV with the NTSC standard.

Table 5-4
VIDEO STANDARDS

FORMAT	VOLTS			IRE UNITS			
	Sync tip	Setup	Peak	Synch tip	Blanking	Setup	Peak
NTSC	-0.286	0.0536	0.714	-40	0	7.5	100
Composite without setup	-0.286	-	0.714	-40	0	-	100
Non-NTSC	-0.300	-	0.700	-40	0	-	100

5.2.5. DIGITAL TELEVISION

Digital image processing is already present in most transmitters and receivers. It seems natural to transmit digitally. The major advantage is that digital signals are relatively immune to noise. Either a bit is present or it is not. A digital voltage signal, which may have been reduced in value and had noise added, can be restored to its full value with no noise in the receiver. An all-digital system avoids the multiple analog-to-digital and digital-to-analog conversions that degrade image quality.

Digital signal "transmission" was first introduced into tape recorders. Because a bit is either present or not, multiple generation copies retain high image quality. In comparison, analog recorders, such as VHS, provide very poor quality after just a few generations. The first digital recorder used a format called D-1 and it became known as the CCIR 601 component digital standard. Digital recording formats[8] now include D-1, D-2, D-3, D-4, and D-5.

The nominal 4.2-MHz bandwidth required by NTSC is not a continuous spectrum but consists of many bands due to the interaction of the line frequency (59.94 Hz) and scan frequency (15.7343 KHz). It is this discrete nature that allows the interleaving of chrominance, luminance, and audio within the allocated bandwidth. A comb filter, present in the receiver, separates the signals to minimize the cross talk that appears as aliased color. The composite video signal can be equated to a signal whose sampling frequency is 3.58 MHz for NTSC and 4.43 MHz for PAL. SECAM has different effective sampling rates for each color difference: 4.25 MHz and 4.41 MHz. These are the subcarrier frequencies.[9]

The most popular sampling frequency is four times the subcarrier frequency and is simply called $4f_{sc}$ sampling. It is equal to 14.3 MHz for NTSC and 14.7 MHz for PAL. This allows the post-reconstruction filter to have a more gradual cutoff with less ripple. This filter is easier to design and is less expensive. Because the data exist at discrete frequencies, strict adherence to the Nyquist criterion (discussed in Chapter 8, *Sampling Theory*) is not required.

In component video there is no subcarrier. A sampling frequency of 13.5 MHz has been selected to accommodate both 525 and 625 line formats. The luminance channel is sampled at 13.5 MHz and the two color difference channels are sampled at 6.75 MHz each. Recall that there is less detail in the color channels so they are sampled at a lower rate. If 13.5 MHz is four times the frequency of some imaginary subcarrier, then 6.75 MHz is twice that same imaginary frequency. This is known as 4:2:2 digital component television. If the three signals are multiplexed into a serial stream, the new sample rate is 27 MHz (13.5 + 6.75 + 6.75 = 27). In the multiplexed form, component signals can be transmitted on a single cable.

An image, whose amplitude is digitized into 8 bits, can provide a cosmetically acceptable image for consumer camcorders. However, nonlinear circuitry is required to minimize the visibility of quantization contours at low signal levels. Otherwise, more bits are necessary. Photo quality imagery requires 12 or more bits. For composite signals, the sync pulse must also be digitized. The actual number of bits available to the imagery is conservatively less. CCIR 601 assigns 16 DN to the black level and 235 DN to the white level. The remaining values (1 to 15 and 236 to 254 DN) allow room for overshoots and control of the white and black levels. The values 0 and 255 DN are used for syncs.

5.2.6. HDTV/ATS

The current accepted meaning of high definition television (HDTV) is a television system providing approximately twice the horizontal and vertical resolution of present NTSC, PAL, and SECAM systems. While the term HDTV implies a receiver, the industry is equally concerned about transmission standards. The video format must be standardized before building cameras and receivers. The acronym HDTV is slowly being replaced with the advanced television system or ATS.

HDTV is envisioned as a system that provides high resolution on large displays and projection screens. Its resolution will not be fully appreciated in the

typical living room where the sofa is nine feet from the television (discussed in Section 7.1., *The Observer*). The Japan Broadcasting Corporation (NHK) provided the first HDTV demonstration in 1981. The aspect ratio was initially 5:3 but this was later changed to 16:9 to match the various aspect ratios used in motion pictures.

The goal is to have worldwide compatibility so that HDTV receivers can display NTSC, PAL, and SECAM transmitted imagery. With today's multimedia approach, any new standard must be compatible with a variety of imaging systems ranging from 35-mm film to the various motion picture formats. The desire is to create composite imagery[10,11] and special effects from a mixture of film clips, motion pictures, and 35-mm-film photos. Compatible frame rates allow the broadcasting of motion pictures and the filming of television.

As various companies entered the HDTV arena, they proposed different transmission formats[12]. To standardize the format, the Grand Alliance was created in May 1993. The seven members are: AT&T, David Sarnoff Research Center, General Instrument Corporation, MIT, North American Philips, Thomson Consumer Electronics, and Zenith Electronics. The Grand Alliance collaborates with a variety of agencies involved with standards (see list on page 146).

In April 1994, the Grand Alliance approved two different resolutions for HDTV (Table 5-5). Both formats have square pixels. The selected line rate should simplify conversion from NTSC and PAL into HDTV. The lines per frame of 1125 is 15/7 times 525 and 9/5 times 625. Similarly, 787.5 is 3/2 times 525 but is approximately 100/79 times 625 lines. Thus, with the lower line rate, it is more difficult to convert PAL into HDTV.

Doubling the resolution, increasing the aspect ratio, and separating color from luminance requires an increased bandwidth of eight-fold over current television requirements. With a nominal bandwidth of 4.2 MHz, the required HDTV bandwidth is approximately 33.6 MHz. A 10-bit system will have a data rate of 336 Mbit/s. At this data rate, transmission losses in conventional wire cable limit the maximum transmission distance to, perhaps, 1 km. This demands image compression.

Table 5-5
GRAND ALLIANCE RECOMMENDED FORMATS
(Recommended in April 1994)

RESOLUTION Pixels/line × active lines	LINES PER FRAME	FRAME RATE (Hz)	SCAN TECHNIQUE
1920 × 1080	1125	24	Progressive
		30	Progressive
		60	Interlaced
1280 × 720	787.5	24	Progressive
		30	Progressive
		60	Progressive

The FCC has allocated only a 6-MHz bandwidth for commercial television channels. Thus, image compression somewhere between 50:1 and 75:1 is required. The Grand Alliance recommends using MPEG-2 image compression. Although current cameras are analog devices,[13] the Grand Alliance recommended digital transmission.

In December 1996, the FCC adopted a standard proposed by the Advanced Television Systems Committee. This versatile standard defines four basic digital formats (Table 5-6). The higher resolution formats will probably be used to broadcast movies while news and commercials will be broadcasted at the lower resolution formats. While the standard allows both interlaced and progressive scan formats, only one will probably survive. It also mandates compressed digital transmission. The conversion from analog to digital television is a complex process.[14] Broadcasting should begin November 1, 1998. The status of HDTV/ATS cameras, standards, and receivers will appear in many journals over the next few years.

Table 5-6
PICTURE FORMATS SUPPORTED by ATSC STANDARD

RESOLUTION pixels/line × active lines	FRAME RATE (Hz)	ASPECT RATIO	SCAN TECHNIQUE
1920 × 1080	24	16:9	Progressive
	30	16:9	Progressive
	60	16:9	Interlaced
1280 × 720	24	16:9	Progressive
	30	16:9	Progressive
	60	16:9	Progressive
704 × 480	24	16:9 or 4:3	Progressive
	30	16:9 or 4:3	Progressive
	60	16:9 or 4:3	Progressive
	60	16:9 or 4:3	Interlaced
640 × 480	24	4:3	Progressive
	30	4:3	Progressive
	60	4:3	Progressive
	60	4:3	Interlaced

5.3. CONSUMER/BROADCAST CAMERAS

Figure 5-4 illustrates a typical color camera functional block diagram. The array output is processed to achieve the standard video signals. This section describes the knee, color correction, gamma, and aperture correction. Monochrome cameras tend to be used for scientific and industrial applications and are described in Section 5.4., *Industrial/Scientific Cameras*.

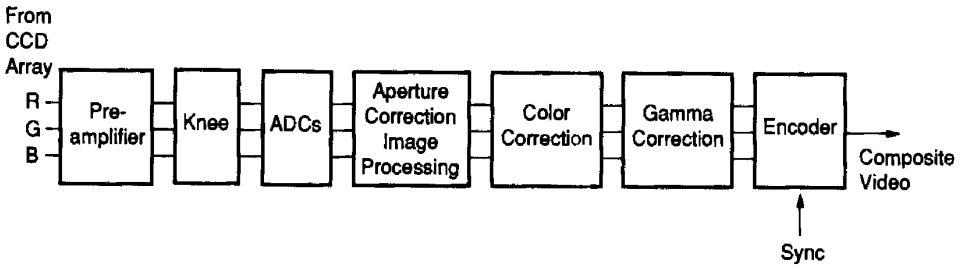


Figure 5-4. Typical color camera functional block diagram. Sync signals and other control logic are not shown. The subsystem location and design vary by manufacturer. Consumer cameras typically have a composite output that is created by the encoder. Scientific and industrial cameras may have a component output which is the signal before the encoder. To increase versatility, many cameras can provide either NTSC, RGB, or complementary color output. The RGB output provides easy interfacing with a computer monitor.

5.3.1. THE KNEE

The antibloom drain (see Section 3.8., *Antibloom Drain*, page 85) creates a knee in the linear response to brightness. The knee slope and location can be any value (Figure 5-5). While scientific cameras operate in a linear fashion, there is no requirement to do so with consumer cameras. Consumer camera manufacturers will provide a mapping that they think will provide a cosmetically pleasing image. The knee also simplifies requirements in that an 8-bit ADC can provide aesthetically pleasing imagery over a wide input dynamic range.

Scientific and industrial applications often require a linear input-output system. For example, linearity is required for radiometric analysis. Interestingly, as some manufacturers add more knee control, others are actively designing algorithms to "de-knee" the signal before image processing.

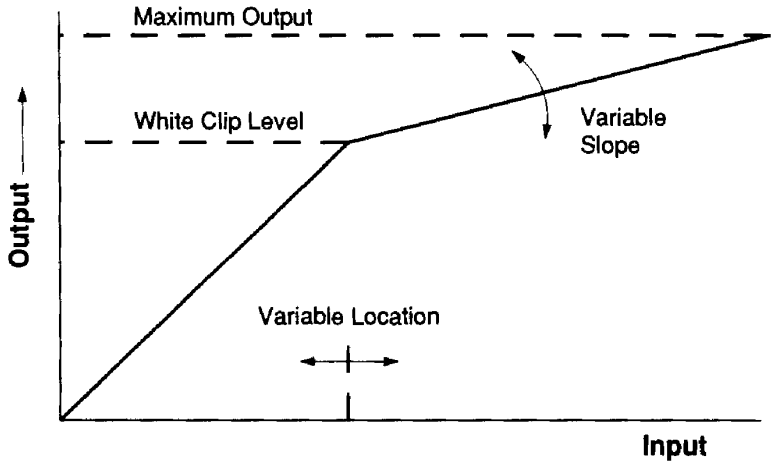


Figure 5-5. The knee extends the dynamic range by compressing high intensity signals. By decreasing the knee slope, the camera can handle a larger scene dynamic range.

5.3.2. COLOR CORRECTION

Figure 5-4 illustrated a typical color camera block diagram. The "color" signals may have originated from a single CFA (see Section 3.11.2., *Color Filter Arrays*, page 94) or three separate arrays as illustrated in Figure 5-6. Because of high cost, three-chip cameras were used almost exclusively for high quality broadcast applications. Now, three-chip color cameras are entering the scientific market. Consumer camera designs, driven by cost, tend to use only one chip. Although this is changing.

The color correction circuitry is an algorithm that can be represented as a matrix

$$\begin{pmatrix} R_2 \\ G_2 \\ B_2 \end{pmatrix} = \begin{pmatrix} k_{11} & k_{12} & k_{13} \\ k_{21} & k_{22} & k_{23} \\ k_{31} & k_{32} & k_{33} \end{pmatrix} \begin{pmatrix} R_1 \\ G_1 \\ B_1 \end{pmatrix}. \qquad (5\text{-}3)$$

When used to improve color reproducibility (i.e., matching the camera spectral response to the CIE standard observer), the process is called masking.[15,16] When manipulating signals into the NTSC standard, it is called matrixing.

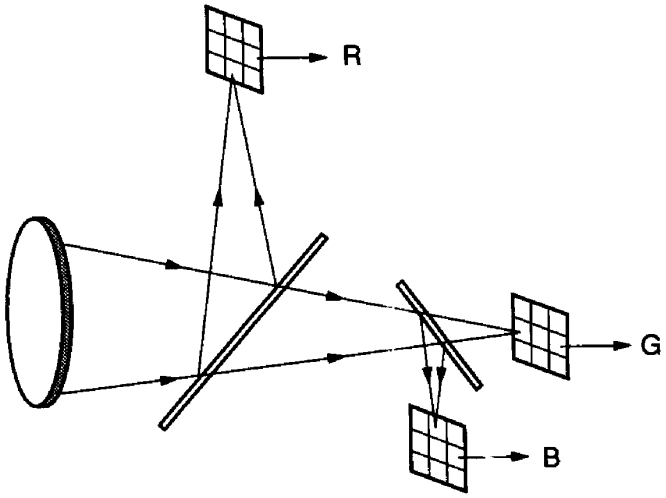


Figure 5-6. A high quality color camera has three separate arrays. One for each primary color or its complement. Light is spectrally separated by coatings on the beam splitters and additional filters. The three-chip camera is listed as CCD×3 or 3CCD in sales brochures. Each color samples the scene equally and this minimizes color moiré patterns when compared to a CFA. Although beam splitters are shown, most 3CCD cameras use prisms for compactness.

Matrixing can be used to alter the spectral response and intensities of the primaries to compensate for changes in scene color temperature. Intensity changes are achieved simply by multiplying a primary by a constant. Spectral changes are approximated by adding various ratios of the primaries together. For example, if an object is viewed at twilight, the matrix can be adjusted so that the object appears to be in full sun light (neglecting shadows). A scene illuminated with a 2600-K source may appear somewhat yellow compared to a scene illuminated with a 6500-K source. This occurs because a 2600-K source has less blue than a 6500-K source. With white balance (matrixing) a white object can appear to be illuminated by different blackbodies - usually ranging from 3200 to 5600 K.

Gamma correction is introduced into each of the three color channels. By convention, the analog signals are represented by E_G, E_R, and E_B. After gamma correction, they are represented by E_G', E_R', and E_B'.

With CFAs, detectors sensitive to the same color are separated resulting in a low fill factor. The optical anti-alias filter blurs the image and effectively increases the optical area of the detector. The birefringent filter is placed between the lens assembly and the detector array. Birefringent crystals break a beam into two components: the ordinary and the extraordinary. This makes the detector appear larger optically. While this changes the MTF (discussed in Section 10.3.4., *Optical Anti-Alias Filter*), the sensitivity does not change. The light that is lost to adjoining areas is replaced by light refracted to the detector.

With unequal sampling, monochrome edges may appear colored and small objects may change color. Sophisticated image processing is required to overcome the unequal sampling of the colors and to format the output into the NTSC standard. The algorithm selected depends upon the CFA architecture (see Figure 3-44, page 61). Algorithms may manipulate the ratios of blue-to-green and red-to-green,[17] separate the signal into high and low frequency components,[18] use a pixel shift processor,[19] or add two alternating rows together[20,21] to minimize color artifacts. The decoding algorithm is unique for each CFA configuration. Clearly, each CFA design requires a new decoding algorithm. Algorithm design is probably more of an art than a science because the acceptability of color aliasing is not known until after the camera is built.



Example 5-1
SINGLE COLOR CHIP ALGORITHM

Figure 5-7 illustrates a typical CFA[21] where rows are added to minimize aliasing. The NTSC odd field consists of CCD rows 1 + 2, 3 + 4, etc., and the NTSC even field consists of 2 + 3, 4 + 5, etc. Tables 5-7 and 5-8 provide the outputs.

Table 5-7
SUMMING TWO ROWS

CCD ROW	OUTPUT LINE
1 + 2	1 (odd field)
3 + 4	3 (odd field)
2 + 3	2 (even field)
4 + 5	4 (even field)

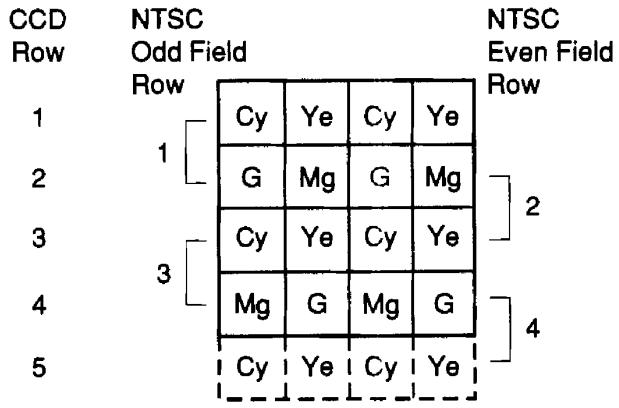


Figure 5-7. Typical CFA (From Reference 21).

Table 5-8
OUTPUT VALUES

TV LINE	PIXEL 1	PIXEL 2	PIXEL 3	PIXEL 4
1	Cy + G = 2G + B	Ye + Mg = 2R + G +B	Cy + G = 2G + B	Ye + Mg = 2R + G +B
3	Cy + Mg = R + G +2B	Ye + G = R + 2G	Cy + Mg = R + G +2B	Ye + G = R + 2G
2	Cy + G = 2G + B	Mg + Ye = 2R + G + B	Cy + G = 2G + B	Mg + Ye =2R + G + B
4	Mg + Cy = R + G +2B	Ye + G = R + 2G	Mg + Cy = R + G +2B	Ye + G = R + 2G

The NTSC signal requires equal R, G, and B information on each line and this requires line interpolation. For example, pixel 3 on the first line does not contain any red data. Red must be interpolated from adjoining pixels. The algorithm selected depends upon the mathematics and the human eye response. The selection depends upon the resultant imagery. That is, the interpolation tends to be empirical.

5.3.3. GAMMA COMPENSATION

A consumer video camera may be purposely made nonlinear to match a monitor response. Gamma correction optimizes the displayed image when using CRT-based monitors. The input predistortion (created at the camera) can only be effective over a strictly defined range. The overall system is linear only when the correct display unit is used. Gamma correction is nonlinear and should be inserted after any required image processing. As flat panel displays replace CRT-based displays, the concern with gamma correction should disappear.

The luminous output of a cathode ray tube is related to its grid voltage by a power law

$$L_{DISPLAY} = K(V_{GRID})^{\gamma} \ . \tag{5-4}$$

If the camera has the inverse gamma (Figure 5-8), then the radiometric fidelity is preserved at the display.

$$L_{DISPLAY} = K(V_{GRID})^{\gamma} = K\left(V_{SCENE}^{\frac{1}{\gamma}}\right)^{\gamma} = K\,V_{SCENE} \ . \tag{5-5}$$

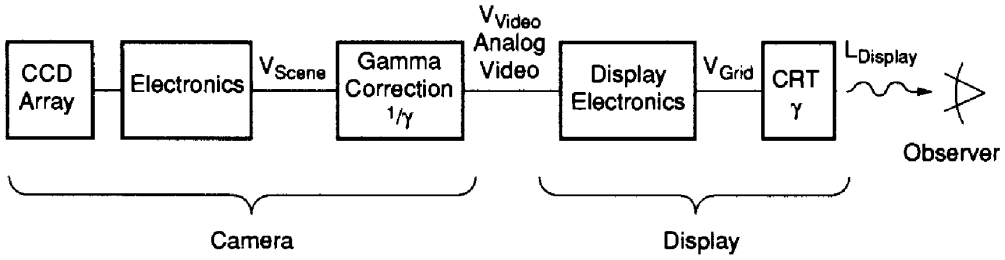


Figure 5-8. Gamma correction should only be used when the imagery is directly presented on a CRT-based display.

Although gamma correction circuitry is placed in the camera and it is numerically equal to the inverse of assumed CRT gamma, popular parlance simply calls it gamma. From now on, gamma will mean the inverse of the CRT gamma value. Gamma compresses small signals and some black detail is lost. In certain high contrast scenes, such as scenes with direct sunlight and shaded areas, the darker parts will lack contrast. It also changes the noise characteristics depending upon the scene level.

Figure 5-9 illustrates a machine vision system or a system where the imagery is evaluated by a computer. Gamma correction should be inserted before any image processing. Although standards recommend a gamma correction value, manufacturers modify these values to create what they perceive to be a cosmetically pleasing image. The output of an imaging processing work station is shown on a computer monitor. Although a machine vision system does not require a monitor, it adds convenience. A gamma correction, internal to the computer, assures that the correct image is shown on the computer monitor.

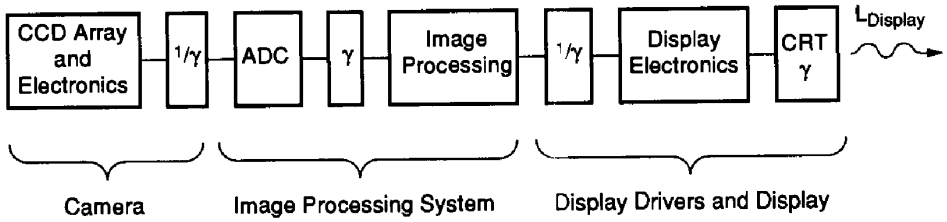


Figure 5-9. Image processing is simplified when gamma has been removed. The camera gamma should be one if the image is to be digitized and displayed on a computer monitor. Although not required for machine vision applications, the monitor offers convenience.

Although CRT displays have a range of gammas, NTSC, PAL, and SECAM "standardized" the display gamma to 2.2. 2.8, and 2.8, respectively. However, all three systems use 0.45 as the inverse. For NTSC, the monitor luminance is proportional to the detector output and target intensity (2.2)(0.45) = 1. With PAL and SECAM, the luminance still has[22] a residual gamma of 1.27. This provides some contrast enhancement.

The gamma slope becomes very large for low values of input brightness. It has therefore become accepted practice to limit the operation of the gamma compensator to an arbitrary level. SMPTE Standard 240M was developed[23] for high definition televisions but now is applied to many systems It has since been replaced by ITU 709.

Normalized to one, 240M states

$$V_{VIDEO} = 1.1115(V_{SCENE})^{0.45} - 0.1115 \quad when\ 0.0228 \le V_{SCENE} \le 1$$
$$V_{VIDEO} = 4V_{SCENE} \quad when\ V_{SCENE} < 0.0228 \ , \tag{5-6}$$

where V_{SCENE} is the voltage before the gamma corrector and V_{VIDEO} is the voltage after. The toe break intensity occurs at $V_{SCENE} = 0.0228$ and the toe slope is 4 (when $L_{SCENE} < 0.0228$). For gamma correction to be accurate, the black reference level must be known. If gamma is inserted after the 7.5% setup, some ambiguity exists in the black level resulting in some intensity distortion. While gamma correction may contain errors, the human eye is very accommodating. The consumer can also adjust the receiver contrast to optimize the image in accordance with his personal preferences. However, this luxury is not available for scientific applications.

Gamma compensation is often performed digitally using a look-up table. Figure 5-10 illustrates the desired output-input transformation recommended by SMPTE 240M. Alternate look-up tables are possible.[24] In fact, some camera manufacturers[21] developed an alternate gamma function *to enhance gray level in a high light intensity region and to obtain high S/N ratio in low light intensity regions simultaneously*. Changing the gamma to minimize the compression of dark areas is also called black stretching. Cameras may have a continuous variable gamma from 0.4 to 1 or may be preselected to 0.45 or 1. The user selects the appropriate value. However, the user rarely knows the CRT gamma. He will simply adjust the camera until he creates an aesthetically pleasing image. This setting will vary from individual to individual.

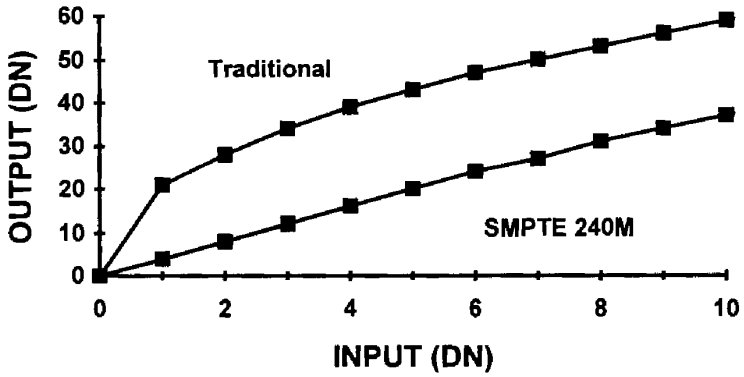


Figure 5-10. Gamma output-input transformation recommended by SMPTE 240M. Expansion of the first 10 levels of an 8-bit ADC system. Data only exist at integer values. Compression of blacks is obvious.

5.3.4. APERTURE CORRECTION

Image sharpness is related to the modulation transfer function (discussed in Chapter 9, *Linear System Theory*, and Chapter 10, *System MTF*). By increasing the MTF at high spatial frequencies, the image usually appears "sharper."

For analysis purposes, a camera is separated into a series of subsystems: optics, detector, electronics, etc. MTF degradation in any one subsystem will soften imagery. The degradation can be partially compensated with electronic boost filters (discussed in Section 10.6.5., *Boost*). Historically, each subsystem was called an "aperture." Therefore boost provides "aperture correction." This should not be confused with the optical system where the optical diameter is the entrance aperture.

Boost filters also amplify noise so that the signal-to-noise ratio remains constant. For systems that are contrast limited, boost appears to improve image quality. However, for noisy images, the advantages of boost are less obvious. As a result, these filters are used only in high contrast situations (typical of consumer applications) and are not used in scientific applications where low signal-to-noise situations are often encountered.

5.4. INDUSTRIAL/SCIENTIFIC CAMERAS

The operation of industrial and scientific cameras is straightforward. They are built around the solid state device capabilities. The array output is amplified and then either processed into a standard video format or left in digital format. Although these may be color cameras, the majority are monochrome.

Progressive scan simply means the noninterlaced or sequential line-by-line scanning of the image (see Section 3.3.5., *Progressive Scan*, page 68). Moving objects can be captured with a strobe light or a fast shutter. Only a progressive scan camera will give the full resolution when the illumination time is short. These cameras can capture imagery asynchronously. That is, the camera timing is initiated from an external sync pulse that is coincident with the strobe flash which may signify that the object is in the center of the field-of-view. Although the image is captured in a progressive scan manner, the camera output is processed into a standard video output so that it can be displayed on commercial monitors. For critical applications, a digital output is available.

TDI offers another method to capture objects moving at a constant velocity. The operation of TDI arrays (see Section 3.3.6, *Time Delay and Integration*, page 70) exactly describes how a TDI camera will operate. The TDI camera output may not be in a standard format and may need a dedicated computer or image processing work station. Reference 25 describes a TDI system used for remote sensing. Here, the aircraft or satellite provides the motion and the objects on the ground are stationary.

Consumer cameras are specified by the minimum detectable signal and dynamic range. In addition to these metrics, scientific and industrial cameras are specified by MTF and the signal-to-noise ratio. Scientific cameras often have a large dynamic range and may have 10-, 12-, 14-, or 16-bit analog-to-digital converters. Key to the operation is that the ADC is linear.



Example 5-2
TDI CAMERA

Bottles move on a conveyor belt at the rate of 1200 ft/min. An image processing system must detect defects without any human intervention. The bottle must be scrapped if a defect is larger than 0.1 inches. The camera sits 48 inches from the conveyor belt. If the detectors are 20 μm square, what focal length lens should be used? What is the camera line rate? If the bottle is 10 inches tall, what should the array size be?

Image processing software accuracy increases as the number of pixels on the target increases. While one pixel on the target may be sufficient for special cases, signal-to-noise ratio considerations and phasing effects typically require that the object cover at least three pixels. Thus, the image of the defect must be at least 60 μm.

The optical magnification is

$$M_{OPTICS} = \frac{R_2}{R_1} = \frac{y_2}{y_1} = \frac{60\ \mu m}{(0.1\ inch)(25{,}400\ \mu m/inch)} = 0.0236\ , \quad (5\text{-}7)$$

where R_1 is the distance from the lens to the object and R_2 is the lens to array distance. The focal length is

$$fl = R_1 \frac{y_2}{y_1} = \frac{R_2 R_1}{R_2 + R_1} = 1.1\ inches. \quad (5\text{-}8)$$

The image is moving at (1200 ft/min)(1 min/60 s)(304,800 μm/ft)(0.0236) = 143,865 μm/s. Because the detectors are 20 μm, the line rate is 7193 lines/s. This creates a detector dwell time of 1/7193 = 140 μs. That is, the edge of the defect has moved across the detector element in 140 μs. The pixel clock must operate at 7193 Hz and the integration time is 140 μs.

The image of the bottle is (10 inches)(25400 μm/inch)(0.0236) = 5994 μm. With 20 μm square detectors, the array must contain 300 detectors in the vertical direction. The number of TDI elements depends upon the detector noise level, light level, and detector integration time. The signal-to-noise ratio increases by $\sqrt{N_{TDI}}$.

5.4.1. ANALOG-to-DIGITAL CONVERTERS

An analog-to-digital converter is an essential component of all digital cameras. For consumer applications, an 8-bit converter is used. Sometimes seemingly slight deviations from perfection in an ADC can modify image fidelity[26] when examined by a trained photointerpreter or by an automatic target detection algorithm. While a nonlinear ADC may not be visually obvious with a single readout, it may become obvious if the array has multiple outputs with each output having its own ADC. Here, any object which spans the two areas with different ADCs will have a discontinuity in intensity.

ADC linearity is specified by differential nonlinearity (DNL) and integral nonlinearity (INL) (Figure 5-11). The differential nonlinearity is a test of missing codes or misplaced codes. Two adjacent codes should be exactly one LSB apart. Any positive or negative deviation from this is the DNL. If the DNL exceeds one LSB, there is a missing code. Many nonlinearity specifications

simply state "no missing codes." This means that the DNL is less than one LSB. However, 1.01 LSB DNL (fail specification) and 0.99 LSB DNL (pass specification) probably look the same visually. Poor DNL can affect the cosmetic quality of images.

Integral nonlinearity is the deviation of the transfer function from an ideal straight line. Most ADCs are specified with endpoint INL. That is, INL is specified in terms of the deviation from a straight line between the end points. Good INL is important for radiometric applications.

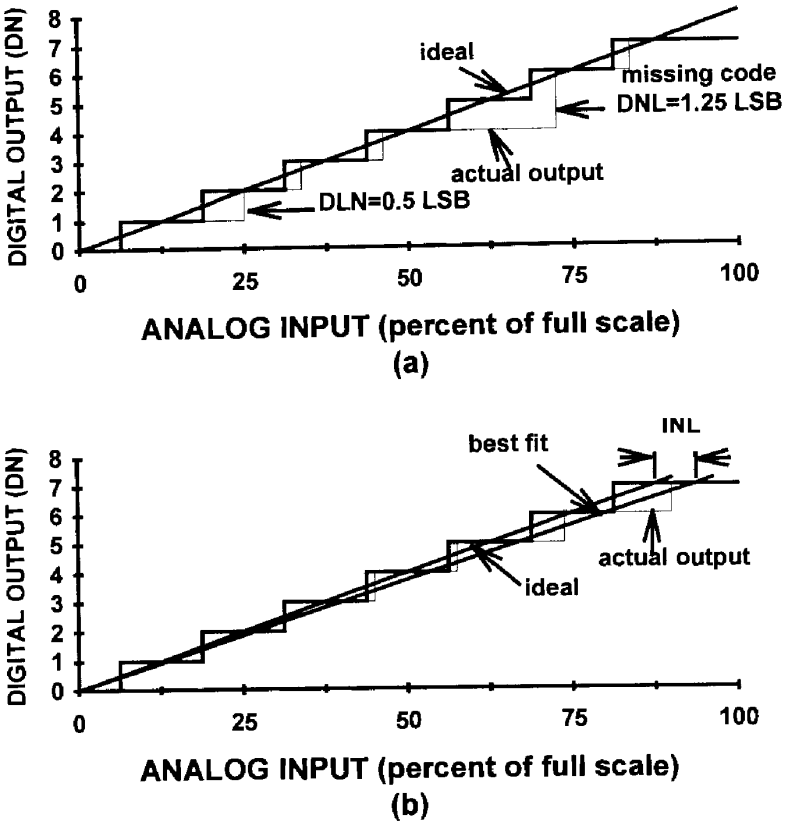


Figure 5-11. ADC nonlinearity for 3-bit ADC. (a) Differential nonlinearity and (b) integral nonlinearity. Missing codes can be caused by the accumulation of DNLs. Accumulation can also cause INL.

ADCs exist in most cameras. With commercially available cameras, the manufacturer has selected the ADC. To ensure that the ADC is linear, the user must experimentally characterize the performance in a manner consistent with his application.[27] This is rather difficult if the camera output is an analog signal. The analog output represents a smoothed output of the ADC. The smoothing can hide ADC nonlinearities.

The same problem may exist within a frame capture board. The user must test the board for any nonlinearities. Because the frame capture board usually resides within a computer, testing is relatively easy.

5.4.2. INTENSIFIED SOLID STATE CAMERAS

Although low light level televisions can be used for many applications, they tend to be used for military and scientific applications. The term *image intensifier* refers to a series of special imaging tubes[28] that have been designed to amplify the number of photons internally. These tubes increase the number of incident photons by several orders of magnitude. The more popular second generation (GenII) and third generation (GenIII) intensifier tubes use a microchannel plate (MCP) for intensification. Third generation is similar in design to second generation with the primary difference being higher quantum efficiency.

When photons hit the photocathode, electrons are liberated and thereby create an electron image. The electrons are focused onto the MCP and about 80% enter the MCP. The MCP consists of thousands of parallel channels (glass hollow tubes) that are about 10 μm in diameter. Electrons entering the channel collide with the coated walls and produce secondary electrons. These electrons are accelerated through the channel by a high potential gradient. Repeated collisions provide an electron gain up to several thousand. Emerging electrons strike the phosphor screen and a visible intensified image is created. The intensifier is an analog device and an observer can view the resultant image on the phosphor screen.

The intensifier output can be optically linked[29] to a solid state array with either a relay lens or a fiberoptic bundle (Figure 5-12). When coupled to a CCD, it is called an ICCD. The intensified camera spectral response is determined solely by the intensifier photocathode responsivity. Although Figure 5-13 illustrates GenII and GenIII spectral responsivities, a variety of photocathodes are available.[30] The window material controls the short wavelength cutoff whereas the photocathode determines the long wavelength cutoff.

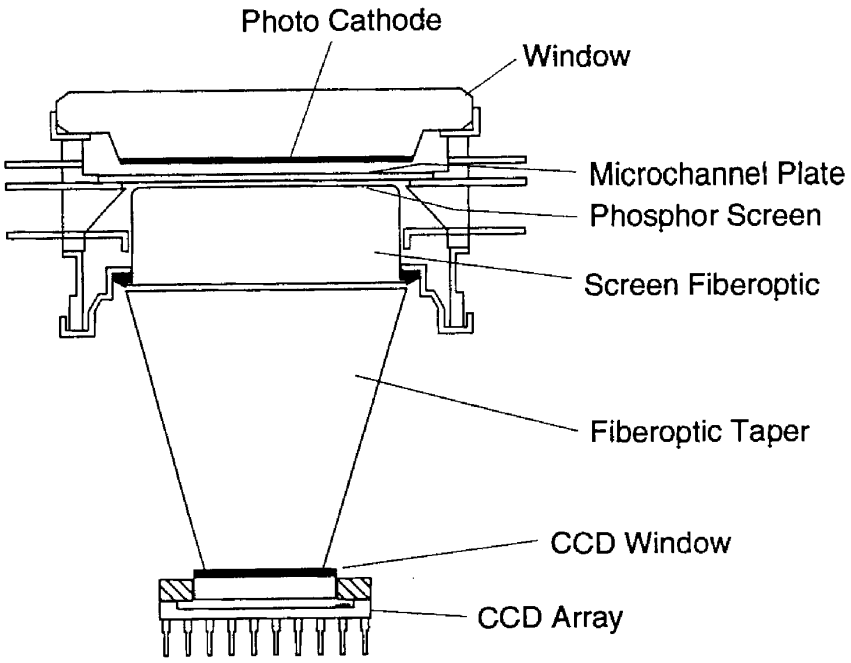


Figure 5-12. CCDs can be coupled to an image intensifier using either fiberoptic bundle or relay lens. The tapered fiberoptic bundle (shown here) tends to be the largest component of the ICCD.

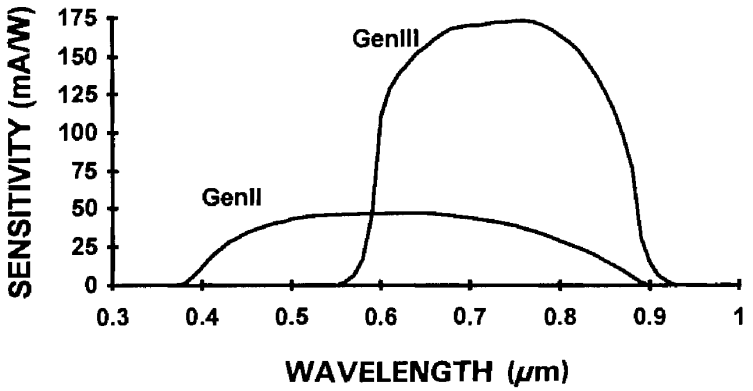


Figure 5-13. Nominal spectral response of militarized (fielded) GenII and GenIII image intensifier tubes. GenIII provides a better match to the night sky illumination (see Figure 2-13, page 39). The responsivity depends upon the window and photocathode material. GenII tubes use a multialkali photocathode whereas GenIII tubes use GaAs photocathodes.

Although many phosphors are available for the intensifier output, a phosphor should be selected whose peak emission is at the peak of the solid state array spectral responsivity. A color camera is not a good choice because it has lower quantum efficiency due to the color-separating spectral filters. Furthermore, single chip color cameras have unequal sampling densities and this can lead to a loss in resolution.

The intensified camera can provide high quality, real-time video when the illumination is greater than 10^{-3} lux (corresponding to starlight or brighter). For comparison, standard cameras (non-intensified) are sensitive down to about 1 lux. Thus, intensified cameras offer high quality imagery over an additional three orders of magnitude in illumination. A three-order magnitude increase in sensitivity implies that the MCP gain should be about a thousand. However, it must be an order of magnitude larger to overcome the transmission loss in the fiber optic bundle or relay lens. For very low illumination levels, it may be necessary to increase the integration time and then real-time video is no longer possible.

By simply changing the voltage on the image intensifier, the gain can be varied. Thus, operation over a wide range of luminance levels ranging from starlight to daylight is possible. Gating is probably the biggest advantage of the intensified camera. Electronic shutter action is produced by pulsing the MCP voltage. Gating allows the detection of low level signals in the presence of interfering light sources of much greater energy by temporal discrimination. Gate times as short as 5 ns FWHM (full width at half maximum) are possible. This allows the detection of laser diagnostic pulses against very intense continuous sources. Because full frame transfer or frame transfer CCDs are used for ICCD applications, the inherent gating capability of the intensifier is used as a shutter during transfer time. This eliminates image smear.

Because the detector size is typically smaller than the intensifier's resolution, the intensifier's image must be minified. Fiber-optic bundles reduce camera size and weight (lenses are relatively heavy). But fiberoptic coupling is complex because it requires critical alignment of the fibers to the individual detectors. The fiber area and pitch, ideally, should match the detector size and pitch for maximum sensitivity and resolution. However, to alleviate critical alignment issues, the fiber diameter is typically one-half the pixel pitch. This reduces sensitivity somewhat.

The lens-coupled system avoids the alignment problems associated with fibers and does not introduce moiré patterns. It offers more flexibility because an image intensifier with an output lens can be connected to an existing solid

state camera. The lens coupling represents a cost-effective way to add gating capability to an existing camera. However, a lens-coupled system provide a much lower throughput (2× to 10× lower) than a fiber coupled system.

There are four spatial samplers in the intensified camera: (1) sampling by the discrete channels in the MCP, (2) the fiberoptic output window within the intensifier, (3) the input to the fiberoptic minifier, and (4) the detector array. At these interfaces, the image is re-sampled. Depending upon the location (alignment) of the fiberoptic minifier, moiré patterns can develop and the MTF can degrade. In addition, manufacturing defects in the fiberoptic can appear[31] as a "chicken wire" effect.

The intensifier tube typically limits the intensified camera resolution. Increasing the array resolution may have little effect on the system resolution. The array is typically rectangular whereas the intensifier is round and the array cannot sense the entire amplified scene. Most commercially available intensified cameras are based on the standard military 18-mm image intensifier. Larger tubes (25 mm and 40 mm) are available but are more expensive and increase coupling complexity.

Intensifiers are electron tubes. Tubes can bloom so that scenes with bright lights are difficult to image. For example, it is difficult to image shadows in a parking lot when bright street lights are in the field-of-view. Intensifiers are subject to the same precautions that should be observed when using most photosensitive coated pickup tubes. Prolonged exposure to point sources of bright light may result in permanent image retention.

The intensifier specifications alone do not accurately portray how the system will work. Only a detailed analysis will predict performance. Resolution of the array will not describe system resolution if the image intensifier provides the limiting resolution. While the array photoresponse may be quite uniform, the overall nonuniformity is limited by the image intensifier. Standard military image intensifier photocathodes have nonuniformities approaching ±30%. Only carefully selected intensifiers with low nonuniformity are used as part of the intensified system.

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6

CAMERA PERFORMANCE

Camera performance metrics are conceptually the same as array metrics (see Chapter 4, *Array Performance*, page 102). The camera is limited by the array noise floor, dark current, and charge well capacity. The camera's fixed pattern noise (FPN) and photoresponse nonuniformity (PRNU) may be better than the array pattern noise when correction algorithms are present. Frame averaging and binning can reduce the random noise floor and thereby appear to increase the camera's dynamic range.

The signal is modified by the spatial response of the optics and detector whereas the noise originates in the detector and electronics. Noise characteristics may be different from signal characteristics. System design requires optimizing the signal-to-noise ratio.

This chapter covers maximum signal, minimum signal, dynamic range, and the signal-to-noise ratio. It assumes that the image size is large compared to the detector's area. Point source detection calculations are more difficult and can be found in References 1 and 2. Camera metrics, depend in part, on the application (see Section 5.2.2., *Broadcast/Non-broadcast Design*, page 155).

Historically, performance metrics were created for broadcast systems. These metrics may be applied to scientific, machine vision, and military systems. Some of these metrics are not appropriate for specific applications and therefore may be considered as superfluous information.

Image intensifier and array characteristics both affect the intensified camera signal-to-noise ratio. ICCDs have a dynamic range that varies with the image intensifier gain. This permits fabrication of general purpose ICCDs that operate in lighting conditions that range from starlight to full sunlight.

The symbols used in this book are summarized in the *Symbol List* (page xviii) which appears after the *Table of Contents*.

6.1. NOMENCLATURE

Figure 6-1 illustrates a functional block diagram of an analog camera. It is functionally identical to Figure 4-1 (page 104). Although the off-chip electronics is shown to have only one amplifier in Figure 4-1, it may consist of several amplifiers. One of the amplifiers may have a variable gain that allows the user to increase the signal under low light level conditions. This gain is turned off (i.e., $G_2 = 1$) when the maximum illumination is measured. The value of G_1 is superfluous because its only purpose is to provide a standard video voltage.

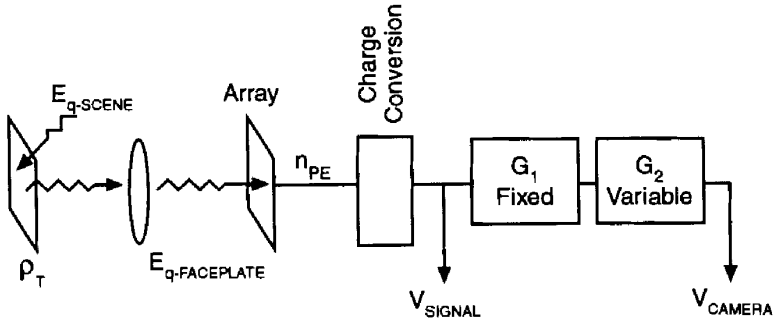


Figure 6-1. Camera function block diagram. The gain G_2 may be automatic (AGC) or manually controlled.

The input can be measured at two different places. With the first measurement, the lens focuses reflected scene illumination, $\rho_T E_{v\text{-SCENE}}$, onto the array where ρ_T is the target reflectivity. Tables 2-5 and 2-6 (page 28) provide typical values of $E_{v\text{-SCENE}}$. Here, the camera's output depends upon the lens f-number and transmittance (or equivalently the T-number). In the second measurement, the faceplate illumination is used. For radiometric inputs, the scene irradiance or faceplate irradiance is used. In Equation 4-2 (page 112), the source was represented by M_e and it is identical to $\rho_T E_{e\text{-SCENE}}$. Because the manufacturer has no control over the user's selection of lenses, the faceplate illumination is often specified.

Array parameters are based upon the photon flux irradiating the detector, $E_{q\text{-FACEPLATE}}$ and the measured output V_{SIGNAL}. The number of photons reaching the detector is

$$n_{DETECTOR} = E_{q\text{-}FACEPLATE} A_D t_{int} , \qquad (6\text{-}1)$$

which is identical to Equation 2-12 (page 34).

The array quantum efficiency is

$$R_q(\lambda) = \frac{n_{PE}(\lambda)}{n_{DETECTOR}(\lambda)} . \tag{6-2}$$

The array signal-to-noise is

$$SNR_{ARRAY} = \frac{n_{PE}}{\langle n_{SYS} \rangle} \tag{6-3}$$

and the array dynamic range is

$$DR_{ARRAY} = \frac{V_{SIGNAL}}{V_{NOISE}} = \frac{N_{WELL} - n_{DARK}}{\langle n_{SYS} \rangle} . \tag{6-4}$$

The array outputs, n_{PE} and $<n_{SYS}>$, are derived theoretically or are calculated from the measured values V_{SIGNAL} or V_{CAMERA}. Often only $<n_{FLOOR}>$ is used for $<n_{SYS}>$ to calculate DR_{ARRAY}. This provides the highest possible dynamic range. If the camera does not introduce any additional noise, modify the noise bandwidth, or minimize the maximum output, the camera SNR and DR_{CAMERA} will be identical to the array values.

For Lambertian targets,

$$E_{v\text{-}FACEPLATE} = \frac{\rho_T E_{v\text{-}SCENE}}{4 F^2 (1 + M_{OPTICS})^2} T_{OPTICS} T_{ATM} \quad lux. \tag{6-5}$$

On a clear day ($T_{ATM} \approx 1$), a white target ($\rho_T \approx 1$) which is far way ($M_{OPTICS} \approx 0$) provides

$$E_{v\text{-}FACEPLATE} \approx \frac{\rho_T E_{v\text{-}SCENE}}{4 F^2} T_{OPTICS} \quad lux. \tag{6-6}$$

For back-illuminated targets (such as those used for calibration), the flux emanating from the target is $\rho_T E_{v\text{-}SCENE}$. The measurement of faceplate illumination is usually performed with a calibrated lens. The value $\rho_T E_{v\text{-}SCENE}$ is measured with a calibrated radiometer or photometer, V_{CAMERA} is measured, and then by using Equation 6-6 or 6-7 $E_{v\text{-}FACEPLATE}$ is calculated.

With four possible inputs (scene irradiance, scene illuminance, faceplate irradiance, and faceplate illuminance) and three outputs (number of electrons, V_{SIGNAL}, and V_{CAMERA}) there potentially exists 12 input-output performance parameters. Each metric is appropriate for a specific application. This chapter will consider only the most widely used metrics. The derivation of the others is straightforward. For image intensified systems, the scene or faceplate values are used as the input to the image intensifier.

The maximum and minimum signals depend on the spectral output of the source and the spectral response of the detector. The source color temperature is not always listed but is a critical parameter for comparing systems. Although the CIE illuminant A is used most often, the user should not assume that this was the source used by the camera manufacturer. Manipulation of the source (CIE illuminant A, B, C, D_{65}, or another unspecified source) and optical filter characteristics can change the maximum and minimum signal values.

Based on signal detection theory, the minimum illumination would imply that the signal-to-noise ratio is one. However, the definition of minimum illumination is manufacturer dependent. Its value may be (a) when the video signal is, say, 30 IRE units, (b) when the SNR is one, or (c) when an observer just perceives a test pattern. Because of its incredible temporal and spatial integration capability, the human visual system can perceive SNRs as low as 0.05. This is further discussed in Section 12.1.1., *Perceived Signal-to-Noise Ratio*. Therefore, comparing cameras based on "minimum" illumination should be approached with care.

6.2. CAMERA METRICS

Both the signal and noise are usually measured. By using a measured value, all noise sources are included: shot noise, noise floor, reset noise, pattern noise, quantization noise, amplifier white noise, and amplifier 1/f noise. The minimum signal is then calculated using the variable amplifier gain, G_2, and signal-to-noise ratio.

6.2.1. CAMERA SNR

For many applications, the object is far away so that M_{OPTICS} approaches zero. When measured at the camera output, the SNR is

$$SNR_{SCENE} = \frac{\frac{G_2 G_1 G q}{C} \frac{A_D}{4F^2} \int_{\lambda_1}^{\lambda_2} R_q(\lambda)\, \rho_T(\lambda)\, M_{q\text{-}SCENE}(\lambda)\, t_{INT}\, T_{OPTICS}(\lambda)\, d\lambda}{\sqrt{\int_0^{\infty} S(f_{elec})\, |H_{SYS}(f_{elec})|^2\, df_{elec}}}, \quad (6\text{-}7)$$

where the subscript *scene* is used to indicate the input is the reflected scene flux. Noise is inserted by the detector and by the amplifiers (see Figure 4-11, page 123). The electronics MTF, $H_{SYS}(f_{elec})$, modifies the noise spectra. The noise power spectral density, $S(f_{elec})$, includes all the noise sources: shot noise, noise floor, reset noise, pattern noise, quantization noise, amplifier white noise, and amplifier 1/f noise. The subscript *elec* emphasizes that electrical frequency applies to the amplifiers and subsequent electronic filters. The MTFs are described in Chapter 10, *System MTF*.

Equation 6-8 is the generalized SNR equation. When equated to electrons,

$$SNR_{SCENE} = \frac{\frac{A_D}{4F^2} \int_{\lambda_1}^{\lambda_2} R_q(\lambda)\, \rho_T(\lambda)\, M_{q\text{-}SCENE}(\lambda)\, t_{INT}\, T_{OPTICS}(\lambda)\, d\lambda}{\langle n_{SYS} \rangle}. \quad (6\text{-}8)$$

For a small spectral band

$$SNR_{SCENE} \approx \frac{\frac{A_D}{4F^2} R_q(\lambda_o)\, \rho_T(\lambda_o)\, M_{q\text{-}SCENE}(\lambda_o)\, t_{INT}\, T_{OPTICS}(\lambda_o)\, \Delta\lambda}{\langle n_{SYS} \rangle}. \quad (6\text{-}9)$$

The SNR is proportional to the detector area and integration time. Figure 6-2 provides the relative SNR as a function of these parameters. Binning is identical to increasing the detector area. The output of four binned detectors is the same as one detector four times larger. For fixed area, increasing the integration time increases the SNR. For fixed integration time, binning increases the SNR. Shorter integration times permit higher frame rates (See Section 4.5., *Frame Rates*, page 142). Shorter integration times also decrease the SNR.

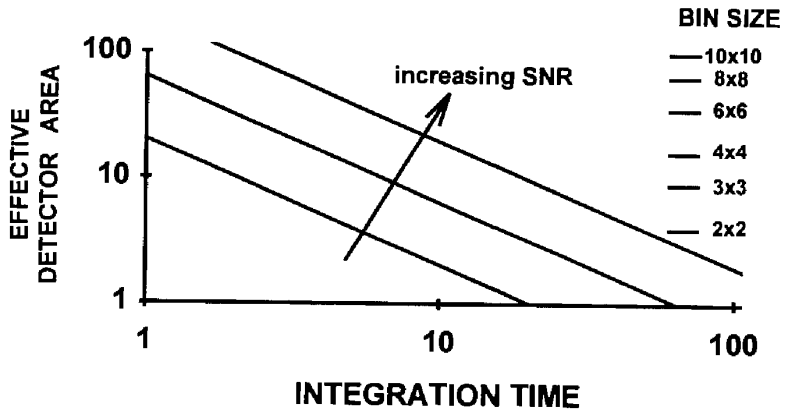


Figure 6-2. Relative SNR as a function of bin size (detector area) and integration time. Only shot noise is considered.

6.2.2. CAMERA DYNAMIC RANGE

Dynamic range is the maximum signal divided by the noise. It depends on integration time, binning, and frame integration. In addition, the spectral content of the source and the array spectral responsivity affect the camera output voltage. Thus, the camera dynamic range can be quite variable depending on test conditions.

Although the theoretical maximum signal just fills the charge wells, the manufacturer may limit the maximum output voltage to a lower stored-charge value. Because the dynamic range is often expressed in decibels,

$$DR_{CAMERA\text{-}dB} = 20 \log\left(\frac{V_{MAX}}{V_{Noise}}\right) \qquad (6\text{-}10)$$

and the noise voltage is

$$V_{NOISE} = V_{MAX} \cdot 10^{\left(-\frac{DR_{CAMERA-dB}}{20}\right)} . \qquad (6\text{-}11)$$

Many camera manufacturers list the dynamic range as the signal-to-noise ratio. This value should not be confused with the actual SNR (see Section 4.3., *Array Signal-to-noise Ratio*, page 139). With most cameras, the noise level is approximately equivalent to the array read noise. The electronics may increase the camera noise, and image processing techniques may reduce it somewhat. Usually the dynamic range is calculated from the measured signal and noise. Because the read noise is amplifier white noise, it is appropriate to include the bandwidth as part of the measurements. For standard video compatible cameras, the bandwidth is equal to the video format bandwidth (see Section 5.2.1., *Video Timing*, page 151).

Example 6-1
DIGITAL DYNAMIC RANGE

A device with a well capacity of 50,000 electrons has a noise floor of 60 electrons rms. What size analog-to-digital converter should be used?

Adding noise powers, the total camera noise is related to the array noise and ADC noise by

$$\langle n_{SYS} \rangle = \sqrt{\langle n_{FLOOR}^2 \rangle + \langle n_{ADC}^2 \rangle} . \qquad (6\text{-}12)$$

If an ADC is selected so that an LSB is equal to the array noise level, the ADC increases the camera noise by 4%. The array dynamic range is 50,000/60 = 833 but the smallest available ADC has 10 bits or 1024 levels. This ADC devotes 1.23 bits to array noise. But if the LSB was one-quarter of the array noise level, the camera noise would increase by only 1%. The ADC dynamic range must be greater than 3332:1. The smallest ADC that covers this range contains 12 bits.

6.2.3. MAXIMUM SIGNAL

If specifying scene illumination, a f-number must be selected. Historically, film-based cameras are compared when the lens f-number is 5.6. Figure 6-3 illustrates the relative change in the maximum signal as the f-number is varied. For consumer video and industrial cameras, the integration is selected to match the video standard (t_{INT} = 1/30 for EIA 170). Automatic irises and variable integration times can increase the maximum level.

The photon level that saturates the charge wells is the camera's maximum input signal and $V_{WELL} = G_1 G q N_{WELL}/C$ where $G_2 = 1$. However, there is no requirement that the camera manufacturer set the maximum output voltage equal to V_{WELL}. If the array has an antibloom drain, the maximum output may be limited to the white clip level (see Figure 3-35, page 87).

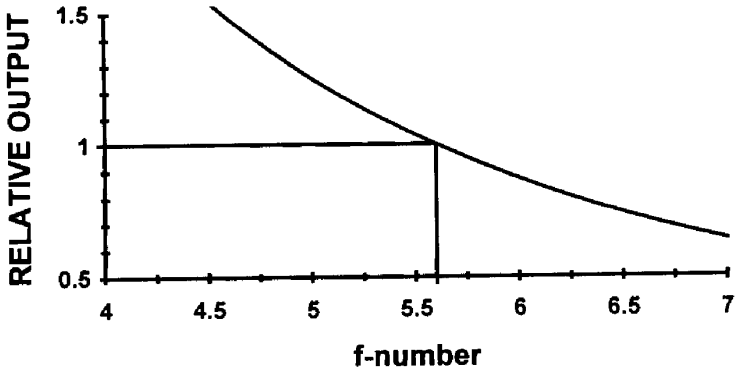


Figure 6-3. Relative maximum output normalized to f/5.6.

6.2.4. MINIMUM SIGNAL

The minimum input signal suggests something about the lowest detectable signal. When using scene illumination, the minimum signal is often specified with different optics than the optics specified for the maximum signal (Figure 6-4). Faster optics is a reasonable choice because these lenses are used in low illumination conditions.

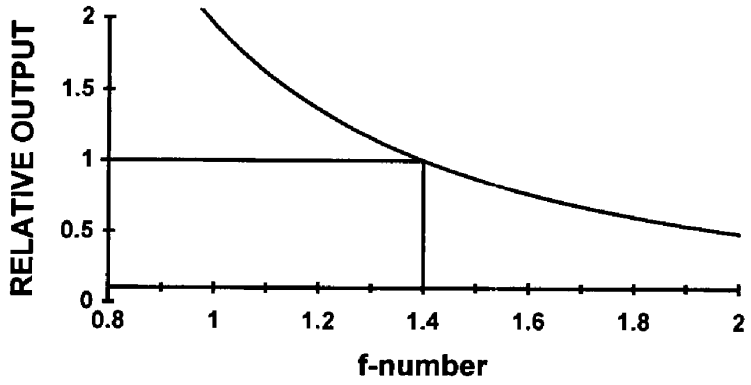


Figure 6-4. Relative minimum output normalized to f/1.4. A camera can appear to have very high sensitivity if a very low f-number lens is used.

The minimum signal provided with gain "on" (G_2 greater than one) is usually calculated due to the difficulty of performing accurate low level radiometric and photometric measurements. These values may be provided at 30%, 50%, or 80% video levels. That is, the illumination given produces an output video that gives 30, 50, or 80 IRE units, respectively (see Section 5.2.4., *IRE Units*, page 157). Although a higher gain amplifier could provide 100% video, the user can optimize the image by adjusting the gain and level of the display. That is, the display's internal amplifiers can be used for additional gain. In this context, the camera *system* consists of the camera and display.

If G_2 is expressed in decibels,

$$G_2 = 10^{\left(\frac{G_{2\text{-}dB}}{20}\right)} . \tag{6-13}$$

The scene illumination that creates a 30% video signal is

$$M_{v\text{-}SCENE}(30\%video) = \frac{0.3 \cdot M_{v\text{-}SCENE}(MAX)}{G_2} , \tag{6-14}$$

where $M_{v\text{-}SCENE}(MAX)$ is the scene illumination that produced the maximum output. For 50% and 80% video, the factor becomes 0.5 and 0.8, respectively.

The input signal that produces a signal-to-noise ratio of one is

$$M_{v\text{-}SCENE}(SNR = 1) = M_{v\text{-}SCENE}(Max) \cdot 10^{\left(-\frac{DR_{CAMERA\text{-}dB}}{20}\right)}. \qquad (6\text{-}15)$$

For faceplate illumination, $M_{v\text{-}SCENE}$ is replaced with $E_{v\text{-}FACEPLATE}$. Actual performance may deviate from the calculated values. The gain used in the equations is typically a nominal value. Usually more gain is available than that specified in the data specifications.

The examples in Chapter 4 (pages 116-118, 122, and 131) should be reviewed prior to reading the following examples.

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Example 6-2
MINIMUM SIGNAL ESTIMATION

A camera provides maximum output when the faceplate illumination is 0.65 lux. The dynamic range is 55 dB. What is the equivalent noise signal?

Using Equation 6-15, the noise signal is 1.16×10^{-3} lux. A signal-to-noise of one provides an extremely noisy image. While a human observer can detect some objects when the SNR is one, a machine vision system cannot.

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Example 6-3
VIDEO SIGNAL ESTIMATION

The camera described in Example 6-2 provides a gain of 20 dB. What is the SNR at 30% and 80% video?

Using Equations 6-14 and 6-15, at 30% video the faceplate illumination is 0.0195 lux and at 80% video, the faceplate illumination is 0.052 lux. The SNR is 17 and 45, respectively. With a SNR of 17, the image will appear slightly noisy but probably would be considered acceptable to most observers. However, if no additional gain is used, the image will appear very dark on the display. Here, the display gain must be increased to make the image viewable. Depending upon the task, a machine vision system may need a higher SNR. While computer programs are usually insensitive to absolute signal values, the frame grabber's ADC may not provide enough levels for adequate image

processing. For example, if the ADC is an 8-bit system, 30% video only provides digital numbers ranging from 0 to 77.

Example 6-4
NOISE EQUIVALENT INPUT

In Example 6-2, the minimum signal was specified in photometric units. In the more general radiometric case, the input that provides SNR = 1 is the noise equivalent input (NEI). That is, $\rho_T M_{q\text{-SCENE}}$ is found from Equation 6-9 when $SNR_{q\text{-SCENE}}$ is one. Over a small spectral band,

$$NEI \approx \frac{4F^2}{A_D t_{INT} \eta \Delta\lambda T_{OPTICS}} \langle n_{SYS} \rangle \quad \frac{photons}{s\text{-}m^2\text{-}\mu m}. \tag{6-16}$$

When the SNR is unity, the number of photons is small and photon noise is negligible (see Figure 4-16b, page 136). If the detector is cooled, dark current is minimized. With PRNU and FPN correction, the minimum NEI is

$$NEI \approx \frac{4F^2}{A_D t_{INT} \eta \Delta\lambda T_{OPTICS}} \langle n_{FLOOR} \rangle \quad \frac{photons}{s\text{-}m^2\text{-}\mu m}. \tag{6-17}$$

If TDI is used, then N_{TDI} is multiplied in the denominator. With binning or super pixeling, the number of pixels combined is multiplied in the denominator.

Example 6-5
NOISE EQUIVALENT REFLECTANCE

The NEI assumes that the target is against a black background. For real scenes, both the target and background create signals. The target is only visible when a sufficient reflectance difference exists. For detecting objects at long ranges, the atmospheric transmittance loss must be included. The signal difference between the target and its background is

$$\Delta n_{pe} = \int_{\lambda_1}^{\lambda_2} R_q(\lambda) \frac{(\rho_T - \rho_B) M_q(\lambda)\, t_{INT}\, A_D}{4F^2} T_{OPTICS}(\lambda)\, T_{ATM}(\lambda) d\lambda \ . \quad (6\text{-}18)$$

Both the target and background are illuminated by the same source. The signals from both depend on the spectral reflectances that are taken as constants over the spectral region of interest. Using the same simplifying assumptions as before, solving for $\rho_T - \rho_B$ and calling this value the noise equivalent reflectance difference (NE$\Delta\rho$) provides

$$NE\ \Delta\rho \approx \frac{4F^2}{A_d\, t_{INT}\, \eta\, M_q(\lambda_o)\, \Delta\lambda\, T_{OPTICS}\, T_{ATM}} \langle n_{SYS} \rangle \ , \quad (6\text{-}19)$$

where T_{ATM} is the total atmospheric transmittance and it depends on range. The value T_{ATM} is usually expressed as $T_{ATM} = \exp(-\sigma_{ATM} R)$. Then

$$NE\ \Delta\rho \approx \frac{4F^2 e^{\sigma_{ATM} R}}{A_D\, t_{INT}\, \eta\, M_q(\lambda_o)\, \Delta\lambda\, \tau_{OPTICS}} \langle n_{SYS} \rangle = \frac{NEI}{M_q(\lambda_o)} e^{\sigma_{ATM} R} \ . \quad (6\text{-}20)$$

Thus, NE$\Delta\rho$ depends on the source illumination, system noise, and the atmospheric conditions. As the range increases, the target reflectance must increase to keep the SNR at one. The maximum range occurs when the NE$\Delta\rho$ is one. At this maximum range,

$$NEI = M_q(\lambda_o)\, e^{-\sigma_{ATM} R_{MAX}} \ . \quad (6\text{-}21)$$

The variable $M_q(\lambda)[\rho_T(\lambda) - \rho_B(\lambda)]$ is a complicated function that depends on the cloud cover, atmospheric conditions, sun elevation angle, surface properties of the target, and the angle of the target with respect to the line-of-sight and sun angle.

These back-of-the-envelope approximations are still not complete. They assume that the total received energy is from the target only. In fact, over long path lengths, path radiance contributes to the energy detected. Path radiance, specified by visibility, reduces contrast. The additional light reflected by the atmospheric particulates introduce photon noise that is independent of the signal from the target. It is quantified by the sky-to-background ratio (discussed in Section 12.6.1, *Contrast Transmittance*).

Example 6-6
MINIMUM PHOTOMETRIC SIGNAL ESTIMATION

A CCD array has a noise floor of 150 electrons rms. If placed into a camera, what is the estimated minimum faceplate detectable signal?

The minimum signal occurs when the signal-to-noise ratio is one. That is, $n_{pe} = \langle n_{FLOOR} \rangle$. Several simplifying assumptions are required to obtain a back-of-the-envelope expression for the minimum signal. If the CIE illuminant D_{6500} is used, the spectral photon sterance is approximately constant over the spectral region, $\Delta\lambda$. If the quantum efficiency is constant,

$$E_{q\text{-}FACEPLATE}(\lambda) \approx \frac{\langle n_{FLOOR} \rangle}{\eta A_D \Delta\lambda t_{INT}} \quad \frac{photons}{s - m^2 - \mu m} . \tag{6-22}$$

Because the energy of one photon is hc/λ, the faceplate spectral power is

$$E_{p\text{-}FACEPLATE}(\lambda) \approx \frac{\langle n_{FLOOR} \rangle}{\eta \Delta\lambda t_{INT}} \frac{hc}{\lambda} \quad \frac{W}{\mu m} . \tag{6-23}$$

The faceplate illumination is

$$E_{v\text{-}FACEPLATE} = \frac{683}{A_D} \int_{0.4\,\mu m}^{0.7\,\mu m} V(\lambda) E_{p\text{-}FACEPLATE}(\lambda) d\lambda \quad lux \tag{6-24}$$

or

$$E_{V\text{-}FACEPLATE} \approx \frac{\langle n_{FLOOR} \rangle hc}{\eta \Delta\lambda t_{INT}} \frac{683}{A_D} \int_{0.4}^{0.7} \frac{V(\lambda)}{\lambda} d\lambda \quad lux. \tag{6-25}$$

From Figure 4-5 (page 108) $\eta \approx 0.3$. For EIA 170 compatibility, $t_{INT} = 1/30$ s, and the spectral bandwidth is $\Delta\lambda = (0.7 - 0.4)\,\mu m = 0.3\,\mu m$. The photometric integral is approximately 0.2. The constant, hc, is approximately 2×10^{-19} J-μm. Then

$$E_{v\text{-}FACEPLATE} = \frac{1.36 \times 10^{-12}}{A_D} \quad lux. \tag{6-26}$$

Assume a 50% fill factor interline transfer array is available. From Table 3-3 (page 99), a ½-inch format detector will have an active size of approximately 4.17 μm × 10 μm ($A_D = 41.7 \times 10^{-12}$ m^2). Then the estimated minimum signal is 3.3×10^{-2} lux.

Consider a target that is pure white, ($\rho_T = 1$) on a black background ($\rho_B = 0$). At low light levels, a f/1.4 lens is often used. Let $T_{OPTICS} = 0.9$ and $T_{ATM} = 1.0$. Using Equation 6-6 (page 184) provides $E_{v\text{-}SCENE} = 0.29$ lux. This target will have a signal-to-noise ratio of one and therefore be very difficult to see. Real targets and backgrounds have reflectivities between 0 and 1. When including the signal-to-noise ratio, $E_{v\text{-}SCENE} = 0.29\,(SNR)/(\rho_T - \rho_B)$. Let the required SNR be 20, $\rho_T = 0.6$, and $\rho_B = 0.4$, then $E_{v\text{-}SCENE} = 29$ lux. From Table 2-5 (page 28), this target can be seen during twilight.

While the assumptions are not unreasonable, the statement that the target can be seen during twilight is an extrapolation. The spectral output of the D_{6500} source is substantially different than twilight with color temperature of approximately 2000 K. Changing the spectral input increases the minimum illumination. Note that these calculations were based solely upon SNR considerations. The camera must have sufficient gain so that these signals can be displayed.

6.3. INTENSIFIED CCD CAMERA

The construction of the ICCD was described in Section 5.4.2., *Intensified Solid State Cameras*, page 176. As illustrated in Figure 6-5, the photocathode creates photoelectrons that are amplified by the MCP. The amplified electrons are converted back into photons by the phosphor screen. These photons are relayed to the CCD by either a fiberoptic bundle or a relay lens. The CCD creates the photoelectrons that are measured. Each conversion has a quantum efficiency less than unity and each optical element yields a finite transmittance loss.

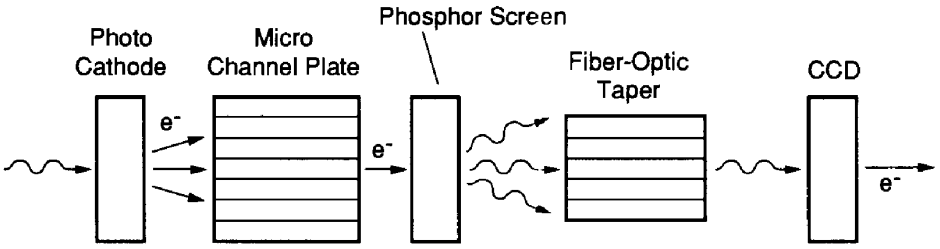


Figure 6-5. Multiple photon-electron conversions occur in an ICCD.

While the image intensifier amplifies the image, the SNR may be reduced due to quantum losses and additive noise. For moderate light levels, the ICCD offers no advantage in SNR performance over the standard CCD camera. Its key attribute is the ability to gate the scene temporally.

6.3.1. ICCD SIGNAL

The ICCD uses a lens to image the target onto the intensifier faceplate. The photon flux reaching the photocathode is

$$\Phi_{CATHODE} = \frac{M_q(\lambda) A_{CATHODE}}{4F^2(1+M_{OPTICS})^2} T_{OPTICS} T_{WINDOW} \cdot \qquad (6\text{-}27)$$

Using the same approximations as given in the preceding section, the number of signal electrons generated by the photocathode is

$$n_{CATHODE} = \frac{\eta_{CATHODE} M_q(\lambda_o) \Delta\lambda}{4F^2} t_{INT} T_{OPTICS} A_{PIXEL} , \qquad (6\text{-}28)$$

where A_{PIXEL} is the projected area of a CCD pixel onto the photocathode. Geometrically, it is the CCD detector area multiplied by the magnification of the fiberoptic bundle. However, A_{PIXEL} depends on fiberoptic bundle characteristics and microchannel pore size. It may be somewhere between 50% of the CCD detector geometric projected area to several times larger.[3] As such, it represents the largest uncertainty in signal-to-noise ratio calculations. The value λ_o is the center wavelength of the photocathode spectral responsivity and $\Delta\lambda$ is the photocathode's spectral bandwidth.

After the microchannel plate, the number of electrons is

$$n_{MCP} = G_{MCP}\, n_{CATHODE} \cdot \tag{6-29}$$

These electrons are then converted to photons by the phosphor screen

$$n_{SCREEN} = \eta_{SCREEN} n_{MCP} \cdot \tag{6-30}$$

The photons travel to the CCD via a fiberoptic bundle whose effective transmittance is T_{fo}. This is a composite value that includes the fiberoptic transmittance and a coupling loss.

$$n_{PHOTON\text{-}CCD} = T_{fo} n_{SCREEN} \cdot \tag{6-31}$$

The number of electrons sensed in the CCD is proportional to its quantum efficiency

$$n_{pe} = \eta_{CCD} n_{PHOTON\text{-}CCD} \tag{6-32}$$

or

$$n_{CCD} = \eta_{CCD}\eta_{SCREEN}\eta_{CATHODE} T_{fo} G_{MCP} \left[\frac{M_q(\lambda_o)\,\Delta\lambda\, t_{INT}\, A_{PIXEL}}{4F^2}\right] . \tag{6-33}$$

For a lens-coupled system, T_{FO} is replaced by an effective relay lens transmittance.[4] Each has its own merits. Transmission losses in a fiberoptic bundle increase proportionally to the square of the minification ratio. This leads to a practical minification of about 2:1. Light is lost because the screen is a Lambertian source whereas the fiberoptic can only accept light over a narrow cone (acceptance angle). But lenses are large and bulky and may provide a throughput as low as 2%. Relay lenses also suffer from vignetting. Here, the "relayed" intensity decreases as the image moves from the center to the periphery of the image intensifier tube.

Because the lens coupling is less efficient than the fiberoptic coupling, the number of electrons produced is lower. The fiberoptic coupled system, with its higher effective transmittance and better sensitivity, can detect lower signals.

6.3.2. ICCD NOISE

The photocathode produces both photon noise and dark noise:

$$\left\langle n^2_{PC\text{-}SHOT} \right\rangle = \left\langle n^2_{CATHODE} \right\rangle + \left\langle n^2_{PC\text{-}DARK} \right\rangle \cdot \tag{6-34}$$

The MCP amplifies these signals and adds excess noise so that

$$\left\langle n_{MCP}^2 \right\rangle = k_{MCP} G_{MCP}^2 \left\langle n_{PC-SHOT}^2 \right\rangle , \tag{6-35}$$

where k_{MCP} is typically taken as 1.8 but varies with bias voltage.[5,6] The value k_{MCP} is also reported as an SNR degradation. The noise power is transformed into photons by the phosphor screen

$$\left\langle n_{SCREEN}^2 \right\rangle = \eta_{SCREEN}^2 \left\langle n_{MCP}^2 \right\rangle . \tag{6-36}$$

It is attenuated by the fiberoptic bundle

$$\left\langle n_{CCD-PHOTON}^2 \right\rangle = T_{fo}^2 \left\langle n_{SCREEN}^2 \right\rangle . \tag{6-37}$$

This value is converted to electrons by the CCD and the CCD noise is added

$$\left\langle n_{CCD}^2 \right\rangle = \eta_{CCD}^2 \left\langle n_{CCD-PHOTON}^2 \right\rangle + \left\langle n_{CCD-DARK}^2 \right\rangle + \left\langle n_{FLOOR}^2 \right\rangle + \left\langle n_{PRNU}^2 \right\rangle . \tag{6-38}$$

The total noise is

$$\left\langle n_{CCD}^2 \right\rangle = \eta_{CCD}^2 T_{fo}^2 \eta_{SCREEN}^2 k G_{MCP}^2 \left\langle n_{PC-SHOT}^2 \right\rangle + \left\langle n_{CCD-SHOT}^2 \right\rangle + \left\langle n_{FLOOR}^2 \right\rangle + \left\langle n_{PRNU}^2 \right\rangle . \tag{6-39}$$

6.3.3. ICCD SNR

The resultant signal-to-noise ratio is

$$SNR = \frac{\eta_{CCD} \eta_{SCREEN} T_{fo} G_{MCP} n_{CATHODE}}{\sqrt{\eta_{CCD}^2 T_{fo}^2 \eta_{SCREEN}^2 k G_{MCP}^2 \left\langle n_{PC-SHOT}^2 \right\rangle + \left\langle n_{CCD-SHOT}^2 \right\rangle + \left\langle n_{FLOOR}^2 \right\rangle + \left\langle n_{FPN}^2 \right\rangle}} . \tag{6-40}$$

Several limiting cases are of interest. When the gain is very high, the intensifier noise overwhelms the CCD noise:

$$SNR = \frac{n_{CATHODE}}{\sqrt{k\left[\left\langle n_{CATHODE}^2 \right\rangle + \left\langle n_{PC-DARK}^2 \right\rangle\right]}} . \tag{6-41}$$

The SNR is independent of gain and CCD characteristics. Under high gain conditions, an expensive, high quantum efficiency or thinned back illuminated CCD is not necessary.

Cooling the photocathode reduces the dark current:

$$SNR = \sqrt{\frac{n_{CATHODE}}{k}} = \sqrt{\frac{\eta_{CATHODE} M_q(\lambda_o)\,\Delta\lambda}{4F^2 k}\, t_{INT}\, T_{OPTICS} A_{PIXEL}}\,. \tag{6-42}$$

High gain is used for photon counting applications. SNR, in this case, is limited by the photocathode quantum efficiency, the excess noise factor, and the optical system.

Under moderate gain situations where the CCD noise is greater than the intensifier noise,

$$SNR = \frac{\eta_{CCD}\eta_{SCREEN} T_{fo} G_{MCP} n_{CATHODE}}{\sqrt{\langle n^2_{CCD\text{-}SHOT}\rangle + \langle n^2_{FLOOR}\rangle + \langle n^2_{PRNU}\rangle}}\,. \tag{6-43}$$

Comparing this with Equation 6-8 (page 186), the ICCD will have lower SNR than a comparable standard camera. The advantage of the ICCD under these conditions is the ability to gate the incoming photon flux temporally.

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Example 6-7
IMAGE INTENSIFIER NOISE

Is there a relationship between the image intensifier noise equivalent input and the ICCD noise?

The noise in an image intensifier is due to random emissions (dark current noise) at the photocathode. When referred to the input (SNR = 1), it is called the equivalent background illumination (EBI). Using the same methodology as in Example 6-4, the EBI for an area A_{PIXEL} is

$$EBI = M_q(\lambda_o)\,\Delta\lambda\, t_{INT}\, A_{PIXEL} = \frac{4\sqrt{k}\,F^2 \langle n_{PC\text{-}DARK}\rangle}{\eta_{CATHODE} T_{OPTICS}}\ photons\,. \tag{6-44}$$

The ICCD will have the same equivalent background input under high gain situations. Cooling the image intensifier reduces the EBI and it may be negligible in gated applications. Under low gain situations, the CCD noise dominates.

Example 6-8
CCD versus ICCD

Under moderate gain situations, what is the relative SNR of the ICCD to the CCD?

The ratio of SNRs is

$$\frac{SNR_{ICCD}}{SNR_{CCD}} = \eta_{SCREEN} T_{fo} G_{MCP} \eta_{PHOTOCATHODE} . \qquad (6\text{-}45)$$

The P20 phosphor screen has a peak emission at 0.56 μm with a conversion efficiency of 0.063. An S20 bialkali photocathode's efficiency is 0.2 at 0.53 μm. The value of T_{fo} is about 0.25. Combined, these factors give 0.00315. The MCP gain must be greater than 1/0.00315 = 317 for the SNR_{ICCD} to be greater than the SNR_{CCD}.

6.4. REFERENCES

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2. M. A. Sartor, "Characterization and Modeling of Microchannel Plate Intensified CCD SNR Variations with Image Size," in *Electron Tubes and Image Intensifiers*, C. B. Johnson and B. N. Laprade, eds., SPIE Proceedings Vol. 1655, pp. 74-84 (1992).
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6. R. J. Hertel, "Signal and Noise Properties of Proximity Focused Image Tubes," in *Ultrahigh Speed and High Speed Photography, Photonics, and Videography*, G. L. Stradling, ed., SPIE Proceedings Vol. 1155, pp. 332-343 (1989).

7

CRT-BASED DISPLAYS

Displays are used for consumer television receivers, computer monitors, scientific applications, and military applications. A display may be called a monitor, visual display unit (VDU), video display terminal (VDT), or simply a television receiver.

The major performance requirements are listed in Table 7-1. This table is not meant to be all inclusive. It just indicates that different users have different requirements. As displays are built for each user, they are specified in units familiar to that user. For example, consumer displays will not have the MTF or spot size listed. These parameters are provided for militarized displays.

Table 7-1
DISPLAY REQUIREMENTS

APPLICATION	REQUIREMENTS
Consumer TV	"Good" image quality
Computer	Alphanumeric character legibility "Good" graphical capability
Scientific and military	High MTF Unity gamma

Television receivers have been available for over 50 years and the technology has matured. They are considered adequate and little improvement in cathode ray tube (CRT) technology is expected. Advances in television displays currently focus on high definition television, flat panel displays, the legibility of alphanumeric characters, and computer graphics capability. As a result, display specifications are a mix of CRT terminology, video transmission standards, alphanumeric character legibility, and graphics terminology.

System resolution depends on the camera response and limitations imposed by the video standard, display characteristics, and observer acuity. High resolution displays do not offer any "extra" resolution from a system point of view if display is not the limiting factor. Rather, high resolution displays just ensure that all the information available is displayed. In many applications,

system resolution is limited by the human eye. If the observer is too far from the screen, not all of the image detail can be discerned.

In almost all cases, the output device sets the system dynamic range. Often, the display is the limiting factor in terms of image quality and resolution. No matter how good the camera is, if the display resolution is poor, then the overall system resolution is poor.

Flat panel displays are an emerging technology with liquid crystal displays (LCDs) prevalent in notebook (laptop) computers. LCDs require only a fraction of the power required by cathode ray tubes and therefore lend themselves to battery operated systems. However, CRTs will probably dominate the display market due to low cost, high resolution, wide color gamut, high luminance, and long life.

The commercially important flat panels are the light emitting diode (LED) displays, AC plasma display panels (AC PDP). DC plasma display panels (DC PDP), AC thin film electroluminescent (ACTFEL) display, DC thin film electroluminescent (DCTFEL) displays, vacuum fluorescent displays (VFD), and the liquid crystal displays (LCD).

LCD arrays can either be active matrix (AMLCD) or passive arrays. The active matrix contains switching devices on each disel to maintain high brightness and high contrast control. The liquid crystals may be either twisted-nematic (TN) or supertwisted-nematic (STN). The details of these displays can be found in References 1 through 6. Although this chapter discusses CRTs, many concepts apply to all displays.

Emerging technology, new designs, and characterization methods can be found in the *Society of Motion Picture and Television Engineers Journal* and the *Proceedings of the Society of Information Display* symposia. The Society of Information Display offers numerous tutorials, complete with published notes, at their symposia.

In accordance with industry convention, the display sizes and viewing distances are expressed in inches. The majority of this book uses the metric system. The symbols used in this book are summarized in the *Symbol List* (page xviii) which appears after the *Table of Contents*.

7.1. THE OBSERVER

The observer is the starting point for display design. Design is based on both perceptual and physical attributes (Table 7-2). For most applications, the design is driven by perceptual parameters. These parameters are partially related to the physical parameters. For example, sharpness is related to MTF. But the precise relationship has not been quantified. While the physical parameters are important to all applications, they tend to be quantified only for scientific and military displays. Tables 7-1 and 7-2 illustrate different ways of specifying the same requirement: the need for a high quality display.

Maximum image detail is only perceived when the observer is at an optimum viewing distance. If the observer is too far away, the detail is beyond the eye's limiting resolution. It the observer moves closer to the display than the optimum, the image does not become clearer because there is no further detail to see. Display size and resolution requirements are based on an assumed viewing distance.

Table 7-2
PERCEPTIBLE AND PHYSICAL PARAMETERS

PERCEPTUAL PARAMETERS	PHYSICAL PARAMETERS
	Luminance
	Resolution
	Uniformity
Brightness	Addressability
Contrast	Gamma
Sharpness	Color saturation
Color rendition	Color accuracy
Flicker	Color convergence (CRT)
	Distortion (CRT)
	Refresh rate
	MTF

For monochrome systems, the optimum viewing distance occurs when the raster pattern is barely perceptible. At closer distances, the raster pattern becomes visible and interferes with image interpretation. That is, it is considered annoying by most. For color CRTs, the observer must be far enough away so that the individual dots of the three primaries are imperceptible. Otherwise, the individual color spots become visible and the impression of full color is lost.

For design purposes, perceptibility occurs when targets are larger than 1 arc minute. This corresponds to the normal visual acuity of 20/20. This design criterion is quite good. An observer can adjust his distance accordingly. An observer with poorer acuity (e.g., 20/40) will simply move closer to the screen whereas someone with better acuity will probably move further away. Most systems are observer-limited in that the observer cannot see all the detail because he is typically too far from the display.

Figure 7-1 illustrates the optimum viewing distance as a function of display diagonal size for monochrome displays. Television receivers and many computer monitors are specified by the diagonal dimension. Each active line (raster line) subtends 1 arc minute (0.291 mrad). At closer distances, the individual raster lines may become visible. The viewing ratio is the viewing distance divided by the display height. The typical viewing ratio for computer monitors is three.

Television viewers sit about seven times the picture height or 4.2 times the diagonal picture dimension. Knowing the dimensions of a typical living room (sofa on one side, television on the other) suggests that consumer televisions should have a diagonal picture size of 21 to 25 inches. These were the most popular television receiver picture sizes. Sizes have changed reflecting changing television viewing habits.

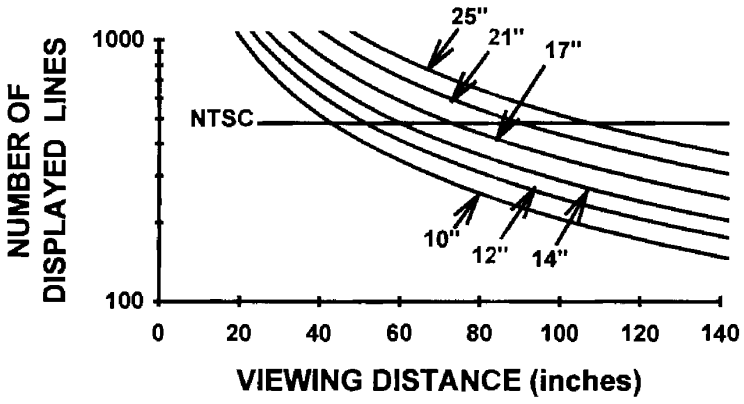


Figure 7-1. Viewing distance as a function of CRT diagonal picture size and number of displayed lines per picture height for monochrome displays. Most CRTs have a 4:3 aspect ratio so that the vertical extent is 60% of the diagonal.

A major design consideration is the elimination of flicker. EIA 170 and NTSC use a 2:1 interface technique which is updated at 30 Hz. For computer monitors which display progressive scan imagery, the frame rate (refresh rate) must be greater than 70 Hz to avoid flicker. Flicker and other design features are not covered here but can be found in numerous books.[2-6]

7.2. CRT OVERVIEW

Figure 7-2 illustrates a typical color cathode ray tube display. Although a color display is illustrated, the block diagram applies to all CRT displays. The input video signal is decoded into its components and then digitized. While digital electronics may be used to process the signal, the CRT is an analog device. Similarly, displays accepting digital inputs must convert the signal into an analog voltage to drive the CRT. Numerous transformations occur to create a visible image. The display matrix and display gain controls allow linear mapping from input image to visible image.[7]

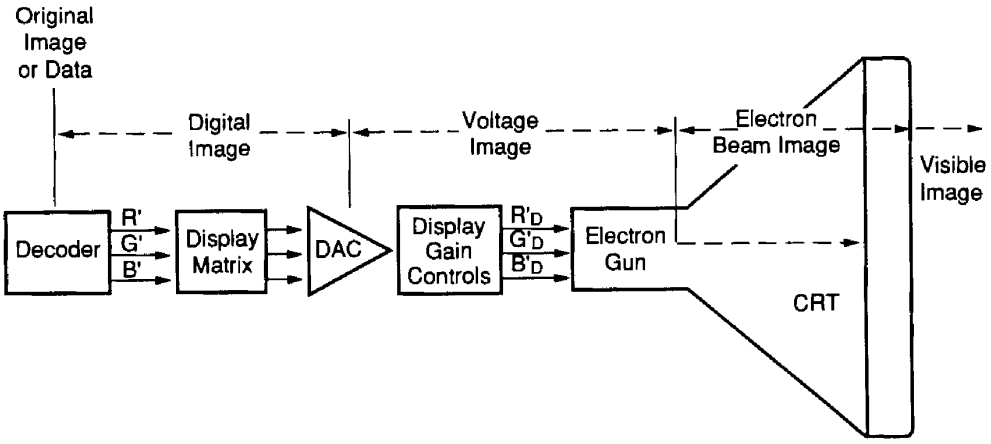


Figure 7-2. Although a color display is illustrated, the block diagram applies to all CRT displays. The digital-to-analog converter (DAC) provides the analog voltages that modulate the electron beam.

The display matrix provides the mapping between the standard video color components and the actual colors emitted by the phosphors on the screen. This color correction circuitry is an algorithm that can be represented as a matrix

$$\begin{pmatrix} R_2 \\ G_2 \\ B_2 \end{pmatrix} = \begin{pmatrix} k_{11} & k_{12} & k_{13} \\ k_{21} & k_{22} & k_{23} \\ k_{31} & k_{32} & k_{33} \end{pmatrix} \begin{pmatrix} R_1 \\ G_1 \\ B_1 \end{pmatrix} . \qquad (7\text{-}1)$$

With the NTSC format, the electron beams paint an image on the CRT phosphor in the scan format shown in Figure 5-2, page 151. The color of the visible image depends on the specific phosphors used. Electron beam density variations, which represent scene intensity differences, create the visible image.

Monochrome displays have a single electron gun and a single phosphor. A color CRT must produce three images (three primary colors) to give a full range of color. To do so requires three electron guns and three phosphors. The three electron beams scan the CRT screen in the same way as a monochrome beam, but arrive at the screen at slightly different angles. The beams strike three different phosphors dots. When the dots (*sub*disels) are beyond the eye's limiting resolution, the eye blends them to create the illusion of a full color spectrum.

The output brightness of a CRT depends on the grid voltage and follows a power law relationship. The slope of this curve, on a log-log scale, is the display gamma (γ):

$$L_{DISPLAY} = k(V_{GRID})^{\gamma} . \qquad (7\text{-}2)$$

Gamma can range[8] from one to five. For design purposes, NTSC standardized gamma at 2.2. PAL and SECAM standardized gamma at 2.8.

To provide a linear relationship in the complete camera-display system, the inverse gamma is inserted in consumer cameras as an image processing algorithm (see Section 5.3.3., *Gamma Compensation*, page 169). For scientific applications and computer monitors, the displays will have an internal gamma correction circuit. Here, the user simply supplies the signal with no gamma compensation (e.g., $1/\gamma = 1$). For color displays, each color will have its own gamma look-up table. This operation is performed in the display matrix.

Digital displays provide excellent alphanumeric and graphic imagery. There is no distortion and the disels are accurately located because there is no jitter in timing signals compared to what might be expected with EIA 170. "Digital" seems to imply high resolution but the displayed resolution is limited by the electron beam spot size. Although called "digital," the CRT is an analog device.

7.2.1. MONOCHROME DISPLAYS

In many industrial and scientific applications, monochrome cameras are used. The military uses monochrome monitors extensively to display imagery from non-visible scenes (e.g., thermal and radar imagery). Monochrome displays are found in cockpits and medical imaging instruments. For television receivers, these are simply called black-and-white TVs. Depending on the phosphor used, monochrome displays can provide nearly any color desired. Certain colors (e.g., orange) tend to reduce eye strain. Others (e.g., blue) tend not to disrupt scoptic vision adaption. Although computers have color monitors, word processing is often performed in a monochrome format.

Black-and-white scenes can be imaged on a color monitor by assigning a color palette (false color or pseudo color) to various intensity levels. This does not increase resolution but draws the observer's attention to selected features. The eye can easily differentiate color differences but may have trouble distinguishing small intensity differences.

7.2.2. COLOR DISPLAYS

A color monitor has three electron beams that scan the CRT faceplate. Near the faceplate is a metal mask that has a regular pattern of holes (Figure 7-3). With the dot arrangement, it is called as shadow mask. With slots, it is called an aperture grille. The three guns are focussed onto the same hole and the emerging beams strike the CRT faceplate at different locations. At each location there is a different phosphor. One fluoresces in the blue, one in the red, and one in the green region of the spectrum. The arrangement is such that the beam corresponding to the desired color will strike only the phosphor dot producing that color. The electron guns emit only electrons and have no color associated with them. Color is only created when the beam hits the phosphor even though the guns are called red, green, and blue guns.

Hexagonal structure masks (the dots) are inherently more rigid than slots. However, slots are easier to manufacture and therefore are usually found in television receivers. The slots have a larger area and therefore aperture-grille CRTs tend to be brighter than shadow-mask CRTs. With this brightness it is said that the colors are richer. The distance between dots is less and more difficult to perceive. Shadow-mask CRTs tend to provide sharper images. Because computer monitors are viewed at a close distance, the dots are used most often. The selection of slots over dots depends upon the application.

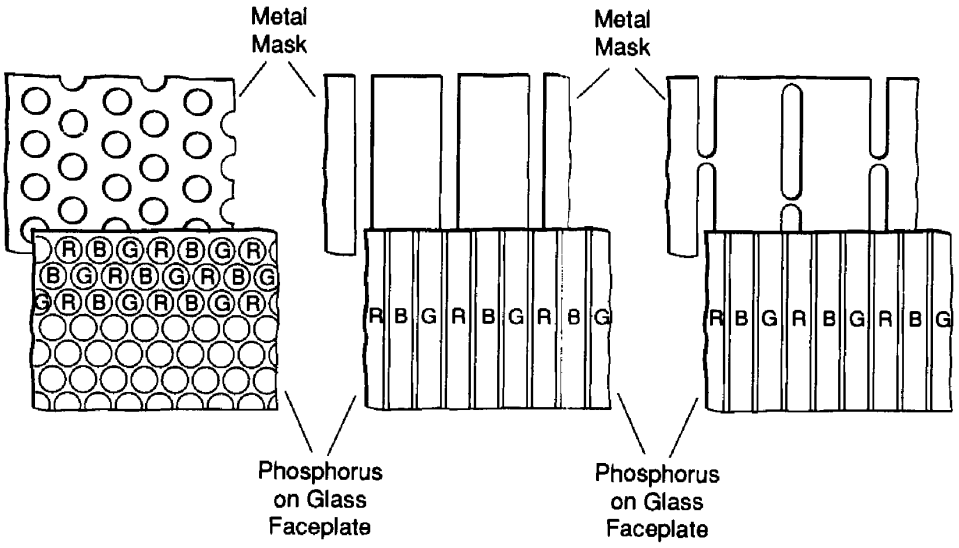


Figure 7-3. Color CRT mask patterns. (a) Dotted, (b) stripes, and (c) slotted. Most consumer television receivers use slots whereas computer displays use dots. The mask design varies with manufacturer.

Dots and stripes cannot be easily compared because the distance between adjacent spots is different and depends upon orientation and the way measured. Because there is $\sqrt{3}/2$ difference, a 0.24-mm aperture-grille pitch is roughly equal to a 0.28-mm shadow mask.

Figure 7-4 illustrates one possible arrangement of color dots. The dot pitch is the center-to-center spacing between adjacent like-colored dots. The three dots create a triad. Because each electron beam passes through the same hole, the mask pitch is the same as the triad pitch. Table 7-3 relates the triad dot pitch to the more common definitions of CRT resolution.

Table 7-3
RESOLUTION OF COLOR DISPLAYS

RESOLUTION	TRIAD DOT PITCH
Ultra-high	< 0.27 mm
High	0.27 - 0.32 mm
Medium	0.32 - 0.48 mm
Low	> 0.48 mm

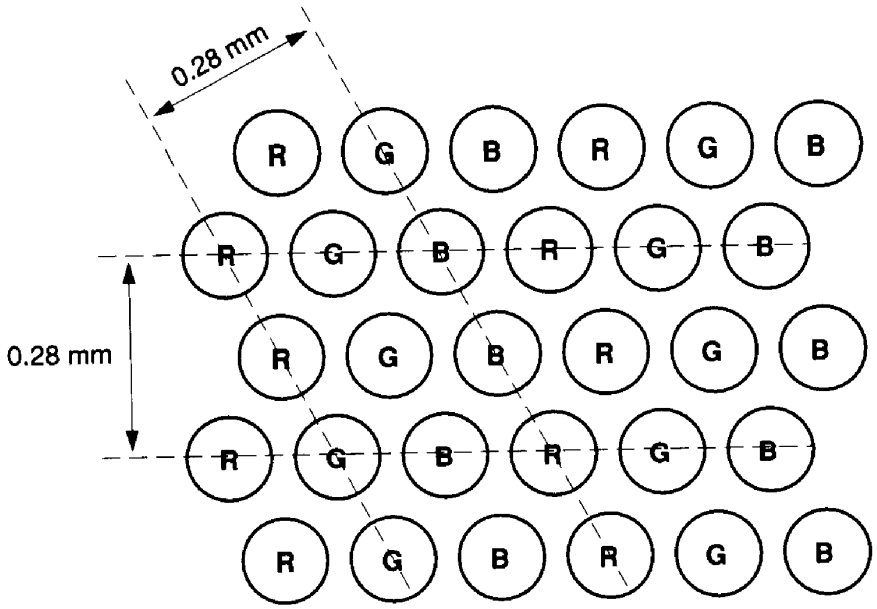


Figure 7-4. Arrangement of phosphor dots on a CRT. There is one shadow-mask hole for each triad. In 1997, most computer monitors had a triad pitch of 0.28 mm. The triad is outlined.

By varying the ratio of red, green, and blue, a variety of effective color temperatures can be achieved. The video signal is simply a voltage with no color temperature associated with it. The display electronics can be adjusted so that a white target appears as if illuminated by a source with color temperature range somewhere between 3200 K and 10,000 K. Most displays are preset to either 6500 K or 9300 K. As the color temperature increases, whites appear to change from a yellow tinge to a blue tinge. The perceived color depends on the adapting illumination (e.g., room lights). Setting the color temperature to 9300 K provides aesthetically pleasing imagery and this setting is unrelated to the actual scene colors (see Section 5.3.2., *Color Correction*, page 165).

Usually there is no relationship between the color temperature and contrast of a scene and what is seen on a display. This is not the fault of the camera and display manufacturers; they strive for compatibility. The observer, who usually has no knowledge of the original scene, will adjust the display for maximum visibility and aesthetics.

For consumer television and consumer computer graphics applications, adequate color imagery is obtained when each primary has 8 bits of intensity (256 shades of gray). The combination creates 24 bits or 16 million colors. Here, each intensity level of each primary is considered a color. It does not indicate that the eye can distinguish all 16 million - only that 16 million combinations are possible. Finer intensity increments may be used in commercial graphics displays. These systems may operate at 10 bits or 12 bits per primary color and provide 2^{30} or 2^{36} "colors," respectively.

7.2.3. HDTV

As the name implies, high definition television (HDTV) provides more resolution than conventional television receivers. The HDTV display has a 16:9 aspect ratio compared to the NTSC 4:3 aspect ratio. It is designed to be viewed at three times the picture height. While the horizontal visual angle subtended by NTSC systems is about 11 degrees, the HDTV subtends about 33 degrees. This larger format gives the feeling of telepresence - that you are there! The operation of a CRT-based HDTV is the same as any other CRT.

7.3. SPOT SIZE

Display spot size is a complex function of design parameters, phosphor choice, and operating conditions. It is reasonable to assume that the spot intensity profile is Gaussian distributed and is radially symmetric with radius r:

$$L(r) = Ae^{-\frac{1}{2}\left(\frac{r}{\sigma_{SPOT}}\right)^2} . \tag{7-3}$$

As illustrated in Figure 7-5, the spot diameter is defined as the full width at half-maximum (FWHM) and is:

$$S = FWHM = \sqrt{8\ln(2)}\,\sigma_{SPOT} = 2.35\,\sigma_{SPOT} . \tag{7-4}$$

Then

$$L(r) = Ae^{-4\ln(2)\left(\frac{r}{S}\right)^2} . \tag{7-5}$$

The advantage of assuming a Gaussian spot is that many resolution measures are easily compared and the display MTF is easily specified (discussed in Section 10.7., *CRT-based Displays*).

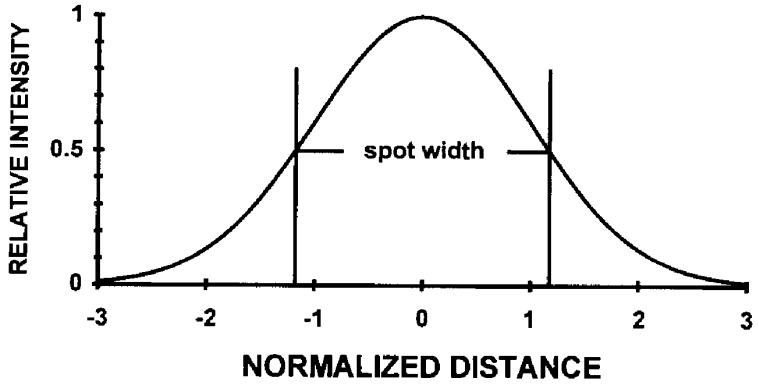


Figure 7-5. The spot diameter is the full width at one-half maximum intensity. The profile has been normalized to σ_{SPOT}.

While the shrinking raster method is listed as a resolution test method, its primary value is in determining the FWHM spot size. With the shrinking raster method, every line is activated (Figure 7-6). If the lines are far apart, the valleys between the lines are visible and the raster pattern is obvious. The lines are slowly brought together until a flat field is encountered. That is, the entire screen appears to have a uniform intensity. The resolution is the number of displayed lines divided by the picture height of the shrunk raster:

$$R_{FF} = \frac{X}{Y} \quad \frac{lines}{cm} \; . \tag{7-6}$$

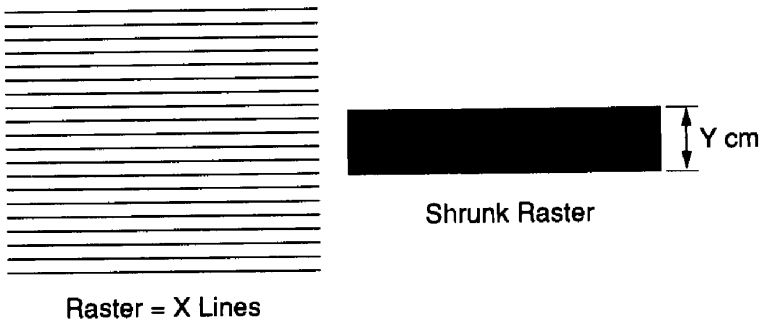


Figure 7-6. Shrinking raster resolution test method. The raster is shrunk until the discrete lines can no longer be discerned.

As the lines coalesce, the MTF drops. Under nominal viewing conditions, experienced observers can no longer perceive the raster when the luminance variation (ripple) is less than 5%. The line spacing has been standardized[9] to $2\sigma_{SPOT}$ (Figure 7-7). Given a shrunk raster resolution of R_{FF} lines/cm, the line spacing in the shrunk raster is $1/R_{FF}$ cm. Then $\sigma_{SPOT} = 1/2R_{FF}$ cm and the spot size is

$$S = FWHM = \frac{2.35}{2R_{FF}} . \qquad (7\text{-}7)$$

While a flat field condition is desirable, the line spacing may be larger. The shrinking raster methodology is applicable for CRTs only and cannot be used for flat panel displays because the "raster" is fixed in those displays.

Sometimes the spot profile tends to be flat-topped. A Gaussian approximation is adequate if the standard deviation, σ_{SPOT}, is calculated from the full width at the 5% intensity level[10]:

$$\sigma_{SPOT} = \frac{FW\,@\,5\%\ level}{\sqrt{8\ln(20)}} \approx \frac{FW\,@\,5\%\ level}{4.9} . \qquad (7\text{-}8)$$

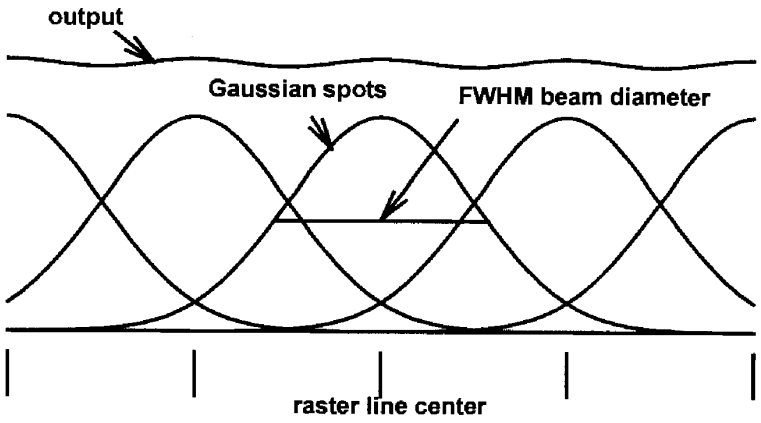


Figure 7-7. When the line spacing is $2\sigma_{SPOT}$, the spots appear to merge and this produces a flat field. The peak-to-peak ripple is 3% and the MTF associated with the residual raster pattern is 0.014. The output is the sum of all the discrete line intensities.

The beam cannot be truly Gaussian because the Gaussian distribution is continuous from $-\infty$ to $+\infty$. Amplifiers may reasonably reproduce the Gaussian beam profile within the $-3\sigma_{SPOT}$ to $+3\sigma_{SPOT}$ limits or a smaller portion. No simple relationship exists between electronic bandwidth and spot size. That is, monitor performance cannot be determined simply by the electronic bandwidth. The bandwidth number quoted depends on the manufacturer's philosophy on rise time issues. Monitors with the same electronic bandwidth may have different resolutions.

7.4. DISELS

Monitor disels are not related to the camera disels. Each is generated by the respective designs. Cameras with a standard video output may not have the resolution suggested by the video standard. For example, a camera containing an array of 320 × 240 pixels may have its output formatted into EIA 170 timing. This standard suggests that it can support approximately 437 × 485 pixels (see Table 5-2, page 153). The signal may be digitized by a frame grabber that creates 1000 × 485 datels. The displayed image still represents 320 × 240 pixels. See Section 5.2.2., *Broadcast/Non-broadcast Design* (page 155), for a discussion of pixels, datels, and disels.

A disel is the smallest imaginary area that can exist on a display (see Section 1.5., *Pixels, Datels, Disels, and Resels*, page 14). In the display literature, "pixel" is used. If necessary, the reader should mentally insert pixel wherever disel is written. The disel size indicates how many individual pieces of information the system can carry. It does not indicate the extent to which the detail will be resolved. The distance between adjoining disels is related to resolution. As the distance decreases, disels overlap and the resolution becomes poorer. This is further discussed in Section 7.6., *Addressability*.

The vertical disel size is defined by the raster pitch. It is simply the display height divided by the number of active scan lines. This is dictated by the video standard. With an optimum system, the electron beam diameter and video bandwidth are matched in the horizontal direction. For television receivers, the number of monitor disels is matched to the video standard. These values were given in Table 5-2, page 153.

The definition of a disel for color systems is more complicated. The representation shown in Figure 7-3 (page 208) implies that the electron beam passes through one hole only. Due to alignment difficulties between the mask and phosphor dots and because the phosphor may have imperfections, CRTs have electron beams that encompass several mask holes. The beam width at the 5% intensity level typically illuminates about 2.5 holes. Encompassing a non-integral number of holes minimizes aliasing and color moiré patterns.[11] The shadow mask samples the continuous electron beam to create a sampled output (Figure 7-8). The phasing effects created by the shadow mask are obvious.

Figure 7-9 illustrates the relationship between the shadow-mask pitch and the beam profile. Assume the shadow-mask pitch is 0.28 mm. If the 5% diameter covers 2.5 holes, then, using Equation 7-9, $\sigma_{SPOT} = (0.28)(2.5)/4.9 = 0.143$ mm. The spot size (Equation 7-4) is $S = (2.35)(0.143) = 0.336$ mm. In Figure 7-9, the spots are contiguous and each is considered a disel.

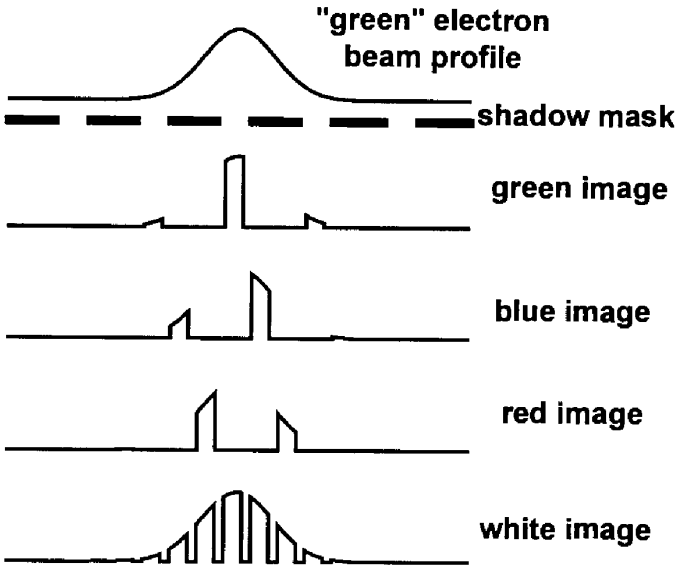


Figure 7-8. Representative image of a single spot on a color CRT. The "green" electron beam is shown, The red and blue beams (not shown) arrive at slightly different angles and provide different intensity profiles. The "sum" appears white when the dot size is less than the eye's resolution limit.

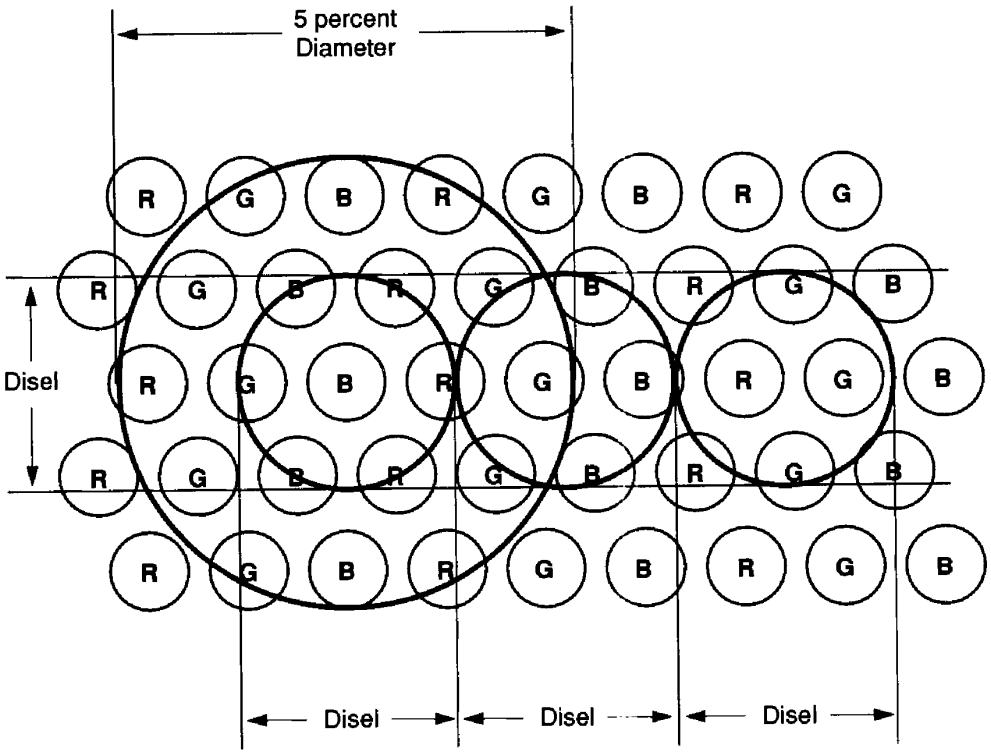


Figure 7-9. Five percent intensity level illuminating 2.5 shadow-mask holes. The spot size (FWHM) is equal to the disel size. If the shadow-mask pitch is X mm, then the beam 5% diameter is 2.5X mm, σ_{SPOT} = 0.51X mm, and the disel is 1.2X mm.

The disel format is the arrangement of disels into horizontal and vertical rows. Table 7-4 lists the common formats found in computer color monitors. The format represents the CRT controller's ability to place the electron beam in a particular location. The CRT is an analog device even though the format is listed as discrete values. These monitors are said to be digitally addressed. The disel format is (erroneously) called the resolution. The relationship between resolution and format is discussed in Section 7.6., *Addressability*.

Disel density is usually specified in units of dots per inch. Table 7-5 provides the approximate relationship between "resolution" and disel density. Confusion exists because dots also refer to the individual phosphor sites. In this context, a "dot" is a disel. The horizontal disel density is the number of horizontal disels (Table 7-4) divided by the horizontal display size.

Table 7-4
FORMAT OF COLOR DISPLAYS

TYPE	FORMAT
CGA (color graphics card adapter)	340 × 200 disels
EGA (extended graphics adapter)	640 × 350 and 640 × 400
VGA (video graphics array)	640 × 480
SVGA (super video graphics array)	800 × 600
XGA (extended graphics array) Typical of multi-sync displays	1024 × 768
High resolution	> 1024 × 1024

Table 7-5
TYPICAL DISEL DENSITY

"RESOLUTION"	DISEL DENSITY (dpi)
Ultra-high	> 120
High	71 - 120
Medium	50 - 70
Low	< 50

Figure 7-10 illustrates the "resolution" of three displays. For a fixed format, as the display size increases, the disel size also increases to yield a decreasing disel density. Plotted also is the human eye's resolution capability of 1 arc minute per line expressed at a viewing distance three times the display height. The 1280 × 960 display provides about the highest perceivable resolution. A higher disel density will be beyond the eye's resolution limit and therefore ineffective. While consumer receivers are viewed at 4.2 times the display height, computer monitors are viewed at a closer distance. Figure 7-10 illustrates that the observer is an integral component of perceived resolution. When monitors are designed, a nominal viewing distance is assumed.

The user is typically interested in performance and not in specific design specifications. For example, the dot pitch is typically superfluous information to the user. Disel size and the display modulation transfer function (discussed in Section 10.7., *CRT-based Displays*) are usually more important.

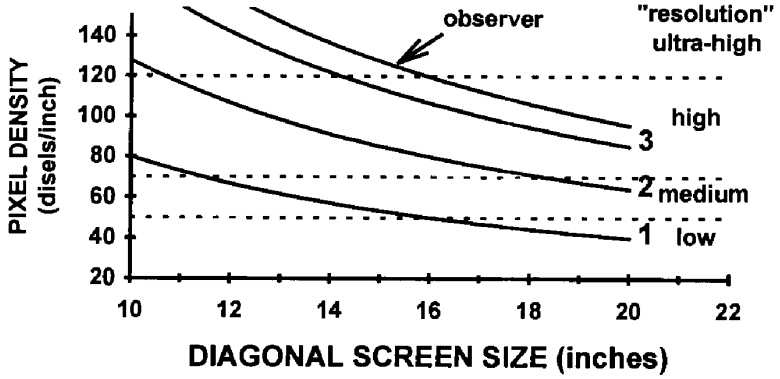


Figure 7-10. "Resolution" of three displays: (1) 640 × 480, (2) 1024 × 768, and (3) 1280 × 960. The observer's resolution is plotted for a viewing ratio of three. The 1280 × 960 display is near the observer's ability to see the disels.

7.5. RESOLUTION

Resolution suggests something about the highest spatial frequency that can be seen. As an electron beam moves across the screen, its intensity can be modulated. The maximum rate at which the beam can be modulated from full off to full on defines the maximum number of (monitor) disels that can be written in a row. The beam moves down vertically to the next line and again travels left to right. The distance the beam moves down is the vertical extent of a disel. While this can be any distance, it is usually selected so that the individual raster lines cannot be seen. Resolution and addressability specify monitor performance. They are combined into the resolution/addressability ratio (RAR). The RAR provides guidance to monitor design.

Resolution metrics are intertwined with television standards such that they are often presented together. Nearly all televisions are built to the same basic design so that by specifying EIA 170 or NTSC, the television receiver bandwidth and spot size is implied. In this sense, a video standard has a "resolution."

Resolution is independent of display size. Displays can be built to any size and the viewing distance affects the *perceived* resolution. For example, if a screen is designed for viewing at 45 inches, then it may have a 10-inch diagonal (see Figure 7-1, page 204). If viewing will be at 90 inches, the entire display can simply be made larger (20-inch diagonal). The larger display has larger raster lines. But the video electronic bandwidth is the same and the resolution remains constant. When viewed at 45 inches, the larger display will appear to have poorer image quality. During design, the selected display size is based upon an assumed viewing distance.

7.5.1. VERTICAL RESOLUTION

The vertical resolution is limited by the number of raster lines. For example, NTSC compatible monitors display 485 lines. However, to see precisely this number, the test pattern must be perfectly aligned with the raster pattern. Because the test pattern may be randomly placed, the pattern at Nyquist frequency can have a zero output if 180° out-of-phase (discussed in Section 8.3.3., *Image Distortion*). To account for random phases, the Kell factor[12] is applied to the vertical resolution to provide an average value. A value of 0.7 is widely used:

$$R_{VERTICAL} = (active\,scan\,lines)\,(Kell\,factor)\ . \qquad (7\text{-}9)$$

Timing considerations force the vertical resolution to be proportional to the number of vertical lines in the video signal. Therefore, NTSC displays have an average vertical resolution of (0.7)(485) = 340 lines. PAL and SECAM displays offer an average of (0.7)(575) = 402 lines of resolution.

7.5.2. THEORETICAL HORIZONTAL RESOLUTION

While the number of horizontal disels was given in Table 5-2, page 153 (see also Section 5.2.2., *Broadcast/Non-broadcast Design*, page 155), the theoretical horizontal resolution is usually normalized to the picture height. If the video electronics has a bandwidth of f_{VIDEO}, then the theoretical number is

$$R_{TVL} = \frac{(2f_{VIDEO})(active\,line\,time)}{aspect\,ratio}\ \frac{TVL}{PH}\ . \qquad (7\text{-}10)$$

The units are television lines/picture height or TVL/PH. Unfortunately, careless usage results in using only "lines." Note that there are two TV lines per cycle. While the video bandwidth can be any value, for consumer applications, it is matched to the video standard. For NTSC television receivers, the nominal horizontal resolution is (2)(4.2 MHz)(52.45 μs)/(4/3) = 330 TVL/PH. PAL and SECAM values are approximately 426 and 465 TVL/PH, respectively. These values change slightly depending on the active line time and bandwidth selected.

Displays designed for scientific applications often operate with standard video format but have a much wider video bandwidth. These monitors can display more horizontal TV lines per picture height (TVL/PH) than that suggested by, say, the NTSC video transmission bandwidth. The horizontal bandwidth can be any value and therefore the theoretical horizontal resolution can be any value.

7.5.3. TV LIMITING RESOLUTION

Whereas the flat field condition exists when two adjacent lines cannot be resolved, the TV limiting resolution is a measure of when alternate vertical bars are just visible (on-off-on-off). The standard resolution test target is a wedge pattern with spatial frequency increasing toward the apex of the wedge. It is equivalent to a variable square wave pattern.

The measurement is a perceptual one and the results vary across the observer population. The industry selected[9] the limiting resolution as a bar spacing of $1.18\sigma_{SPOT}$. This result is consistent with the flat field condition. The flat field condition was determined for two Gaussian beams whereas square waves are used for the TV limiting resolution test. Suppose the Gaussian beams in Figure 7-7 (page 213) were separated by an imaginary "black" beam. Then the beams would be separated by just σ_{SPOT} but the intensity distribution would be identical to Figure 7-7. The black beam does not contribute to the visible image. For TV limiting resolution, the "on" lines are separated by (2)(1.18 σ_{SPOT}). Because bar targets are used, the resultant image is not a precise Gaussian beam and a larger line separation is required ($1.18\sigma_{SPOT}$ versus σ_{SPOT}) for the TV limiting resolution.

The flat field condition and high TV limiting resolution are conflicting requirements. For high TV limiting (horizontal) resolution, σ_{SPOT} must be small. But raster pattern visibility (more precisely, invisibility) suggests that σ_{SPOT} should be large. This is further discussed in Section 7.6., *Addressability*.

Example 7-1
SPOT SIZE versus TV LIMITING RESOLUTION

Consider a 14-inch diagonal monitor used to display an image encoded in the EIA 170 format. Assume the raster line spacing is $2\sigma_{SPOT}$. What is the horizontal resolution?

The vertical extent of the 4:3 aspect ratio monitor is 8.4". With 485 lines, each line is separated by 0.0173". The value σ_{SPOT} is 0.0173/2 = 0.00865" and the spot size (FWHM) is 0.0204".

EIA 170 contains approximately 440 elements in the horizontal direction. The display width is 11.2 inches and each element width is 11.2/440 = 0.0254". But TV limiting resolution suggests that a bar width of (1.18)(0.0865) = 0.102" can be perceived. Because the element width due to the video bandwidth is narrower than the TV limiting resolution, resolution is limited by the spot size. That is, resolution is not limited by the EIA 170 bandwidth.

7.5.4. MTF

TV limiting resolution occurs when the bar spacing is $1.18\sigma_{SPOT}$. Because a cycle consists of two TV lines, the square wave fundamental frequency is $1/(2.35\sigma_{SPOT})$ and the MTF is 0.028. Conversely, the display resolution is selected as that spatial frequency that provides an MTF of 0.028. The MTF equation is found in Section 10.6., *CRT-based Displays*. Any spatial frequency could be used to specify resolution and the slightly different values are cited in the literature. For commercial applications, the resolution is often specified by the spatial frequency where the MTF is 10%.

But square waves are the most popular test patterns. A specification could be: The CTF must be greater than 10% when viewing 320 line pairs. This is equivalent to 640 disels in an on-off-on-off configuration). Note that by using square wave targets, the system response is the contrast transfer function and not the MTF (discussed in Section 9.5., *Contrast Transfer Function*). Careless usage results in calling the system response to square waves, the MTF. This makes it extremely difficult to compare specifications or to calculate performance from published specifications.

When designing a simulation system, the distance to the display and display size are selected first. These are based on physical constraints of the overall system design. The simulation industry generally accepts resolution as that spatial frequency (line pair) which provides a CTF of 10% at this viewing ratio. Because the number of lines depends on what is seen visually, the simulation industry uses units of optical line pairs (OLP). This translates into arc-minutes per line pair.

7.6. ADDRESSABILITY

Addressability is a characteristic of the display controller and represents the ability to select and activate a unique area on the screen. It defines how precisely an electron beam can be positioned on the CRT screen. Addressability is given as the number of discrete lines per picture height or disels per unit length. With this definition, the inverse of addressability is the center-to-center spacing between adjacent disels. Addressability is the image format discussed in Section 7.4., *Disels* (page 213), and provided in Table 7-4 (page 217).

Addressability and resolution are independent of each other. If the resolution is low, successive lines will overwrite preceding lines. If addressability is low, adjacent raster lines will not merge and they will appear as stripes. This was illustrated in Figure 7-7 (page 213) where the line spacing is inverse of the addressability and resolution is the inverse of σ_{SPOT}. Figure 7-7 illustrates good addressability (because lines can be placed close together) but poor resolution (because lines cannot detected when the modulation is low).

There are two opposing design requirements. The first design requirement is that the raster pattern be imperceptible to the observer. This is called the adjacent disel requirement. If the display meets this requirement, the picture will appear uniform and solid. It provides the flat field condition. Alphanumeric characters will appear well constructed and highly legible. The second design requirement is the alternating disel requirement. Here, individual lines (one disel on and one disel off) should be highly visible.

Increased addressability favors the adjacent disel requirement. Placing large spots close together will eliminate the visibility of the raster. But this also reduces the visibility of alternating disels. Similarly an increase in resolution favors the alternating requirement but may make the raster pattern visible.

The resolution/addressability ratio[13] (RAR) is the ratio of FWHM spot size to disel spacing, P:

$$RAR = \frac{S}{P} = \frac{2.36\,\sigma_{SPOT}}{P}, \qquad (7\text{-}11)$$

where P is the disel pitch. For example, if a display is 27.5 cm high and it displays (addresses) 1024 lines, then P is 27.5 cm/1024 lines = 0.27 mm/line. Assuming a 0.28-mm-wide spot then RAR is 0.28/0.27 = 1.04.

As shown in Figure 7-7 (page 213), the summation of periodically spaced spots creates a modulated output. Modulation is defined as $(V_{MAX} - V_{MIN})/(V_{MAX} + V_{MIN})$ where V_{MAX} and V_{MIN} are the maximum and minimum values in the output. Figure 7-11 illustrates the adjacent disel (on-on-on-on) and alternating disel (on-off-on-off) modulation as a function of the RAR. A RAR of 1.0 is considered desirable. In Figure 7-7, the RAR is 1.18.

Before the RAR was defined, display design was based on the experimentally determined flat field condition. The flat condition occurs when $P = 2\sigma_{SPOT}$ or RAR = 1.18. Here, the adjacent disel modulation is near zero - the lines are not visible. The TV limiting resolution describes the alternating disel situation. Now, $P = 1.18\sigma_{SPOT}$, RAR = 2, and the alternating disel modulation is near zero (e.g., the lines are not discernible).

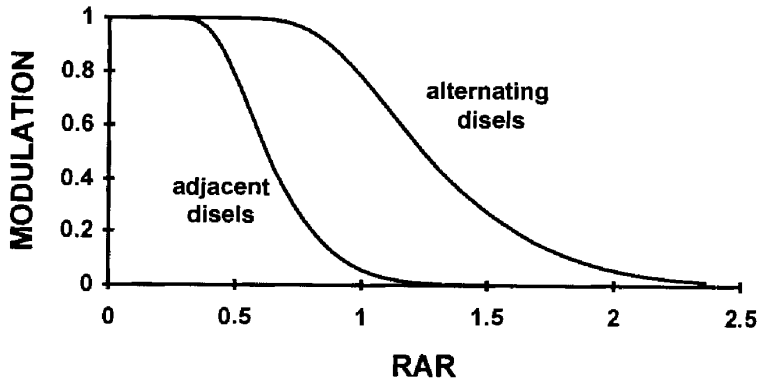


Figure 7-11. Modulation based on Gaussian beam profiles for the adjacent disel and alternating disels. A RAR of one is considered desirable. The modulation of the alternating disel is associated with the display's Nyquist frequency. The modulation of the adjacent disel is associated with the display's sampling frequency. These are imaginary frequencies because the CRT is an analog device. They represent the ability to place a spot at the desired location on the CRT faceplate.

Note that the modulation transfer function is traditionally defined for sinusoidal inputs. The residual ripple is not truly sinusoidal and therefore the modulation is not exactly what would be expected if the input was sinusoidal. That is, the modulation shown in Figure 7-11 is not a true MTF. The measured display response may provide different values than those shown in Figure 7-11.

The alternating disel modulation represents one Gaussian beam on and one off. This is different from one bar on and one bar off. Resolution tests are performed with square waves. For an analog system, the contrast transfer function is $4/\pi$ times greater than the MTF (discussed in Section 9.5., *Contrast Transfer Function*).

If the horizontal format supports 640 disels (see Table 7-4, page 217), then 320 cycles should be perceived. But the modulation is not specified at this resolution. For high quality monitors, the 320 cycles are easily visible (RAR < 1). With average monitors, the 320 cycles are visible but with reduced modulation (RAR $\approx$ 1). On a poorly designed monitor, the cycles will be barely perceived (RAR > 1).

While any disel format can be specified, the RAR determines if the disels are visible. For the configuration shown in Figure 7-9, (page 216), if the shadow mask pitch is 0.28 mm, then the disels will be separated by 0.336 mm when the RAR is one. If using a 13-inch diagonal display, the width is 264 mm and 786 horizontal disels are viewable when the RAR = 1. More disels can be displayed, but with reduced modulation (Table 7-6 and Figure 7-12). Thus the disel format, by itself, does not fully characterize the display capability. For optimized displays, it is reasonable to assume that the RAR is about one.

Table 7-6
ALTERNATING DISEL MODULATION
13-inch diagonal display and 0.28-mm shadow-mask pitch
5% intensity level illuminating 2.5 shadow-mask holes

DISELS	RAR	MODULATION
800	1.02	0.75
900	1.15	0.61
1000	1.27	0.47
1100	1.40	0.35
1200	1.53	0.25

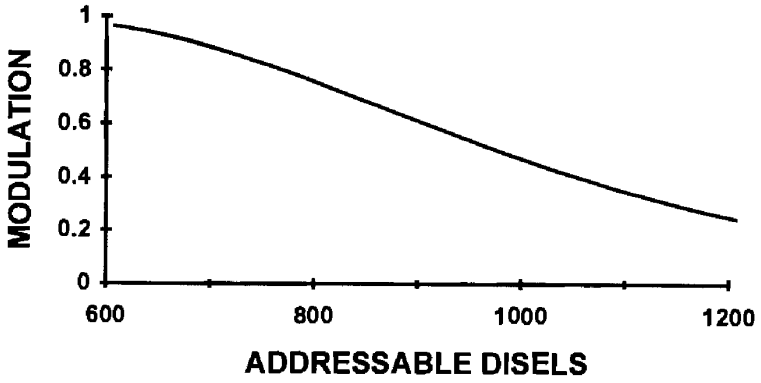


Figure 7-12. 13-inch diagonal display alternating disel (Gaussian beam) modulation. The shadow-mask pitch is 0.28 mm. The 5% intensity level illuminates 2.5 shadow-mask holes.

ANSI/HFS 100-1988 requires that the adjacent disel modulation be less than 20%. This deviates significantly from the flat field condition (adjacent disel modulation is 0.014). ISO 9241 recommends that the alternating disel modulation be greater than 0.4 for monochrome and greater than 0.7 for color systems. For monochrome systems, the RAR will vary from 0.8 to 1.31. For color systems the RAR varies from 0.8 to 1.04. These standards were developed to assure legibility of alphanumeric characters.

If the RAR is too high, then the output of two adjacent "on" lines is much greater then the output of two separated lines due to the summing effect (Figure 7-13). For the flat field condition (Figure 7-7, page 213), the RAR is 1.18 and the summed lines are 27% brighter than an individual line. If the RAR is very large, the intensity of several adjacent lines "on" can be significantly brighter than a single line "on". Thus, there is also a tradeoff in intensity with RAR.

Multi-sync monitors automatically adjust the internal line rate to the video line rate. These monitors can display any format from 525 lines up to 1225 lines. Because the displayed image size remains constant, the vertical line spacing changes. At the 1225 line format, the raster lines are close together and form a uniform (flat) field. At the lower line rates, the individual raster lines are separated and may be perceived. Because the same video amplifiers are used for all line rates, the horizontal resolution is independent of the line rate.

That is, the RAR in the horizontal direction stays constant whereas the RAR in the vertical direction changes with the number of lines. If the vertical RAR is one at 1225 lines, then it must be 525/125 = 0.43 at 525 lines.

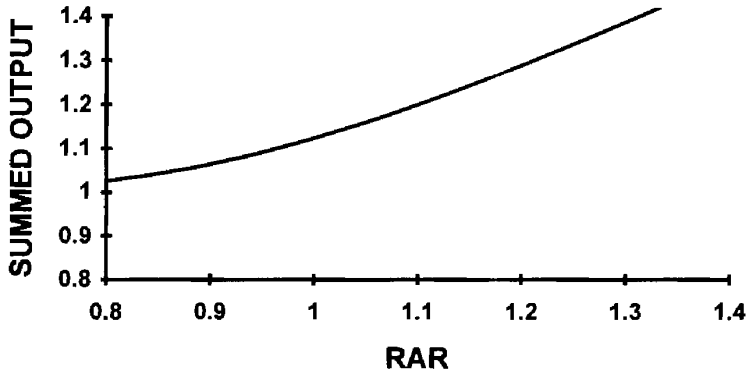


Figure 7-13. Summed output of contiguous lines "on". Ideally, the intensity should remain constant whether one or multiple lines are "on".

Example 7-2
DISPLAY RESOLUTION

A multi-sync monitor has a horizontal resolution of 800 TV lines per picture height. If the display diagonal is 14", what is the spot size? Are the raster lines visible?

For a 4:3 aspect ratio display, the CRT vertical extent is 284 mm. The estimated spot size is 284/800 = 0.355 mm and σ_{SPOT} is S/2.35 = 0.335/2.35 =0.15 mm. If the number of displayed lines is N_{LINE}, the RAR is

$$RAR = \frac{S N_{LINE}}{H_{MONITOR}} = \frac{0.355}{284} N_{LINE} = \frac{N_{LINE}}{800} . \qquad (7\text{-}12)$$

With 485 displayed lines (EIA 170), the RAR is 0.61. From Figure 7-11 the raster pattern (adjacent disels) is quite visible. For EIA 343A with 809 active lines, the RAR is at the desired value of one. At 946 active lines, the RAR increases to 1.18. Here the alternating disel modulation starts to drop and the vertical resolution starts to decrease.

7.7. SHADES OF GRAY

An often used, but widely misunderstood, concept is "shades of gray." While displays may be specified in shades of gray where each step is square root of 2, human vision cannot. The misunderstanding originated with the thought that the eye requires a $\sqrt{2}$ increment to just detect an increment in luminance. Studies of visual perception clearly indicate that just noticeable increments in luminance vary with background luminance level, size and shape of the target, the ambient luminance, and a variety of other variables. To use a single number to characterize the human eye is too simplistic. The $\sqrt{2}$ approach is merely another way to indicate display dynamic range. No other inference should be made about the definition.

7.8. CHARACTER RECOGNITION

Computer monitors are designed to for maximum legibility of alphanumeric characters and enhanced graphical capability. Readable characters can be formed in any block of disels from 5×7 to 9×16 and still be aesthetically pleasing. More complex symbols such as Japanese characters may require 16×16 disels.

The ability to see detail is related to the RAR. Figure 7-14 illustrates three letters and the resultant intensity traces. The RAR must be near one so that a reasonable contrast ratio exists between "on" and "off" disels. With reasonable contrast, the inner detail of the character is seen and the character is legible. Similarly, with a reasonable contrast ratio, adjacent letters will appear as separate letters. With characters, the alternating disel pattern is called one stroke separated by a space.

Figure 7-15 illustrates how reduced modulation affects character legibility. For easy interpretation, the system contains a shadow mask but only white and black can be seen. The image is magnified so that the individual phosphor dots can be seen. The sampled nature of the Gaussian electron beam is evident. As the beam width increases, the modulation decreases and the RAR increases. The characters become blurry as the RAR increases.

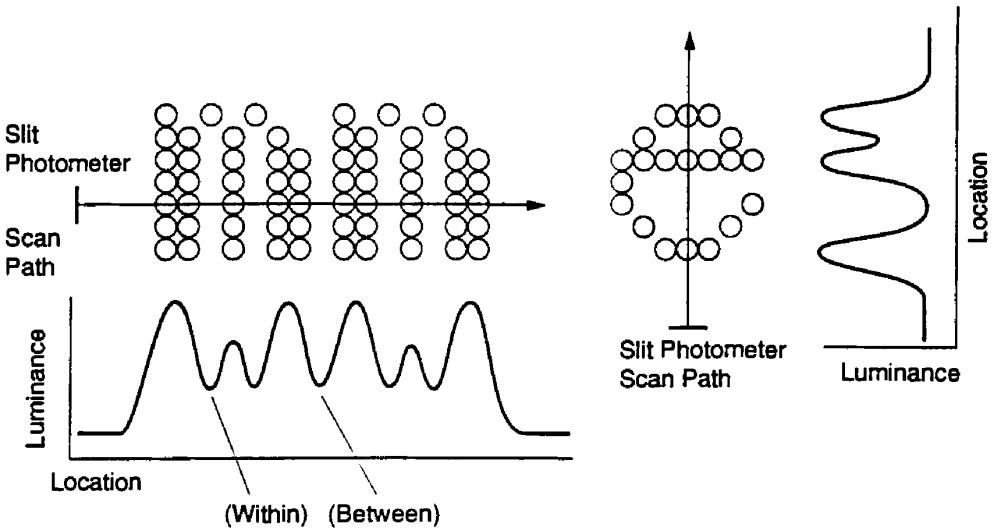


Figure 7-14. The RAR must be near one so that the inner details of characters are visible and the double width appears solid. Similarly with RAR near one, two adjacent characters appear separate. Each dot represents a disel. Lower RARs will make the characters appear very sharp. However, the raster pattern will become visible and the characters will not appear solid.

7.9. CONTRAST

Selection of one minute of arc as a measure of human visual acuity provided back-of-the-envelope calculations for selecting disel size, display size, and viewing distance. However, the eye's response varies according to the displayed contrast.

The air-glass interface and the phosphor reflect ambient light. This reduces contrast between disels and reduces the display's color gamut. As a result, most displays are measured in a darkened room where the reflected light is less than 1% of the projected light. Typically the contrast is measured with a checkerboard pattern consisting of 16 alternating rectangles. The average value of the eight white rectangles and the average value of the eight black rectangles are used to calculate the contrast ratio.

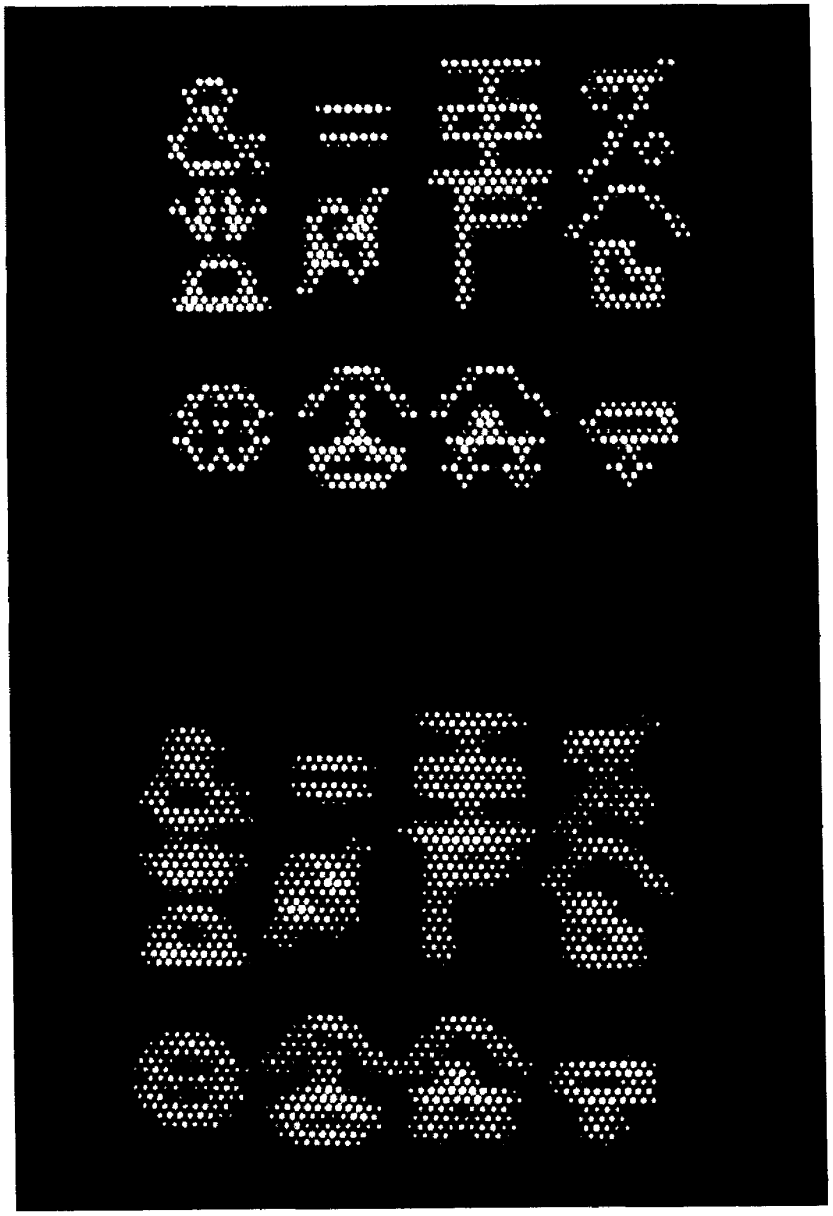


Figure 7-15. Complex symbols are more legible when the display modulation is high. Each dot represents a hole in the shadow mask. Top: modulation = 0.5 at the Nyquist frequency. Bottom: modulation = 0.1 at the Nyquist frequency. When viewed at 10 feet, the individual dots are no longer perceptible. At this distance, the top characters appear sharp (RAR $\approx$ 1.25) and the bottom ones appear fuzzy (RAR $\approx$ 1.8). By courtesy of the Mitre Corporation.

The perceived contrast ratio is

$$Contrast\ ratio = \frac{L_{WHITE} + L_{AMBIENT} \cdot reflectivity}{L_{BLACK} + L_{AMBIENT} \cdot reflectivity}, \qquad (7\text{-}13)$$

where L_{WHITE} and L_{BLACK} represent the luminances from the white and black rectangles, respectively. The reflections are the same regardless if a disel is on or off. About 4 percent of the ambient light ($L_{AMBIENT}$) is reflected at the air-glass interface. The CRT phosphor is an excellent Lambertian reflector with a typical reflectivity of 70%. "Black" displays minimize these reflections and thereby increase the perceived contrast.

Unfortunately, specifications that are based on no ambient lighting can only be achieved in a totally darkened room. Safety considerations require some lighting in all rooms so that the specification can never be achieved in practice.

The contrast ratio for typical displays is about 20:1 under normal ambient lighting conditions. This decreases as the ambient light increases. The eye operates in the reverse way. As the ambient lighting increases, more contrast is necessary to see target-background differences. Thus, as the displayed contrast decreases in bright light, the eye requires more contrast. This explains why television imagery is so difficult to see in sunlight and why it appears so bright in a darkened room.

7.10. REFERENCES

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8

SAMPLING THEORY

Sampling is an inherent feature of all electronic imaging systems. The scene is spatially sampled in both directions due to the discrete locations of the detector elements. This sampling creates ambiguity in target edges and produces moiré patterns when viewing periodic targets. Aliasing becomes obvious when (a) the image size approaches the detector size and (b) the detectors are in a periodic lattice (the normal situation). Spatial aliasing is rarely seen in photographs or motion pictures because the grains are randomly dispersed in the photographic emulsion.

If the detector size and spacings are different in the horizontal and vertical directions, sampling effects will be different in the two directions. This leads to moiré patterns that are a function of the target orientation with respect to the array axis. Although sampling is two-dimensional, for simplicity sampling effects will be presented in one-dimension.

The highest frequency that can be faithfully reconstructed is one-half the sampling rate. Any input signal above the Nyquist frequency, f_N (which is defined as one-half the sampling frequency, f_S), will be aliased down to a lower frequency. That is, an undersampled signal will appear as a lower frequency after reconstruction (Figure 8-1).

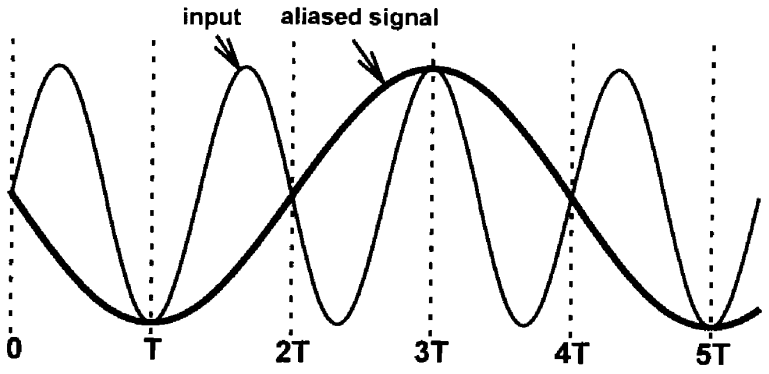


Figure 8-1. An undersampled sinusoid will appear as a lower frequency after reconstruction. The sampling frequency is $f_S = 1/T$. When T is the measured in mrad, mm, or time, the sampling frequency is expressed in cycles/mrad, cycles/mm, or Hz, respectively.

After aliasing, the original signal can never be recovered. It would appear that aliasing is an extremely serious problem. However, the extent of the problem depends upon the final interpreter of the data.

Signals can be undersampled or oversampled. Undersampling is a term used to denote that the input frequency is greater than the Nyquist frequency. It does not imply that the sampling rate is inadequate for any specific application. Similarly, oversampling does not imply that there is excessive sampling. It simply means that there are more samples available than that required by the Nyquist criterion.

After aliasing, the original signal can never be recovered. Undersampling creates moiré patterns (Figure 8-2). Diagonal lines appear to have jagged edges or "jaggies." Periodic structures are rare in nature and aliasing is seldom reported when viewing natural scenery although aliasing is always present. It may become apparent when viewing periodic targets such as test patterns, picket fences, plowed fields, railroad tracks, and Venetian blinds. Distortion effects can only be analyzed on a case-by-case basis. Because the aliasing occurs at the detector, the signal must be band-limited by the optical system to prevent it.

We have become accustomed to the aliasing in commercial televisions. Periodic horizontal lines are distorted due to the raster. Cloth patterns such as herringbones and stripes produce moiré patterns. Cross-color effects occur in color imagery. Many video tape recordings are undersampled to keep the price modest and yet the imagery is considered acceptable when observed at normal viewing distances.

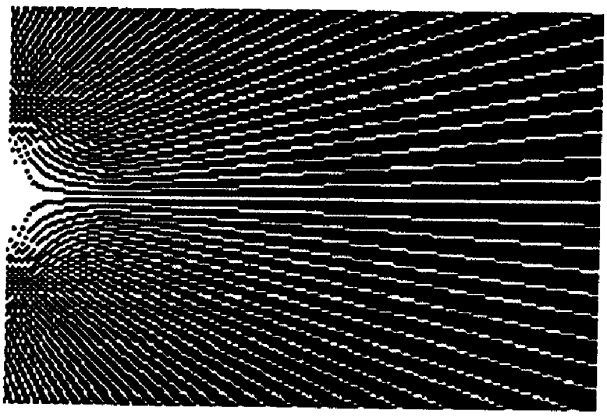


Figure 8-2. A raster scan system creates moiré patterns when viewing wedges or star bursts.

Aliasing is reduced to an acceptable level in consumer color sensors. For specific applications such as medical imaging, it may be considered unacceptable. In medical imagery, an aliased signal may be misinterpreted as a medical abnormality that requires medication, hospitalization, or surgery.

While aliasing is never considered desirable, it is accepted in scientific and military monochrome applications where the MTF must be maintained. High MTF is related to image sharpness. Aliasing becomes bothersome when the scene geometric properties must be maintained as with mapping. It affects the performance of most image processing algorithms.

Sampling theory states that the *frequency* can be unambiguously recovered for all input frequencies below Nyquist frequency. It was developed for band-limited electrical circuits. The extension to imaging systems is straightforward. However, the eye is primarily sensitive to intensity variations.

Sampling theory is traditionally presented from a modulation transfer function viewpoint. MTF theory is presented in Chapter 9 and the subsystem MTFs are discussed in Chapter 10. Linear system theory is used for system analysis because of the wealth of mathematical tools available. Approximations are used to account for sampling effects. While these approximations are adequate to describe the MTFs, they do not indicate how imagery may be distorted.

Sampled data systems are nonlinear and do not have unique MTFs.[1-6] The "MTF" depends on the phase relationships of the scene with the sampling lattice. Superposition does not hold and any MTF derived for the sampler cannot, in principle, be used to predict results for general scenery. To account for the nonlinear sampling process, a sample-scene MTF is added (discussed in Section 10.10., *Sampling Effects*). As the sampling rate increases, the MTF becomes better defined. As the sampling rate approaches infinity, the system becomes an analog system and the MTF is well defined. Equivalently, as the detector size and detector pitch decrease, signal fidelity increases. Reference 7 provides an in-depth discussion on sampling effects. This chapter highlights those results.

The symbols used in this book are summarized in the *Symbol List* (page xviii) and it appears after the *Table of Contents*.

8.1. SAMPLING THEOREM

The sampling theorem, as introduced by Shannon,[8] was applied to information theory. He stated that if a time-varying function, v(t), contains no frequencies higher than f_{MAX} (Hz), it is completely determined by giving its ordinates at a series of points spaced $1/2f_{MAX}$ sec apart. The original function can be reconstructed by using an ideal low-pass filter. To just satisfy Shannon's theorem, the sampling frequency, f_S, must be $2f_{MAX}$. Shannon's work is an extension of others[9] and the sampling theorem is often called the Whittaker-Shannon theorem.

Three conditions must be met to satisfy the sampling theorem. The signal must be band-limited, the signal must be sampled at an adequate rate, and a low-pass reconstruction filter must be present. When any of these conditions are not present, the reconstructed analog data will not appear exactly as the originals.

In a sampled-data system, the sampling frequency interacts with the signal to create sum and difference frequencies. Any input frequency, f_o, will appear as $nf_S \pm f_o$ after sampling ($n = -\infty$ to $+\infty$). Figure 8-3 illustrates a band-limited system with frequency components replicated by the sampling process. The base band ($-f_H$ to f_H) is replicated at nf_S. To avoid distortion, the lowest possible sampling frequency is that value where the base band adjoins the first side band (Figure 8-3c). This leads to the sampling theorem that a band-limited system must be sampled at twice the highest frequency ($f_S \geq 2f_H$) to avoid distortion in the reconstructed image. The sampling theorem applies to any periodic input frequency. The units can be either spatial frequency or electrical frequency.

After digitization, the data reside in data arrays (e.g., computer memory location) with nonspecific units. The user assigns units to the arrays during image reconstruction. That is, the data are read out of the memory in a manner consistent with display requirements. Because monitors are analog devices, the data are transformed into an analog signal using a sample-and-hold circuit. This creates a "blocky" image and can be removed by a reconstruction filter (discussed in Section 10.6.4., *Post-Reconstruction Filter*). If the original signal was oversampled and if the post-reconstruction filter limits frequencies to f_N, then the reconstructed image can be identical to the original image.

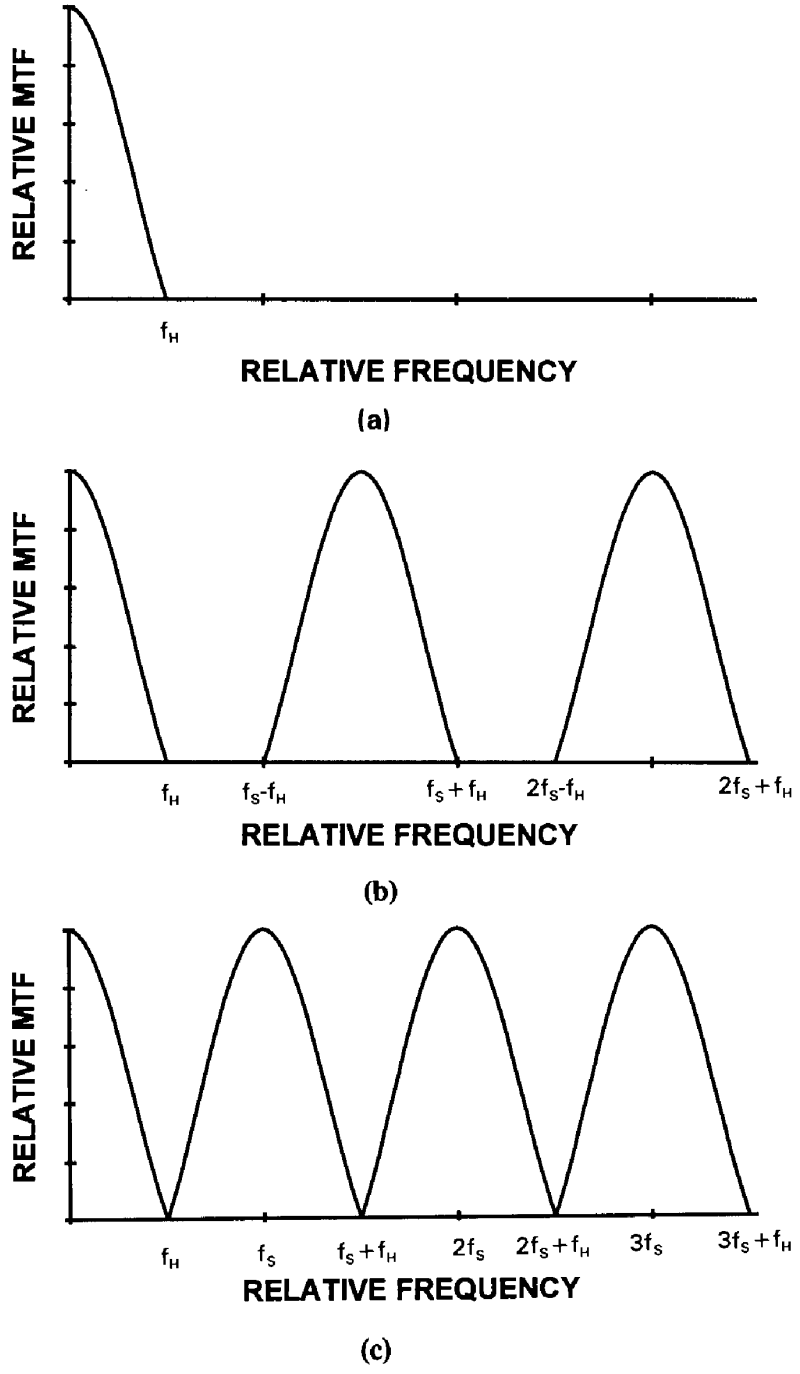


Figure 8-3. Sampling replicates frequencies at $nf_S \pm f$. (a) Original band-limited signal, (b) frequency spectrum after sampling, and (c) when $f_S = 2f_H$, the bands just adjoin.

8.2. ALIASING

As the sampling frequency decreases, the first side band starts to overlap the base band. It is the summation of these power spectra that create the distorted image (Figure 8-4). The overlaid region creates distortion in the reconstructed image. This is aliasing. Once aliasing has occurred, it cannot be removed. Within an overlapping band, there is an ambiguity in frequency. It is impossible to tell whether the reconstructed frequency resulted from an input frequency of f_o or $nf_S \pm f_o$.

All frequency components above f_N are folded back into the base band so that the base band contains

$$O_{BASE-BAND} = \sum_{n=-\infty}^{\infty} O(nf_S \pm f) \quad where\ nf_S \pm f \le f_N\ . \tag{8-1}$$

To avoid aliasing in the electronic domain, the signal may be passed though a low-pass filter (anti-aliasing filter). These filters cannot remove the aliasing that has taken place at the detector. They can only prevent further aliasing that might occur in the downstream analog-to-digital converter. Figure 8-5 illustrates the cutoff features of an ideal filter. The ideal filter passes all frequencies below f_N and attenuates all frequencies above f_N. The ideal filter is, of course, unrealizable.[10] It also can produce undesirable effects such as ringing.

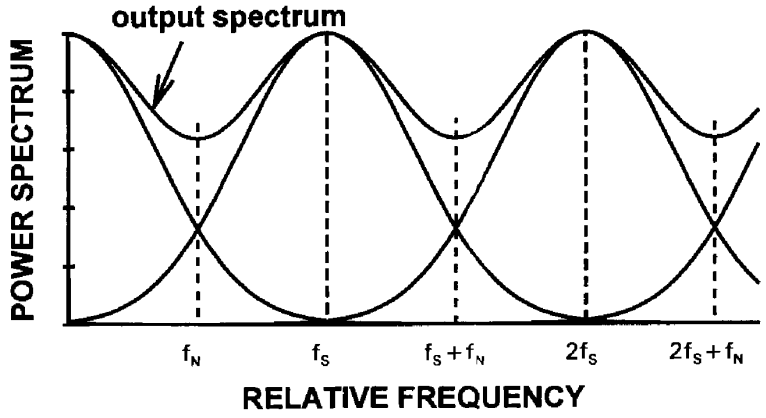


Figure 8-4. Aliasing alters both the signal and noise base band spectra. In a real system, the signal and noise are not necessarily band-limited and some aliasing occurs.

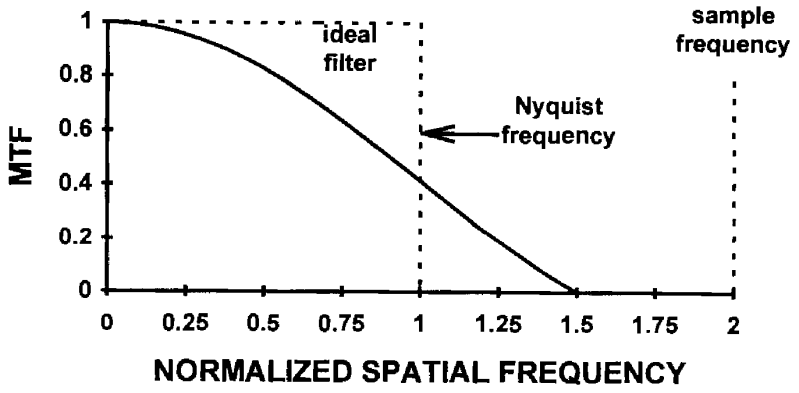


Figure 8-5. An undersampled system must be band-limited to avoid aliasing. The ideal anti-aliasing filter passes all the signals below f_N and no signal above f_N. Whether aliasing is considered undesirable depends on the application.

In solid state cameras, the sampling frequency is determined by the detector pitch. That is, the scene is optically sampled by the detectors. If the scene contains frequencies greater then the array Nyquist frequency, aliasing will occur. Optical band-limiting can be achieved by using small diameter optics, defocusing, blurring the image, or by inserting a birefringent crystal between the lens and array. The birefringent crystal changes the effective sampling rate and is found in almost all single chip color cameras (discussed in Section 10.3.4., *Optical Anti-Alias Filter*). Unfortunately, these approaches also degrade the MTF (reduce image sharpness) in the base band and typically are considered undesirable for scientific applications. For medical applications, where aliased imagery may be misinterpreted as an abnormality, reduced aliasing usually outweighs any MTF degradation.

According to the sampling theorem, any sampled frequency, f, where $f \leq f_N$, can be uniquely recovered. However, the square wave is the most popular test target and it is characterized by its fundamental frequency f_o. When expanded into a Fourier series, the square wave consists of an infinite number of frequencies (discussed in Section 9.5., *Contrast Transfer Function*). Although the square wave fundamental may be oversampled, the higher harmonics will not. The appearance of the square wave after reconstruction depends on the relative values of the optical, detector, and electronic MTFs.

Although no universal method exists for quantifying aliasing, it is reasonable to assume that it is proportional to the MTF that exists above f_N. In Figure 8-6 a significant MTF exists above the Nyquist frequency. Whether this aliasing is objectionable, depends on the camera application.

If a system is Nyquist frequency limited, then the Nyquist frequency is used as a measure of resolution. Because no frequency can exist above the Nyquist frequency, many researchers represent the MTF as zero above the Nyquist frequency (Figure 8-7). This representation may be too restrictive for modeling purposes.

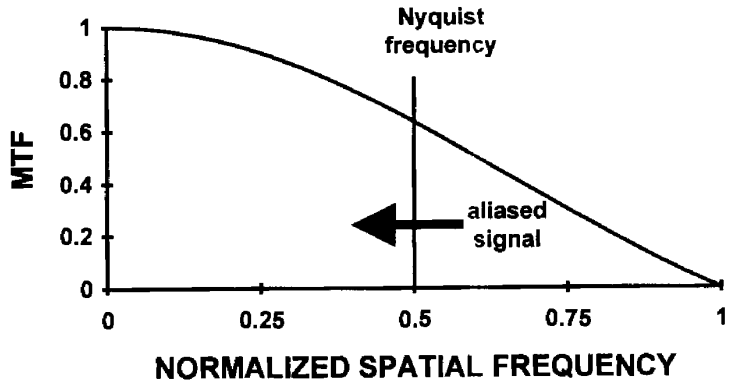


Figure 8-6. Signals above Nyquist frequency are aliased down to the base band. The area bounded by the MTF above f_N may be considered as an "aliasing" metric.[11]

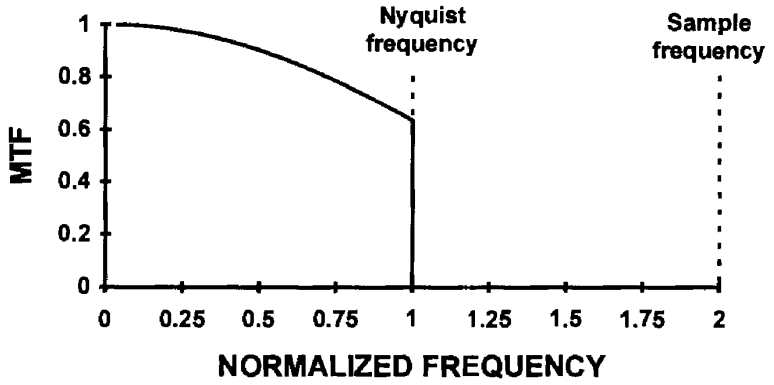


Figure 8-7. MTF representation of an undersampled system as a function of f/f_N. This restrictive representation erroneously suggests that there is no response above f_N.

8.3. The DETECTOR as a SAMPLER

Figure 8-1 (page 231) illustrated a signal sampled at discrete points. It typifies extremely small detectors and flash analog-to-digital converters. Detectors have a finite size and integrate the signal spatially. This spatial integration reduces the modulation and is the detector MTF.

Sections 8-1 and 8-2 described sampling in generic terms. The variable f was used to denote frequency. There are four different frequency domains that can exist with an electro-optical imaging system (discussed in Section 10.1., *Frequency Domains*). Imagery at the detector plane is described by image-space spatial frequency. The horizontal and vertical variables are represented by u_i and v_i, respectively. They have units of cycles/mm.

8.3.1. DETECTOR MTF

Figure 8-8 illustrates the spatial integration afforded by a staring array. In Figure 8-8a, the detector width is one-half of the center-to-center spacing (detector pitch). That is, only 50% of the input sinusoid is detected. The detector averages the signal over the range indicated and the heavy lines are the detector outputs. The output MTF is $(V_{MAX} - V_{MIN})/(V_{MAX} + V_{MIN})$ where V_{MAX} and V_{MIN} are the maximum and minimum voltages, respectively. As the detector size increases, it integrates over a larger region and the MTF decreases (compare Figure 8-8a with 8-8b). As the phase changes between the detector location and the peak of the sinusoid, the output voltages change. This creates a variable MTF caused by sampling.

The detector MTF cannot exist by itself. Rather, the detector MTF must also have the optical MTF to make a complete imaging system. In the horizontal direction, the MTF of a single rectangular detector is

$$MTF_{DETECTOR}(u_i) = \left| \frac{\sin(\pi d_H u_i)}{\pi d_H u_i} \right|, \qquad (8\text{-}2)$$

where d_H is the physical extent of the photosensitive surface.

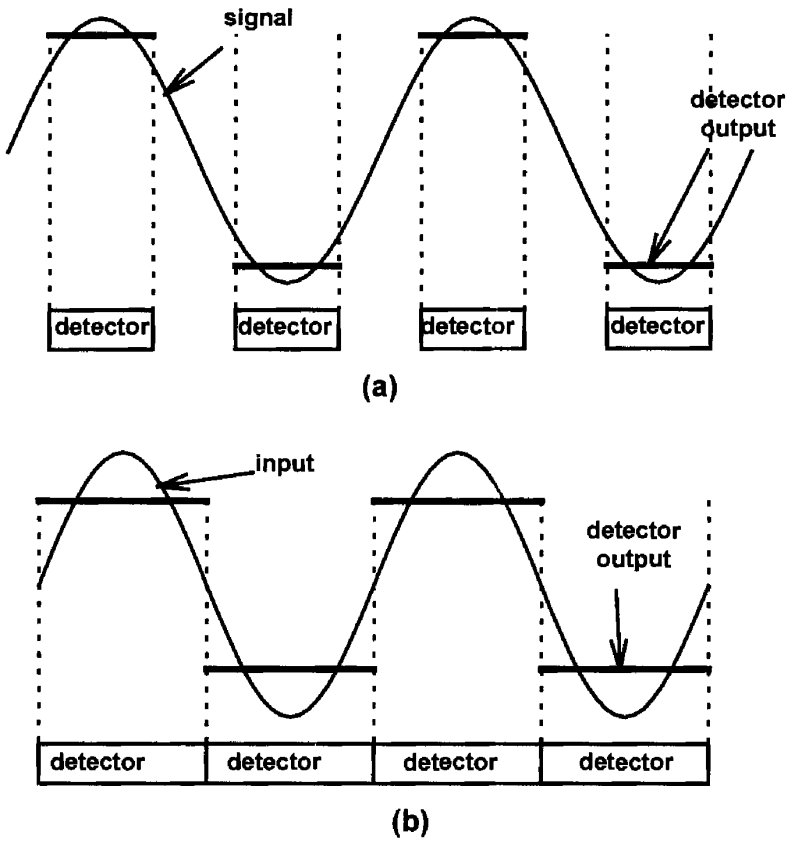


Figure 8-8. A detector spatially integrates the signal. Figure 8-1 (page 231) represents the output of extremely small detectors. (a) Detector width is one-half of the center-to-center spacing and (b) detector width is equal to the center-to-center spacing. (a) Typifies an interline transfer CCD array in the horizontal direction (see Figure 3-16, page 64) and (b) is representative of frame transfer arrays. The heavy lines are the detector output voltages. As the phase changes, the output also changes.

Figure 8-9 illustrates the detector MTF in one dimension. The MTF is equal to zero when $u_i = k/d_H$. The first zero ($k = 1$) is considered the detector cutoff, u_{iD}. Any input spatial frequency above detector cutoff will be aliased down to a lower frequency. It is customary to plot the MTF only up to the first zero (Figure 8-10). The optical system cutoff limits the absolute highest spatial frequency that can be faithfully imaged. The detector cutoff may be either higher (optics-limited system) or lower (detector-limited system). Most CCD-based imaging systems are detector-limited (discussed in Section 10.4., *Optics-Detector Subsystem*).

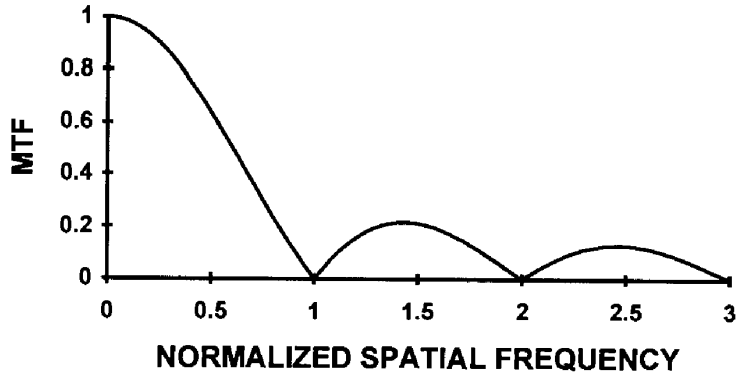


Figure 8-9. Detector MTF as a function of normalized spatial frequency u_i/u_{iD}. Detector cutoff is $u_{iD} = 1/d$.

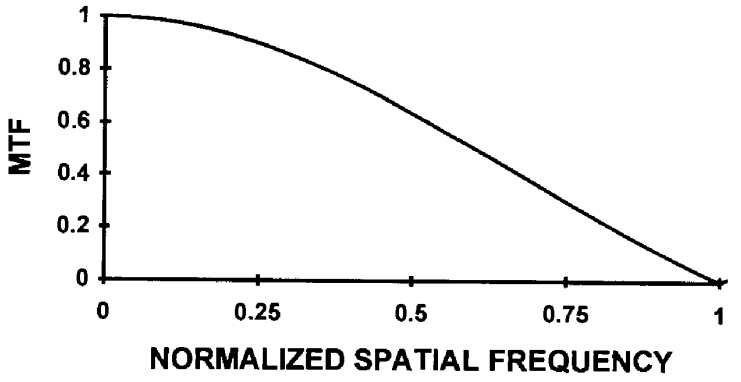


Figure 8-10. Typical detector MTF representation as a function of normalized spatial frequency u_i/u_{iD}. This representation erroneously suggests that the detector does not respond to frequencies greater than u_{iD}.

8.3.2. DETECTOR ARRAY NYQUIST FREQUENCY

A staring array acts a sampler whose sampling rate is $1/d_{CC}$ (cycles/mm) where d_{CC} is the detector center-to-center spacing (detector pitch). The pitch in the horizontal and vertical directions, d_{CCH} and d_{CCV}, respectively, may be different. Detector arrays are specified by the fill factor which is the detector area divided by the cell area. It is $d_H d_V / d_{CCH} d_{CCV}$. Staring arrays can faithfully reproduce horizontal signals up to $u_{iN} = 1/(2d_{CCH})$. Although the individual detectors can reproduce higher spatial frequencies, the horizontal scene spectrum is sampled at $u_{iS} = 1/d_{CCH}$ (Figure 8-11).

Microlenses increase the effective detector size but do not affect the Nyquist frequency. By increasing the detector area, the detector cutoff decreases. With microlenses, the array in Figure 8-11b can optically appear as the array in Figure 8-11a.

Staring arrays are inherently undersampled when compared to the detector spatial frequency cutoff. Any scene spatial frequency above u_{iN} or v_{iN} will appear as a lower spatial frequency in the reconstructed image. To avoid aliasing, the scene frequencies must be optically band-limited similar to that shown in Figure 8-5 (page 237).

Most single chip color filter arrays have an unequal number of red, green, and blue detectors. A typical array designed for NTSC operation will have 768 detectors in the horizontal direction with 384 detectors sensitive to green, 192 sensitive to red, and 192 sensitive to the blue region of the spectrum. Suppose the arrangement is G-B-G-R-G-B-G-R. The "green" detectors will have a center-to-center spacing as shown in Figure 8-11b.

The spacing of the "blue" and "red" detectors is twice the "green" detector spacing. This produces a "blue" and "red" array Nyquist frequency that is one-half of the "green" array Nyquist frequency (Figure 8-12). Other detector layouts will create different array Nyquist frequencies. The "color" Nyquist frequencies can be different in the horizontal and vertical directions. These unequal array Nyquist frequencies create color aliasing in single chip cameras that is wavelength specific. Black-and-white scenes can appear as green, red, or blue imagery.[12] A birefringent crystal, inserted between the lens and the array, changes the effective sampling rate and minimizes color aliasing (discussed in Section 10.3.4., *Optical Anti-Alias Filter*).

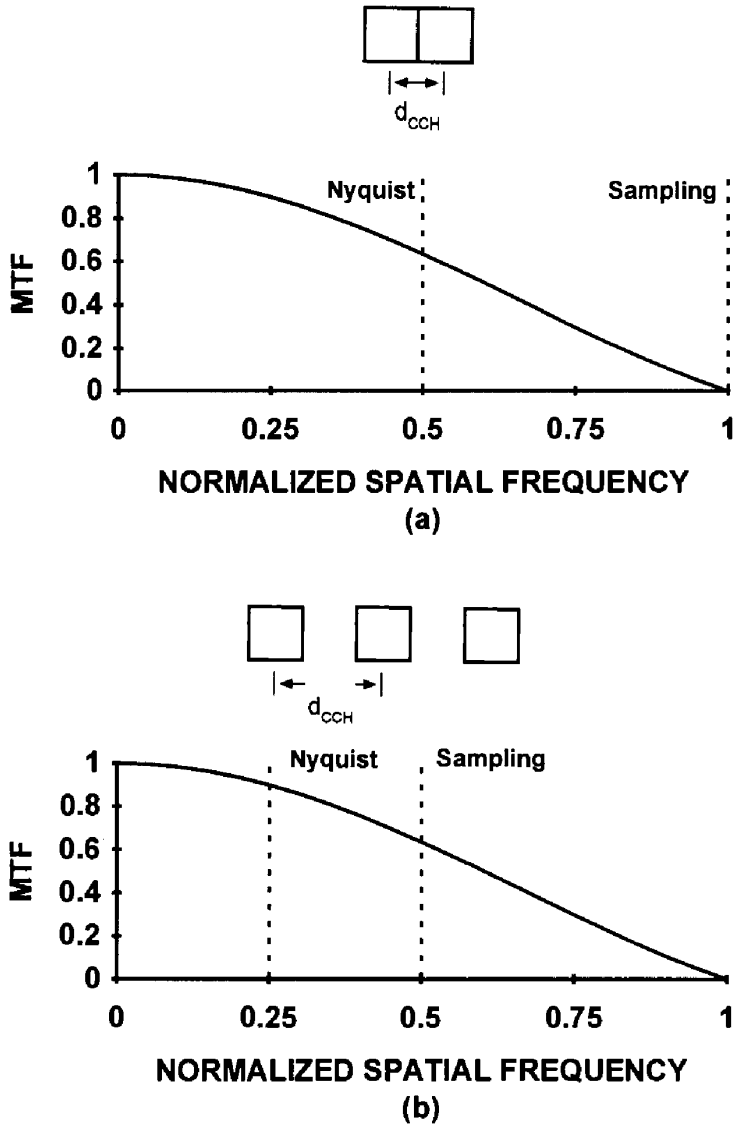


Figure 8-11. Two arrays with different horizontal center-to-center spacings. The detector size, d_H, is the same for both. (a) $d_H/d_{CCH} = 1$. This typifies frame transfer devices. (b) $d_H/d_{CCH} = 0.5$. This is representative of interline transfer CCD arrays. The detector MTF is plotted as a function of u_i/u_{iD}.

Aliasing in the vertical direction can be reduced by summing alternate detector outputs (field integration) in a two-field camera system (see Figure 3-19, page 67). Here, the effective detector height is $2d_V$ and the cutoff is $1/2d_V$ (Figure 8-13). This eliminates aliasing but also reduces the vertical MTF and, therefore, reduces image sharpness in the vertical direction. Horizontal sampling still produces aliasing.

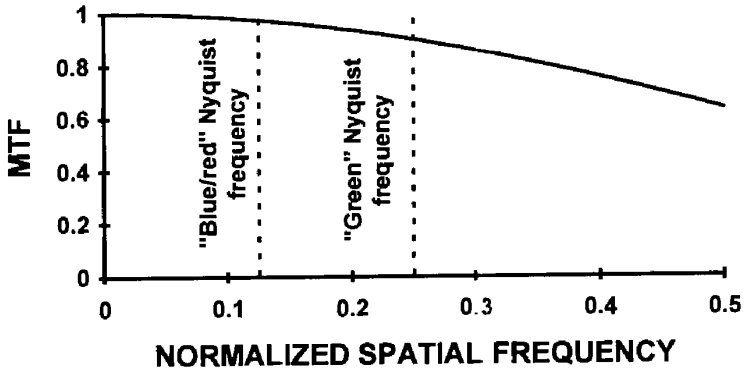


Figure 8-12. Horizontal detector MTF normalized to u_i/u_{iD}. Unequally spaced red, green, and blue sensitive detectors creates different array Nyquist frequencies. This creates different amounts of aliasing and black-and-white scenes may break into color. The spacing between the "red" and "blue" detectors is twice the "green" detector spacing.

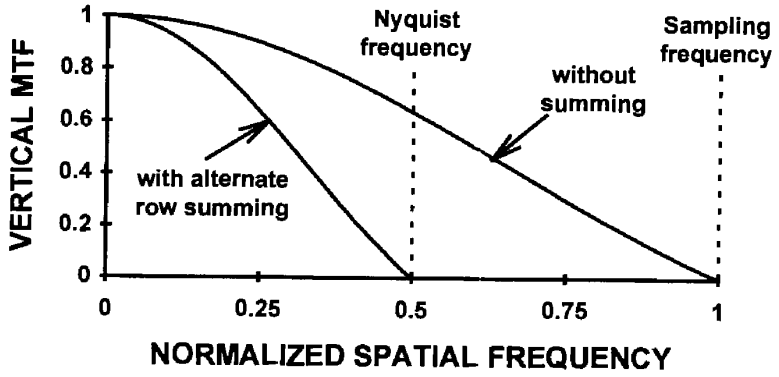


Figure 8-13. Alternate detector summing can reduce aliasing in the vertical direction. Vertical MTF with and without summing normalized to u_i/u_{iD}.

8.3.3. IMAGE DISTORTION

The square wave (bar pattern) is the most popular test target. It is characterized by its fundamental frequency only. The expansion of a square wave into a Fourier series clearly shows that it consists of an infinite number of sinusoidal frequencies. Although the square wave fundamental frequency may be oversampled, the higher harmonics may not. During digitization, the higher order frequencies will be aliased down to lower frequencies and the square wave will change its appearance. There will be intensity variations from bar-to-bar and the bar width will not remain constant.

Sampling replicates frequencies. When two frequencies are close together, they create a beat frequency that is equal to the difference. The fundamental and its replication create a beat frequency of $f_{BEAT} = (f_S - f_o) - f_o$. The beat frequency period lasts for N input frequency cycles:

$$N = \frac{f_o}{2(f_N - f_o)} . \tag{8-3}$$

Figure 8-14 illustrates N as a function of f_o/f_N. As f_o/f_N approaches one, the beat frequency becomes obvious. Lomheim et. al.[13] created these beat frequencies when viewing multiple bar patterns with a CCD camera.

An ideal reconstruction filter will eliminate the beat frequency. However, ideal filters do not exist. Real filters will reduce the MTF and soften edges. Here a square wave may appear as a sinusoid. Thus, there is a tradeoff between edge sharpness and aliasing.

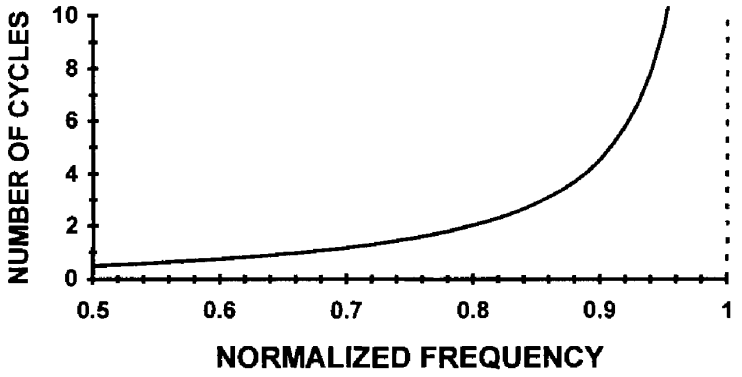


Figure 8-14. Number of input frequency cycles required to see one complete beat frequency cycle as a function of f_o/f_N.

Figures 8-15 through 8-18 illustrate an ideal staring array output when the optical MTF is unity for all spatial frequencies and therefore represents a worst case scenario. That is, all higher harmonics that would have been attenuated by the optical system are available for aliasing by the detector. For these figures, d_H/d_{CCH} is one. The individual detectors sample the square wave in the same manner as illustrated in Figure 8-8b (page 240). Section 10.4., *Optics-Detector Subsystem* describes how the optical MTF modifies the imagery.

If $u_o/u_{iN} = 0.952$, the beat frequency is equal to 9.9 cycles of the input frequency (Figure 8-15). Although a square wave consists of an infinite number of frequencies, it is characterized by its fundamental, u_o. The target must contain at least 10 cycles to see the entire beat pattern. A 4-bar pattern may either be replicated or nearly disappear depending on the phase.

Standard characterization targets, however, consist of several bars. Therefore the beat pattern may not be seen when viewing a 3-bar or 4-bar target. The image of the bar pattern would have to be moved $\pm$½ d (detector extent) to change the output from a maximum value (in-phase) to a minimum value (out-of-phase). This can be proven by selecting just four adjoining bars in Figure 8-15.

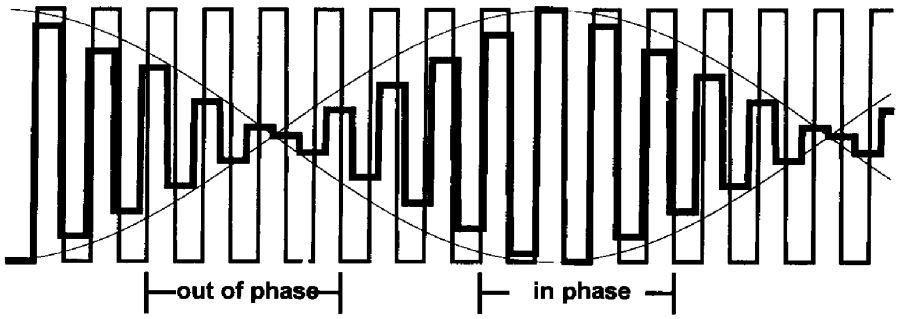


Figure 8-15. Beat frequency produced by an ideal staring system when $u_o/u_{iN} = 0.952$. The value N = 9.9 and $d_H/d_{CCH} = 1$. The light line is the input and the heavy line is the detector output. The beat frequency envelope is shown.

When u_o/u_{iN} is less than about 0.6 (Figure 8-16), the beat frequency is not obvious. Now the output nearly replicates the input but there is some slight variation in pulse width and amplitude. In the region where u_o/u_{iN} is approximately between 0.6 and 0.9, adjacent bar amplitudes are always less than the input amplitude (Figure 8-17).

When u_o/u_{iN} is less than about 0.6, a 4-bar pattern will always be seen (select any four adjoining bars in Figure 8-16). When $u_o/u_{iN} < 0.6$, phasing effects are minimal and a phase adjustment of $\pm$½d in image space will not affect an observer's ability to resolve a 4-bar target. In the region where f_o/f_N is approximately between 0.6 and 0.9, 4-bar targets will never *look* correct (Figure 8-17). One or two bars may be either much wider than the others or one or two bars may be of lower intensity than the others. This phasing effect is a measurement concern and is not normally included in modeling.

Input frequencies of $u_o = u_{iN}/k$, where k is an integer, are faithfully reproduced (i.e., no beat frequencies). When k = 1, as the target moves from in-phase to out-of-phase, the output will vary from a maximum to zero. Selection of u_{iN}/k targets avoids the beat frequency problem but significantly limits the number of spatial frequencies selected.

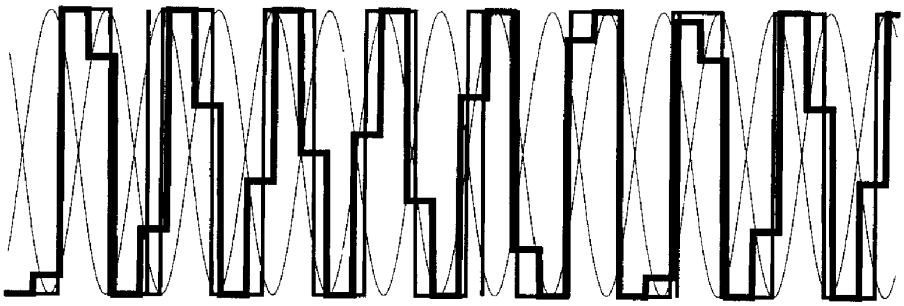


Figure 8-16. Ideal staring system output when $u_o/u_{iN} = 0.522$. The value N = 0.54 and $d_H/d_{CCH} = 1$. The light line is the input and the heavy line is the detector output. The output nearly replicates the input when $u_o/u_{iN} < 0.6$.

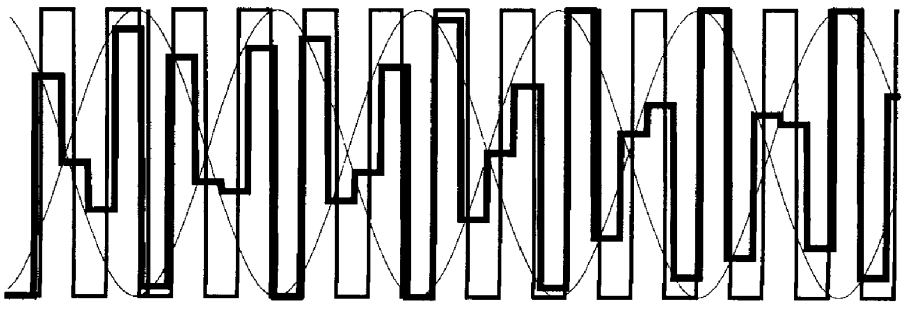


Figure 8-17. Ideal staring system output when $u_o/u_{iN} = 0.811$. The value N = 2.14. The light line is the input and the heavy line is the detector output. The output never *looks* quite right when u_o/u_{iN} is between 0.6 and 0.9.

Signals with frequencies above Nyquist frequency will be aliased down to lower frequencies. This would be evident if an infinitely long periodic target was viewed. However, when u_o is less than about $1.15\,u_{iN}$, it is possible to select a phase such that four adjoining bars *appear* to be faithfully reproduced (Figure 8-18). These targets can be *resolved* although the underlying fundamental frequency has been aliased to a lower frequency.

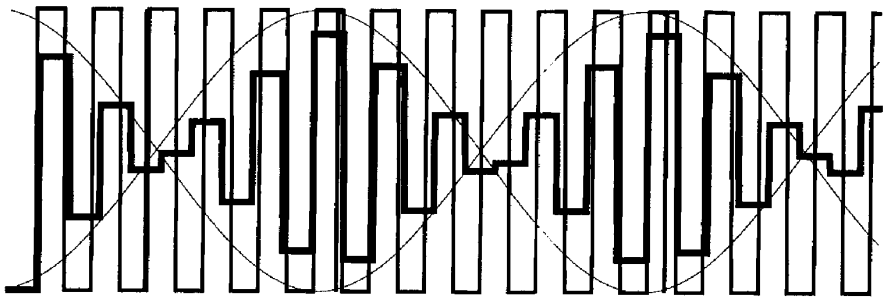


Figure 8-18. Ideal staring system output when $u_o/u_{iN} = 1.094$. The value $N = 5.8$. The light line is the input and the heavy line is the detector output. By selecting the appropriate phase, the output *appears* to replicate an input 4-bar pattern.

Systems can *detect* signals with spatial frequencies above cutoff but cannot faithfully reproduce them. For example, patterns above the Nyquist frequency are aliased to a frequency below Nyquist and a 4-bar pattern may appear as a distorted 3-bar pattern.

The phasing effects shown in Figures 8-15 through 8-18 "disappear" when the target is moving. Here, each frame provides a different image. For each target whose spatial frequency is above Nyquist frequency, one, two, or three bars are visible depending on the relative phase. As the pattern moves, a different set of bars is visible. The eye blends these individual patterns so that you perceive four bars. This prompted some researchers[14] to develop a dynamic test in which the 4-bar target moves.

Example 8-1
SYSTEM CUTOFF

A staring array consists of detectors that are 10 μm × 10 μm in size. The detector pitch is 15 μm. The focal length is 15 cm. The aperture diameter is 3 cm and the average wavelength is 0.5 μm. What is the system cutoff?

System cutoff is the smaller of the optical cutoff, detector cutoff, or Nyquist frequency. In image space, the optical cutoff is $u_{iC} = D_o/(\lambda fl) = 400$ cycles/mm. The detector cutoff is $u_{iC} = 1/d_H = 100$ cycles/mm. The detector pitch provides sampling every 15 μm for an effective sampling rate at 66.7 cycles/mm. Because the Nyquist frequency is one-half the sampling frequency, the system cutoff is 33.3 cycles/mm.

Because object space is related to image space by the lens focal length, the optical cutoff is 30 cycles/mrad, detector cutoff is 15 cycles/mrad, sampling is 10 cycles/mrad, and the Nyquist frequency is 5 cycles/mrad.

Because the MTF remains zero for all frequencies higher than the optical cutoff, any scene frequency above u_{iC} will appear as a uniform blob with no modulation. Spatial frequencies higher than the detector cutoff or the Nyquist frequency (but less than u_{iC}) will be aliased down to lower frequencies.

8.4. ALIASING in FRAME GRABBERS and DISPLAYS

For many applications, the camera output is an analog signal that is then re-sampled by a frame grabber (frame capture device). If the frame grabber's sampling rate is sufficiently high and the analog signal is band-limited, the reconstructed signal will replicate the analog signal in frequency, amplitude, and pulse width.

In principle, the clock rate of an analog-to-digital converter can be set at any rate. However, to conserve on memory requirements and minimize clock rates, some frame grabbers tend to just satisfy the Nyquist frequency of a standard video signal. That is, if the video bandwidth is f_{BW}, then the frame grabber sampling clock operates at $2f_{BW}$ (see Table 5-2, page 153, for f_{BW} values). A frame grabber, with its flash converter, can distort the signal as shown in Figure 8-19. The variation in edge locations affects all image processing algorithms.

The variations in pulse width can only be seen on a monitor because the frame grabber data reside in a computer memory. Note that output pulse widths are equally spaced. They just do not match up with the input signal.

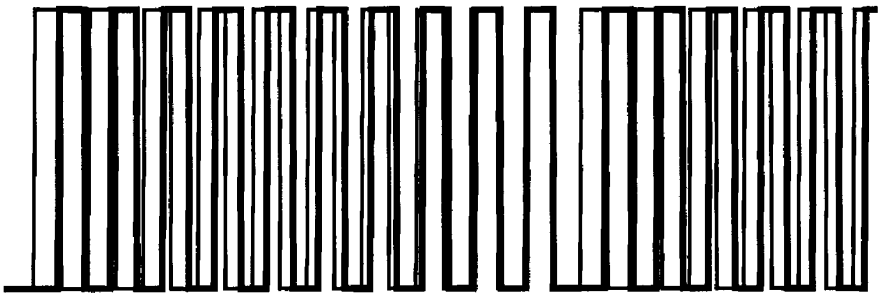


Figure 8-19. Frame grabber output after sample-and-hold circuitry when $u_o/u_{iN} = 0.952$. The light line is the input and the heavy line is the output. Here, u_{iN} is the Nyquist frequency created by the frame grabber clock rate. The output is representative of what is seen on a monitor.

Some frame grabbers have an internal anti-alias filter. This filter ensures that the frame grabber does not produce any additional aliasing. The filter cutoff is linked to the frame grabber clock and is not related to the camera output. Once aliasing has occurred in the camera, the frame grabber anti-alias filter cannot remove it. If the filter does not exist, the frame grabber may create additional aliasing.[15]

Aliasing is rarely discussed with displays, but under certain conditions can occur. Many displays employ digital techniques to match the electronic signal to the CRT characteristics. Ideally, the internal analog-to-digital converter should have a low-pass filter to eliminate possible aliasing. Although good engineering design recommends that the low-pass filter be included, cost considerations may eliminate it. With standard video formats, the bandwidth is limited by the video format and there is no need for the low-pass filter. If a nonstandard bandwidth is used such as that required by a high resolution CCD camera, these monitors may exhibit some aliasing. This becomes noticeable as the array size increases. For example, a high quality monitor can display 1000 $\times$ 1000 pixels. If the array consists of 4000 $\times$ 4000 elements, the display may alias the image as depicted in Figure 8-1 (page 231). There is often a loss of resolution when changing to a lower resolution format.

8.5. REFERENCES

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9

LINEAR SYSTEM THEORY

Linear system theory was developed for electronic circuitry and has been extended to optical, electro-optical, and mechanical systems. It forms an indispensable part of system analysis. For modeling purposes, electronic imaging systems are characterized as linear spatial-temporal systems that are shift-invariant with respect to both time and two spatial dimensions. Although space is three-dimensional, an imaging system displays only two dimensions.

Electrical filters are different from spatial filters in two ways. They are single-sided in time and must satisfy the causality requirement that no change in the output may occur before the application of an input. Optical filters are double-sided in space. Electrical signals may be either positive or negative, whereas optical intensities are always positive. As a result, optical designers and circuit designers often use different terminology.

With a linear-shift-invariant (LSI) system, signal processing is linear. A shift of the input causes a corresponding shift in the output. For electronic circuits, the shift is in time, whereas for optical systems, the shift is in space. In additional, the input-to-output mapping is single-valued. For optical systems, one addition condition exists: the radiation must be incoherent if the system is to be described in terms of radiance.

A sampled-data system may be considered "globally" shift invariant on a macro-scale. For example, with an electronic imaging system, as a target moves from the top of the field-of-view to the bottom, the image also moves from the top to the bottom. On a micro-scale, moving a point source across a single detector does not change the detector output. That is, the system is not shift-invariant on a micro-scale. Similarly, with electronic circuits, large time shifts of the input produce corresponding large time shifts in output. A shift during a sample time, does not change the output. Here also, the system is not shift-invariant on a micro-scale.

Single-valued mapping only occurs with non-noisy and non-quantized systems. No system is truly noiseless but can be approximated as one when the signal has sufficient amplitude. With digital systems, the output is quantized. The smallest output is the least significant bit and the analog-to-digital converter generally limits the largest signal. If the signal level is large compared to the

least significant bit, then the system can be treated as quasi-linear over a restricted region.

In spite of the disclaimers mentioned, systems are treated as quasi-linear and quasi-shift-invariant over a restricted operating region to take advantage of the wealth of mathematical tools available. An LSI system merely modifies the amplitude and phase of the input. These are specified by the modulation transfer function and phase transfer function.

The symbols used in this book are summarized in the *Symbol List* (page xviii) which appears after the *Table of Contents*.

9.1. LINEAR SYSTEM THEORY

A linear system provides single mapping from an input to an output. Superposition allows the addition of individual inputs to create an unique output. Let h{ } be a linear operator that maps one function, f(t), into another function, g(t):

$$h\{f(t)\} = g(t) \ . \tag{9-1}$$

Let the response to two inputs, $f_1(t)$ and $f_2(t)$, be $g_1(t)$ and $g_2(t)$:

$$h\{f_1(t)\} = g_1(t) \quad \textit{and} \quad h\{f_2(t)\} = g_2(t) \ . \tag{9-2}$$

For a linear system, the response to a sum of inputs is equal to the sum of responses to each input acting separately. For any arbitrary scale factors, the superposition principle states

$$h\{a_1 f_1(t) + a_2 f_2(t)\} = a_1 g_1(t) + a_2 g_2(t) \ . \tag{9-3}$$

When passing the signal through another linear system, the new operator provides:

$$h_2\{g(t)\} = h_2\{h_1\{f(t)\}\} \ . \tag{9-4}$$

9.1.1. TIME-VARYING SIGNALS

An electrical signal can be thought of as the sum of an infinite array of impulses (Dirac delta functions) located inside the signal boundaries. Thus, the signal can be decomposed into a series of weighted Dirac delta functions (Figure 9-1):

$$v_{IN}(t) = \sum_{t'=-\infty}^{\infty} v_{IN}(t')\delta(t - t')\,\Delta t' \,, \tag{9-5}$$

where $\delta(t - t')$ is the Dirac delta or impulse function at $t = t'$ and $v_{IN}(t')$ is the signal evaluated at t'.

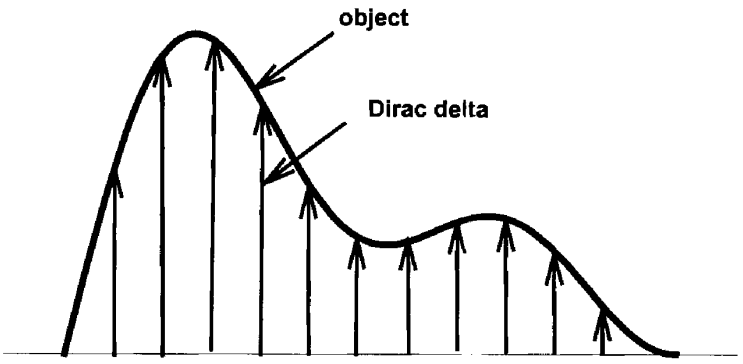


Figure 9-1. A time-varying signal can be decomposed into a series of closely spaced impulses with amplitude equal to the signal at that value. They are shown widely separated for clarity and should not be confused with sampling.

If $v_{IN}(t)$ is applied to a linear circuit, using $h\{\ \}$ will provide the output

$$v_{OUT}(t) = \sum_{t'=-\infty}^{\infty} h\{v_{IN}(t')\delta(t - t')\,\Delta t'\} \quad . \tag{9-6}$$

Comparing Equation 9-5 to Equation 9-3, for each t', $v_{IN}(t')$ replaced a_i and $\delta(t - t')$ replaced $f_i(t)$. That is, the input has been separated into a series of functions $a_1f_1(t) + a_2f_2(t) + \cdots$.

As $\Delta t' \rightarrow 0$, this becomes the convolution integral

$$v_{OUT}(t) = \int_{-\infty}^{\infty} v_{IN}(t')\, h\{\delta(t - t')\}\, dt' \tag{9-7}$$

and is symbolically represented by

$$v_{OUT}(t) = v_{IN}(t) * h(t) , \tag{9-8}$$

where $*$ indicates the convolution operator (other texts may use $\star$ or $\otimes$). The system impulse response is $h\{\delta(t)\}$. In Figure 9-2, each impulse response is given for each t'. The individual impulse responses are added to produce the output. This addition is the definition of superposition.

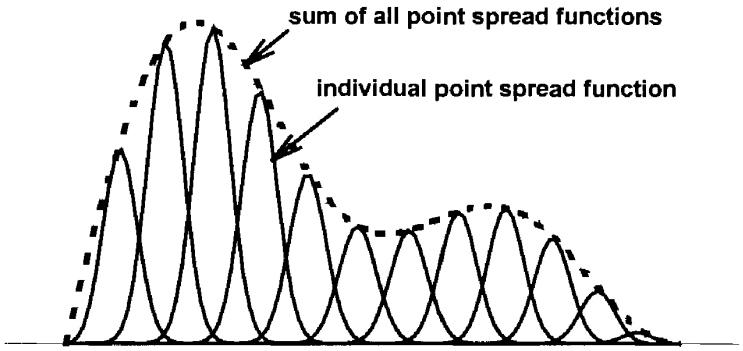


Figure 9-2. The linear operator, h{ }, transforms each input Dirac delta into an output impulse response. The sum of the impulse responses creates the output. Although shown separated for clarity, the impulse responses have infinitesimal separations.

The convolution theorem of Fourier analysis states that the Fourier transform of the convolution of two functions equals the product of the transform of the two functions. That is, multiple convolutions are equivalent to multiplication in the frequency domain. Using frequency domain analysis is convenient because multiplications are easier to perform and easier to visualize than convolutions. Then

$$V_{OUT}(f) = V_{IN}(f)\, H(f) . \tag{9-9}$$

The variable f denotes electrical frequency (Hz). Upper case variables represent the Fourier transform of the signal (lower case variables). Let the input be an impulse. The Fourier transform of an impulse response is

$$V_{IN}(f) = 1 \ . \tag{9-10}$$

That is, all frequencies are present. Because the input to the system contains all frequencies, the output must be a function of the system only. Any variation in phase or amplitude must be due to the system itself. The output is

$$V_{OUT}(f) = H(f) \ . \tag{9-11}$$

9.1.2. SPATIALLY VARYING SIGNALS

The one-dimensional electronic signal decomposition can be easily extended to two-dimensional imagery. An object can be thought of as the sum of an infinite array of impulses located inside the target boundaries. Thus, an object can be decomposed into a two-dimensional array of weighted Dirac delta functions, $\delta(x - x')$, $\delta(y - y')$:

$$o(x,y) = \sum_{x'=-\infty}^{\infty} \sum_{y'=-\infty}^{\infty} o(x',y')\delta(x - x')\,\delta(y - y')\,\Delta x'\,\Delta y' \ . \tag{9-12}$$

An optical system with operator h{ } produces an image

$$i(x,y) = \sum_{x'=-\infty}^{\infty} \sum_{y'=-\infty}^{\infty} h\{o(x',y')\delta(x - x')\,\delta(y - y')\,\Delta x'\,\Delta y'\} \ . \tag{9-13}$$

For small increments, this becomes the convolution integral

$$i(x,y) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} o(x',y')\; h\{\delta(x - x')\,\delta(y - y')\}\; dx'\,dy' . \tag{9-14}$$

It is symbolically represented by

$$i(x,y) = o(x,y) ** h(x,y) , \tag{9-15}$$

where ** represents the two-dimensional convolution. The function h(x,y) is the optical system's response to an input impulse. The resulting image is the point spread function (PSF). For an ideal circular aperture, the central portion of the PSF is the Airy disk from which the Rayleigh criterion and other resolution metrics are derived. In one dimension h(x) is the line spread function, LSF. The LSF is the resultant image produced by the imaging system when viewing an ideal line. There is no equivalent interpretation for h(t) for electrical circuits. The function h(t) is simply the impulse response.

The transform of the convolution becomes a multiplication in the frequency domain

$$I(u,v) = O(u,v)\, H(u,v) . \tag{9-16}$$

If all frequencies are present in the image (i.e., an impulse), O(u,v) = 1, then I(u,v) = H(u,v). The relationship between spatial frequency (u,v) and electrical frequency (f) is further discussed in Section 10.1., *Frequency Domains*.

9.2. ELECTRONIC IMAGING SYSTEM

The electronic imaging system response consists of both the optical response and the electronic response: h(x,y,t). Time and spatial coordinates are treated separately. For example, optical elements do not generally change with time and therefore are characterized only by spatial coordinates. Similarly, electronic circuitry exhibits only temporal responses. The detector provides the interface between the spatial and temporal components, and its response depends on both temporal and spatial quantities. The conversion of two-dimensional optical information to a one-dimensional electrical response assumes a linear photodetection process. Implicit in the detector response is the conversion from input photon flux to output voltage.

The optical transfer function (OTF) plays a key role in the theoretical evaluation and optimization of an optical system. The modulation transfer function (MTF) is the magnitude and the phase transfer function (PTF) is the phase of the complex-valued OTF. In many applications, the OTF is real-valued and positive so that the OTF and MTF are equal. When focus errors or aberrations are present, the OTF may become negative or even complex valued.

Electronic circuitry also can be described by an MTF and PTF. The combination of the optical MTF and the electronic MTF creates the electronic imaging system MTF. The MTF is the primary parameter used for system design, analysis, and specifications. When coupled with the three-dimensional noise parameters, the MTF and PTF uniquely define system performance (discussed in Chapter 12, *Minimum Resolvable Contrast*).

Symbolically

$$OTF(u,v) = H_{SPATIAL}(u,v) = MTF(u,v)\, e^{jPTF(u,v)} \tag{9-17}$$

and

$$H_{ELECTRONICS}(f) = MTF(f)\, e^{jPTF(f)} . \tag{9-18}$$

With appropriate scaling, the electronic frequencies can be converted into spatial frequencies. This is symbolically represented by f→u. The electronic circuitry is assumed to modify the horizontal signal only (although this depends on the system design). The combination of spatial and electronic responses is sometimes called the system OTF:

$$OTF_{SYSTEM}(u,v) = MTF(u,v)\, MTF(f{\rightarrow}u) e^{j[PTF(u,v)\, +PTF(f{\rightarrow}u)]} . \tag{9-19}$$

For mathematical convenience, the horizontal and vertical responses are considered separable (usually coincident with the detector array axes). The electrical response is considered to affect only the horizontal response

$$H_{SYSTEM}(u) = H_{SPATIAL}(u)\, H_{ELECTRONICS}(f{\rightarrow}u) \tag{9-20}$$

and

$$H_{SYSTEM}(v) = H_{SPATIAL}(v) . \tag{9-21}$$

A system is composed of many components that respond to either spatial or temporal signals. For independent MTFs,

$$MTF_{SYSTEM}(u,v) = \prod_{i=1}^{N} \prod_{j=1}^{M} MTF_i(u,v)\, MTF_j(f{\rightarrow}u) . \tag{9-22}$$

While individual lens elements each have their own MTF, the MTF of the lens system is not usually the product of the individual MTFs. This occurs because one lens may minimize the aberrations created by another.

9.3. MTF and PTF INTERPRETATION

The system MTF and PTF alter the image as it passes through the circuitry. For linear-shift-invariant systems, the PTF simply indicates a spatial or temporal shift with respect to an arbitrarily selected origin. An image where the MTF is drastically altered is still recognizable, whereas large PTF nonlinearities can destroy recognizability. Modest PTF nonlinearity may not be noticed visually except those applications where target geometric properties must be preserved (i.e., mapping or photogrammetry). Generally, PTF nonlinearity increases as the spatial frequency increases. Because the MTF is small at high frequencies, the nonlinear-phase-shift effect is diminished.

The MTF is the ratio of output modulation to input modulation normalized to unity at zero frequency. While the modulation changes with system gain, the MTF does not. The input can be as small as desired (assuming a noiseless system with high gain) or it can be as large as desired because the system is assumed not to saturate.

Modulation is the variation of a sinusoidal signal about its average value (Figure 9-3). It can be considered as the AC amplitude divided by the DC level. The modulation is:

$$MODULATION = M = \frac{V_{MAX} - V_{MIN}}{V_{MAX} + V_{MIN}} = \frac{AC}{DC}, \qquad (9\text{-}23)$$

where V_{MAX} and V_{MIN} are the maximum and minimum signal levels, respectively. The modulation transfer function is the output modulation produced by the system divided by the input modulation as a function of frequency:

$$MTF(f) = \frac{M_{OUTPUT}(f)}{M_{INPUT}(f)}. \qquad (9\text{-}24)$$

The concept is presented in Figure 9-4. Three input and output signals are plotted in Figures 9-4a and 9-4b, respectively, and the resultant MTF is shown in Figure 9-4c. As a ratio, the MTF is a relative measure with values ranging from zero to one.

The MTF is a measure of how well a system will faithfully reproduce the input. The highest frequency that can be faithfully reproduced is the system cutoff frequency. If the input frequency is above the cutoff, the output will be proportional to the signal's average value with no modulation.

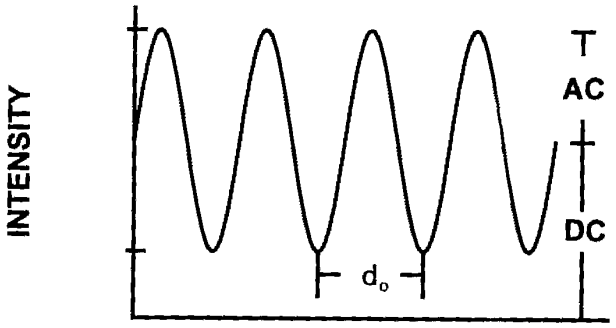


Figure 9-3. Definition of target modulation. The value d_o is the extent of one cycle.

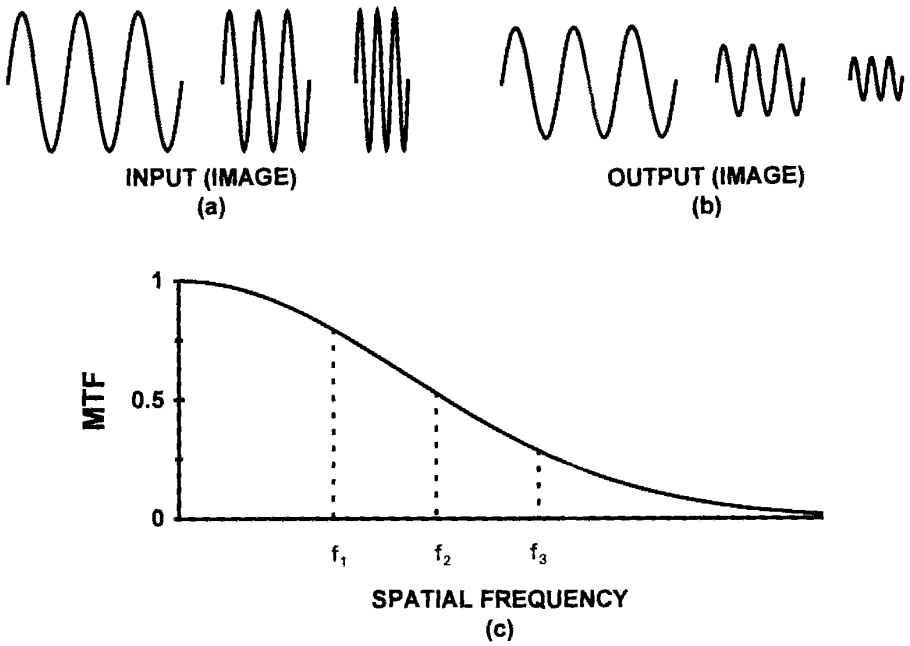


Figure 9-4. Modulation transfer function. (a) Input signal for three different spatial frequencies, (b) output for the three frequencies, and (c) the MTF is the ratio of output-to-input modulation.

9.4. SUPERPOSITION APPLIED to OPTICAL SYSTEMS

If the system MTF is known, the image for any arbitrary object can be computed. First, the object is dissected into its constituent spatial frequencies (i.e., the Fourier transform of the object is obtained). Next, each of these frequencies is multiplied by the system MTF at that frequency. Then, the inverse Fourier transform provides the image.

To illustrate the superposition principle and MTF approach, we will show how an ideal optical system modifies an image. An ideal optical system is, by definition, a linear-phase-shift system. The most popular test target consists of a series of bars: typically three or four bars although more may be used. For illustrative purposes, the periodic bars are assumed of infinite extent. A one-dimensional square wave, when expanded into a Fourier series about the origin, contains only odd harmonics:

$$o(x) = \frac{1}{2} + \frac{2}{\pi}\sum \frac{1}{n}\sin\left(\frac{2\pi n x}{d_o}\right) \quad n = 1, 3, 5, \cdots, \tag{9-25}$$

where d_o is the period of the square wave. The fundamental frequency u_o is $1/d_o$. Note that the peak-to-peak amplitude of the fundamental is $4/\pi$ times the square wave amplitude. In the frequency domain, the square wave provides discrete spatial frequencies of $u_n = 1/d_o, 3/d_o, 5/d_o, \cdots$, with amplitudes $2/\pi$, $2/3\pi$, $2/5\pi$, $\cdots$, respectively.

Let a circular optical system image the square wave. The MTF for a circular, clear aperture, diffraction-limited lens is

$$MTF_{OPTICS}(u_i) = \frac{2}{\pi}\left[\cos^{-1}\left(\frac{u_i}{u_{iC}}\right) - \frac{u_i}{u_{iC}}\sqrt{1-\left(\frac{u_i}{u_{iC}}\right)^2}\right] \quad \textit{when } u_i < u_{iC} \tag{9-26}$$

$$= 0 \quad \textit{elsewhere} .$$

The optical cutoff in image space is $u_{iC} = D_o/(\lambda\, fl)$, where D_o is the aperture diameter, λ is the average wavelength, and fl is the focal length.

By superposition, the diffraction-limited optical MTF and square wave Fourier series amplitudes are multiplied together at each spatial frequency:

$$I(u_n) = MTF_{OPTICS}(u_n)\, O(u_n) \ . \tag{9-27}$$

Taking the inverse Fourier transform provides the resultant image. Equivalently,

$$\begin{aligned} i(x) = \frac{1}{2} &+ MTF_{OPTICS}(u_o)\left[\frac{2}{\pi}\sin(2\pi u_o x)\right] \\ &+ MTF_{OPTICS}(3u_o)\left[\frac{2}{3\pi}\sin(6\pi u_o x)\right] + \cdots \ . \end{aligned} \tag{9-28}$$

If u_o is greater than $u_{iC}/3$, only the fundamental of the square wave will be faithfully reproduced by the optical system. Here, the square wave will appear as a sine wave. Note that the optical MTF will reduce the image amplitude. As u_o decreases, the image will look more like a square wave (Figure 9-5). Because the optics does not pass any frequencies above u_{iC}, the resultant wave form is a truncation of the original series modified by the optical MTF. This results in some slight ringing. This ringing is a residual effect of the Gibbs phenomenon. Note that with imaging systems, the intensity is always positive. As the input frequency approaches u_{iC} (Figure 9-5d), the modulation is barely present in the image. However, the average scene intensity approaches 0.5. That is, the scene detail can no longer be perceived at or above u_{iC}. *The scene did not disappear.*

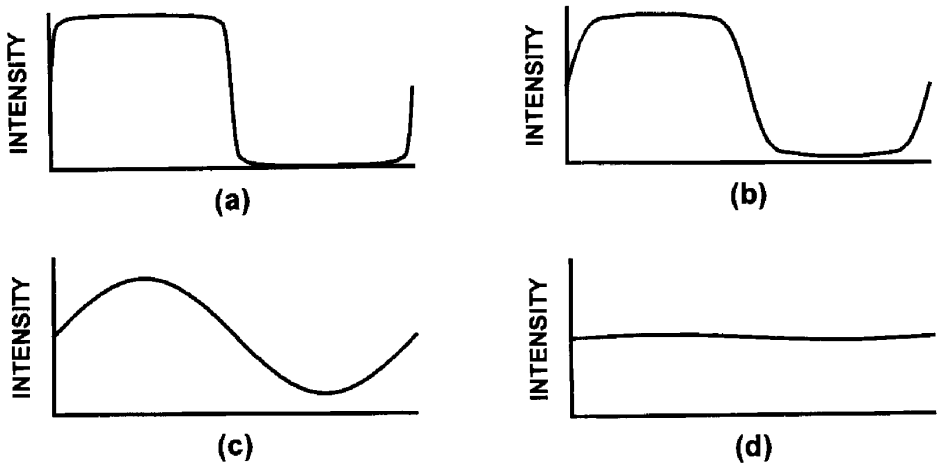


Figure 9-5. A square wave modified by a circular aperture as a function of x/d_o. As the square-wave fundamental frequency increases, the edges become rounded. It will appear as a sinusoid when $u_o \geq u_{iC}/3$. (a) $u_o = u_{iC}/40$, (b) $u_o = u_{iC}/10$, (c) $u_o = u_{iC}/3$, and (d) $u_o = 9u_{iC}/10$.

9.5. CONTRAST TRANSFER FUNCTION

The system response to a square-wave target is the contrast transfer function (CTF) or square-wave response (SWR). The CTF is a convenient measure because of the availability of square-wave targets. It is not a transfer function in the same sense that the MTF is and, as such, subsystem CTFs cannot be cascaded. Figure 9-6 illustrates the relationship between square-wave and sinusoidal amplitudes. The CTF is typically higher than the MTF at all spatial frequencies.

A square wave can be expressed either as an infinite sine (Equation 9-25) or cosine series. The only difference is the arbitrarily selected origin. Coltman[1] selected the cosine expansion. The output amplitude of the square wave, whose fundamental frequency is f_o, is an infinite sum of the input cosine amplitudes modified by the system's MTF:

$$CTF(u_o) = \frac{4}{\pi}\left| MTF(u_o) - \frac{MTF(3u_o)}{3} + \frac{MTF(5u_o)}{5} - \ldots \right| \quad (9\text{-}29)$$

or

$$CTF(u_o) = \frac{4}{\pi}\left| \sum_{k=0}^{\infty} (-1)^k \frac{MTF[(2k+1)u_o]}{2k+1} \right| . \quad (9\text{-}30)$$

By adding and subtracting terms, the MTF at frequency u_o can be expressed as an infinite sum of CTFs.

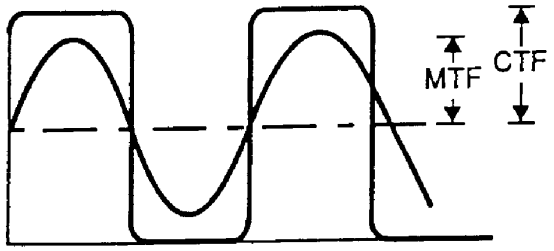


Figure 9-6. AC components of the CTF and MTF. The CTF is usually equal to or greater than the MTF.

Again, assuming a linear-shift-invariant system, the MTF is[1,2]:

$$MTF(u_o) = \frac{\pi}{4}\left|CTF(u_o) + \frac{CTF(3u_o)}{3} - \frac{CTF(5u_o)}{5} + \frac{CTF(7u_o)}{7} + \frac{CTF(11u_o)}{11} + \textit{irregular terms}\right| \tag{9-31}$$

or

$$MTF(u_o) = \frac{\pi}{4}\left|\sum_{k=0}^{\infty} B_k \frac{CTF(ku_o)}{k}\right|, \tag{9-32}$$

where k takes on odd values only: 1, 3, 5, ... and B_k is -1 or 1 according to:

$$B_k = (-1)^m(-1)^{\frac{k-1}{2}} \qquad \textit{for } r = m\ . \tag{9-33}$$

The value r is the number of different prime factors in k. The value m is the total number of primes into which k can be factored. The value $B_k = 0$ for $r < m$.

Theoretically, to obtain the MTF at frequency u_o, an infinite number of square-wave responses must be measured. However, the number required is limited by the spatial cutoff frequency, $u_{MTF=0}$, where the MTF approaches zero and remains zero thereafter. For bar targets with spatial frequency above $\frac{1}{3}u_{MTF=0}$, the MTF is equal to $\pi/4$ times the measured CTF. That is, above $\frac{1}{3}$ $u_{MTF=0}$, only one target is necessary to compute[3] the MTF.

For low spatial frequencies, the output nearly replicates the input (Figure 9-7a). For frequencies near $\frac{1}{3}$ cutoff, the output starts to appear sinusoidal (Figure 9-7b). Above $\frac{1}{3}$ cutoff (Figure 9-7c), the MTF amplitude is $\pi/4$ times the CTF amplitude.

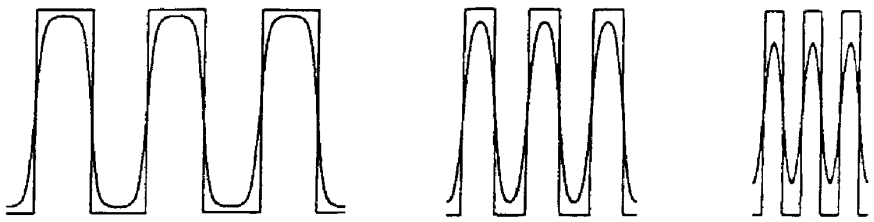


Figure 9-7. Input and output wave forms for a linear system. (a) Very low frequency signals are faithfully reproduced, (b) mid-spatial frequencies tend to look like sinusoids, and (c) input square waves with spatial frequencies above ⅓ $u_{MTF=0}$ appear as sinusoidal outputs.

The relationship between the CTF and MTF was developed for analog optical systems and is appropriate for wet-film photographic cameras and image intensifiers. It can also be applied in the scan direction for analog scanning devices (vidicons and displays).

For sampled data systems, where aliasing can occur, the relationship should be used cautiously. CTF measurements are appropriate tests for system performance verification. Conversion to the MTF that can have significant mathematical complexity when aliasing is present.

Sampling is present in all solid state imaging systems due to the discrete location of the detectors. Phasing effects between the detector and the location of the target introduce problems at nearly all spatial frequencies. The interaction between the bar frequency and the system sampling frequency produces sum and difference frequencies that produce variations in amplitude and bar width (see Section 8.3.3., *Image Distortion*, page 245).

The CTF is well behaved (in the sense that the bar width remains constant) when the bar spatial frequency is proportional to the system Nyquist frequency,

$$u_o = \frac{u_{iN}}{k}, \tag{9-43}$$

where k is an integer. These spatial frequencies provide the in-phase CTF. The CTF can be used to assess system performance at the spatial frequencies selected. It is usually specified only at the Nyquist frequency (k = 1).

9.6. REFERENCES

1. J. W. Coltman, "The Specification of Imaging Properties by Response to a Sine Wave Input," *Journal of the Optical Society of America*, Vol. 44(6), pp. 468-471 (1954).
2. I. Limansky, "A New Resolution Chart for Imaging Systems," *The Electronic Engineer*, Vol. 27(6), pp. 50-55 (1968).
3. G. C. Holst, *Testing and Evaluation of Infrared Imaging Systems*, pp. 238-246, JCD Publishing, Winter Park, FL (1993).

10

SYSTEM MTF

The equations describing array (Chapter 4) and camera (Chapter 6) performance assume that the image is very large and it illuminates many detector elements. That is, the object contained only very low spatial frequencies and that the system MTF is essentially unity over these spatial frequencies.

The optics and detector MTFs modify the signal spatial frequencies. These frequencies may also be affected by electronic filter MTFs although these electronic filter functions are typically designed to pass the entire image frequency spectrum without attenuation.

But noise originates at the detector and within the electronic circuitry. It is modified by the electronic MTFs only. Detector array noise is fixed but analog amplifier noise increases as the electronic bandwidth increases. The camera SNR is maximized when the electronic bandwidth passes the signal with minimal degradation. Wider bandwidth electronics will increase the noise but not the signal and thereby reduce the SNR.

For mathematical convenience, a specific target feature can be associated with a fictitious spatial frequency (Figure 10-1). The SNR for this feature is

$$SNR(u_o) = MTF_{SYS}(u_o)\frac{n_{pe}}{\langle n_{SYS}\rangle}, \qquad (10\text{-}1)$$

where $\langle n_{SYS}\rangle$ includes shot, reset, amplifier, quantization, and fixed pattern noise sources (see Section 4.2., *Noise*, page 123). The total amplifier noise depends upon the electronic bandwidth and that depends on the electronic frequency response associated with the readout signal chain.

A solid state camera consists of optics, an array of pixels, and a signal chain with electronic frequency response characteristics. The complete imaging system includes the display:

$$MTF_{SYS} = MTF_{OPTICS}MTF_{DETECTOR}MTF_{SIGNAL\text{-}CHAIN}MTF_{DISPLAY}. \qquad (10\text{-}2)$$

The observer processes this information to create a perceived MTF:

$$MTF_{PERCEIVED} = MTF_{SYS}\, MTF_{HVS} \,. \qquad (10\text{-}3)$$

MTF_{HVS} is the human visual system MTF which includes both the eye optical MTF and neural processing. When $MTF_{PERCEIVED}$ is coupled to system noise, system responsivity, and the eye integration capabilities, it is possible to predict the minimum resolvable contrast (described in Chapter 12, *Minimum Resolvable Contrast*). MRC is used by the military to predict target detection and recognition ranges for a given probability of success.

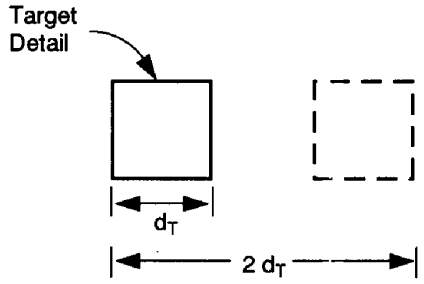


Figure 10-1. Fictitious spatial frequency associated with a target feature. If the image detail size is d_T mm at the detector plane, then the fictitious horizontal frequency is $u_o = 1/(2d_T)$ cycles/mm.

Because solid state arrays are undersampled, the highest frequency that can be reproduced is the array Nyquist frequency, u_{iN}. As a result, it is common practice to evaluate Equation 10-1 at $u_o = u_{iN}$. This dictates the smallest target feature that can be faithfully reproduced. The value u_{iN} should be added to all MTF curves (see Section 8.3.2., *Detector Array Nyquist Frequency*, page 242).

The MTFs presented in this chapter apply to all staring arrays. Only the optics and detector array are sensitive to the scene spectral and spatial content. The remaining subsystem MTF components only modify the electrical signals. These signal chain MTFs apply to all imaging systems independent of the system spectral response.

Optical spatial frequency is two-dimensional with the frequency ranging from $-\infty$ to $+\infty$. Although not truly separable, for convenience, the horizontal MTF, MTF(u), and vertical MTF, MTF(v), are analyzed separately. Electrical filters are causal, one-dimensional, and are considered to operate in the direction of the readout clocking only. Thus, the horizontal and vertical MTFs may be different.

The symbols used in this book are summarized in the *Symbol List* (page xviii) which appears after the *Table of Contents*.

10.1. FREQUENCY DOMAINS

There are four different locations where spatial frequency domain analysis is appropriate. They are object space (before the camera optics), image space (after the camera optics), display, and observer (at the eye) spatial frequencies. Simple equations relate the spatial frequencies in all these domains.

Figure 10-2 illustrates the spatial frequency associated with a bar target. Bar patterns are the most common test targets and are characterized by their fundamental spatial frequency. Using the small angle approximation, the angle subtended by one cycle (one bar and one space) is d_o/R_1, where d_o is the spatial extent of one cycle and R_1 is the distance from the imaging system entrance aperture to the target. When using a collimator to project the targets at apparently long ranges, the collimator focal length replaces R_1. Targets placed in the collimator's focal plane can be described in object space.

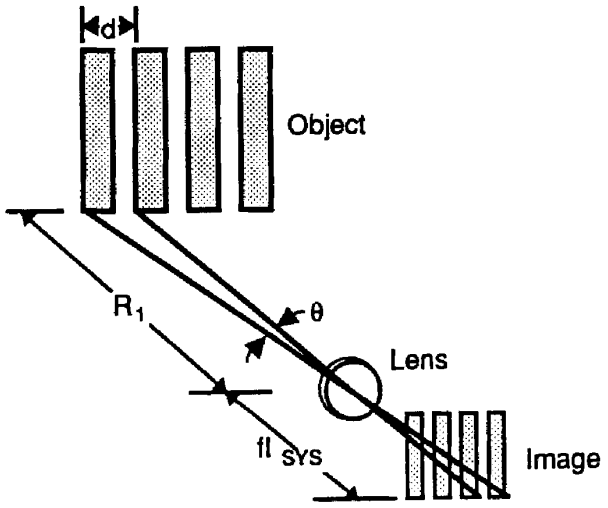


Figure 10-2. Correspondence of spatial frequencies in object and image space. Although the MTF is defined for sinusoidal signals, the bar target is the most popular test target (shown here). Bar targets are characterized by their fundamental frequency.

The horizontal object-space spatial frequency, u_{ob}, is the inverse of the horizontal target angular subtense and is usually expressed in cycles/mrad:

$$u_{ob} = \frac{1}{1000}\left(\frac{R_1}{d_o}\right) \quad \frac{cycles}{mrad} . \tag{10-4}$$

A similar equation exists for the vertical object-space spatial frequency. The object-space domain is used by the military for describing system performance.

Optical designers typically quote spatial frequencies in image space to specify the resolving capability of lens systems. Photographic cameras and CCD cameras are typically specified with spatial frequencies in image space which is the object-space spatial frequency divided by the system focal length:

$$u_i = \frac{u_{ob}}{fl} \quad \frac{line\text{-}pairs}{mm} \quad or \quad \frac{cycles}{mm} , \tag{10-5}$$

where u_i is the inverse of one cycle in the focal plane of the lens system. Although used interchangeably, line-pairs suggest square wave targets and cycles suggest sinusoidal targets. To maintain dimensionality, if u_{ob} is measured in cycles/mrad then the focal length must be measured in meters to obtain cycles/mm.

Analog electronic filters are one-dimensional and modify a serial data stream. The electrical frequency is related to the horizontal field-of-view (HFOV) and the time it takes to read out one line. For analog filters immediately following the detector array, where the readout time is $t_{H\text{-}LINE}$,

$$f_e = \frac{HFOV \cdot fl}{t_{H\text{-}LINE}} u_i \quad Hz . \tag{10-6}$$

For staring arrays with N_H horizontal detectors,

$$f_e = \frac{(N_H - 1) d_{CCH} + d_H}{t_{H\text{-}LINE}} u_i \quad Hz . \tag{10-7}$$

While digital filters operate on a data array, the effective sampling rate is related to the timing of the readout clock:

$$f_{eS} = \frac{1}{T_{CLOCK}} \quad Hz \ . \tag{10-8}$$

After the digital-to-analog converter, the serial stream data rate and therefore the filter design is linked to the video standard. The active line time, $t_{VIDEO\text{-}LINE}$, (Table 10-1) and array size provide the link between image space and video frequencies:

$$f_v = \frac{HFOV \cdot fl}{t_{VIDEO\text{-}LINE}} u_i \quad Hz \ . \tag{10-9}$$

Video standards were discussed in Section 5.2.1., *Video Timing* (page 151). For staring arrays,

$$f_v = \frac{(N_H - 1) d_{CCH} + d_H}{t_{VIDEO\text{-}LINE}} u_i \quad Hz \ . \tag{10-10}$$

Table 10-1
STANDARD VIDEO TIMING

FORMAT	TOTAL LINE TIME (μs)	MINIMUM ACTIVE LINE TIME (μs) $t_{VIDEO\text{-}LINE}$
EIA 170	63.492	52.092
NTSC	63.555	52.456
PAL	64.0	51.7
SECAM	64.0	51.7

The field-of-view and monitor size link image spatial frequency to the horizontal and vertical display spatial frequencies:

$$u_d = \frac{HFOV \cdot fl}{W_{MONITOR}} u_i \quad \frac{cycles}{mm} \tag{10-11}$$

and

$$v_d = \frac{VFOV \cdot fl}{H_{MONITOR}} v_i \quad \frac{cycles}{mm} . \tag{10-12}$$

Both the monitor width, $W_{MONITOR}$, and height, $H_{MONITOR}$, are usually measured in millimeters. When the monitor aspect ratio is the same as the FOV ratio (the usual case),

$$\frac{HFOV}{W_{MONITOR}} = \frac{VFOV}{H_{MONITOR}} . \tag{10-13}$$

The spatial frequency presented to the observer depends on the observer's viewing distance and the image size on the display (Figure 10-3). Observer response is assumed to be rotationally symmetric so that the horizontal and vertical responses are the same. The usual units[1] are cycles/deg:

$$u_{eye} = \frac{1}{2 \tan^{-1}\left(\frac{1}{2} \frac{1}{D u_d}\right)} \quad \frac{cycles}{deg} . \tag{10-14}$$

Here, the arc tangent is expressed in degrees. Because image detail is important, the small angle approximation provides

$$u_{eye} = 0.01745 D u_d \quad \frac{cycles}{deg} . \tag{10-15}$$

Table 10-2 summarizes the various spatial frequencies.

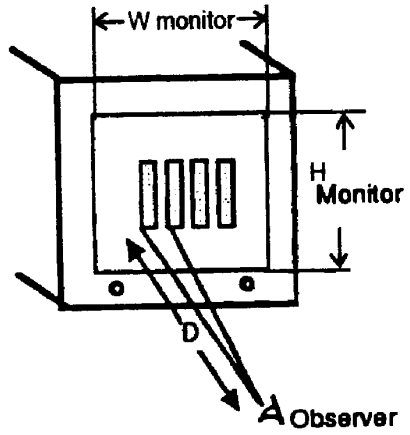


Figure 10-3. Correspondence of spatial frequencies for the display and for the eye.

Table 10-2
TRANSFORM PAIR UNITS

SUBSYSTEM RESPONSE	SIGNAL VARIABLES	FREQUENCY VARIABLES
Optics, detector	x denotes distance (mm) y denotes distance (mm)	u_i expressed as cycles/mm v_i expressed as cycles/mm
Optics, detector	θ_x denotes angle (mrad) θ_y denotes angle (mrad)	u_{ob} expressed as cycles/mrad v_{ob} expressed as cycles/mrad
Analog electronics	t denotes time (sec)	f_e expressed as cycles/s (Hz)
Video electronics	t denotes time (sec)	f_v expressed as cycles/s (Hz)
Display	x denotes distance (mm) y denotes distance (mm)	u_d expressed as cycles/mm v_d expressed as cycles/mm
Observer	θ_x denotes angle (deg) θ_y denotes angle (deg)	u_{eye} expressed as cycles/deg v_{eye} expressed as cycles/deg

10.2. OPTICS MTF

Optical systems consist of several lenses or mirror elements with varying focal lengths and varying indices of refraction. Multiple elements are used to minimize lens aberrations. While individual element MTFs are used for design and fabrication, these individual MTFs cannot be cascaded to obtain the optical system MTF. For modeling purposes, the optical system is treated as a single lens that has the same effective focal length and aberrations as the lens system.

The optical anti-aliasing filter, which is used to blur the image on a single chip color filter array, is also part of the lens system. Its performance is best described by the way it affects the detector MTF. Therefore, its description is included in the detector section.

Optical spatial frequency is two-dimensional with the frequency ranging from $-\infty$ to $+\infty$. The diffraction-limited MTF for a circular aperture was first introduced in Section 9.4., *Superposition Applied to Optical Systems* (page 261). For an aberration free and radially symmetric optical system, MTF_{OPTICS} is the same in the horizontal and vertical directions. In the horizontal direction,

$$MTF_{OPTICS}(u_i) = \frac{2}{\pi}\left[\cos^{-1}\left(\frac{u_i}{u_{iC}}\right) - \frac{u_i}{u_{iC}}\sqrt{1-\left(\frac{u_i}{u_{iC}}\right)^2}\right] \quad when\ u_i < u_{iC} \qquad (10\text{-}16)$$

$$= 0 \quad elsewhere\ .$$

The image-space optics cutoff is $u_{iC} = D_O/(\lambda\ fl) = 1/(F\lambda)$, where D_O is the aperture diameter and fl is the effective focal length. The f-number, F, is equal to fl/D_O.

Figure 10-4 illustrates MTF_{OPTICS} as a function of u_i/u_{iC}. Because the cutoff frequency is wavelength dependent, Equation 10-16 and Figure 10-4 are only valid for noncoherent monochromatic light. The extension to polychromatic light is lens specific. Most lens systems are color corrected (achromatized) and therefore there is no simple way to apply this simple formula to predict the MTF. As an approximation to the polychromatic MTF, the average wavelength is used to calculate the cutoff frequency:

$$\lambda_{ave} \approx \frac{\lambda_{MAX} + \lambda_{MIN}}{2}\ . \qquad (10\text{-}17)$$

For example, if the system spectral response ranges from 0.4 to 0.7 μm, then $\lambda_{AVE} = 0.55\,\mu$m.

For most systems operating in the visible spectral region, the optical system may be considered near diffraction limited and in focus. Approximations for aberrated and defocused optical systems are in Reference 2. The MTFs for optical systems with rectangular apertures[3] or telescopes with a central obscuration (Cassegrainian optics) are also available.[4]

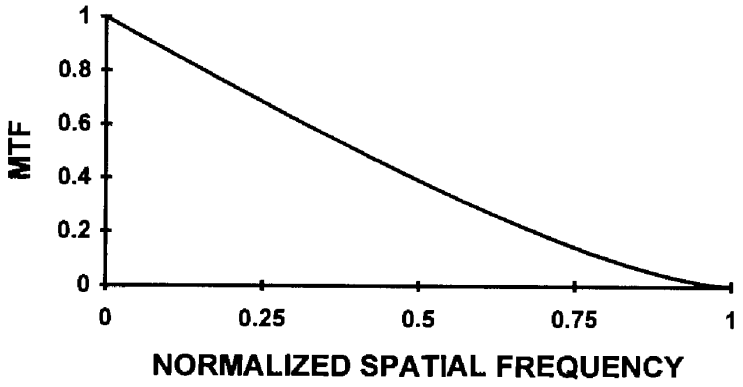


Figure 10-4. MTF_{OPTICS} for a circular aperture normalized to u_i/u_{iC}.

10.3. DETECTORS

The two-dimensional spatial response of a rectangular detector is

$$MTF_{DETECTOR}(u_i, v_i) = \left|sinc(d_H u_i)\right|\left|sinc(d_V v_i)\right| , \qquad (10\text{-}18)$$

where sinc(x) = sin(πx)/(πx) and d_H and d_V are the photosensitive detector sizes in the horizontal and vertical directions, respectively. Note that arrays are often specified by the pixel size. With 100% fill factor arrays, the pixel size is equal to the detector size. With finite fill factor arrays, the photosensitive detector dimensions are less than the pixel dimensions. A microlens or an anti-alias filter may optically modify the effective size (discussed in Section 10.3.4., *Optical Anti-Alias Filter*).

Although the detector MTF is valid for all spatial frequencies from $-\infty$ to $+\infty$, it is typically plotted up to the first zero (called the detector cutoff) which occurs at $u_{iD} = 1/d_H$ (Figure 10-5). Because d_H may be different than d_V, the horizontal and vertical MTF can be different.

A phase shift occurs when $u_i > 1/d_H$ and $v_i > 1/d_V$. Figure 10-5 illustrates the MTF without regard to the array Nyquist frequency. The analyst must add the array Nyquist frequency to the curve (see Section 8.3.2, *Detector Array Nyquist Frequency*, page 242). The MTF of virtual phase detectors is a complex expression.[5]

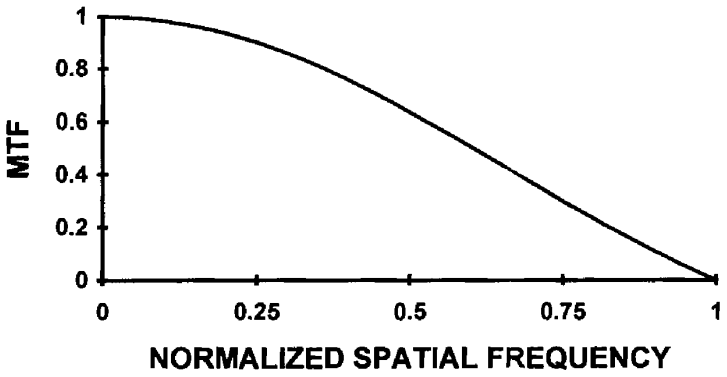


Figure 10-5. Horizontal detector MTF as a function of normalized spatial frequency $d_H u_i$. The MTF is usually plotted up to the first zero ($d_H u_i = 1$). For staring arrays, the array Nyquist frequency must be added: $u_{iN} = 1/(2d_{CCH})$.

10.3.1. DIFFUSION MTF

As the wavelength increases, photon absorption occurs at increasing depths in the detector material (see Section 4.1.1., *Spectral Response*, page 104). A photoelectron generated deep within the substrate will experience a three-dimensional random walk until it recombines or reaches the edge of a depletion region where the pixel electric field exists. A photoelectron generated under one well may eventually land in an adjoining well. This blurs the image and its effect is described by an MTF. Beyond 0.8 μm, diffusion (random walk) affects the detector MTF and the response is expressed by $MTF_{DETECTOR}MTF_{DIFFUSION}$. Imagery produced by near-IR sources will appear slightly blurry compared to imagery produced by a visible source.

The diffusion MTF[6] for a front-illuminated device is

$$MTF_{DIFFUSION}(u_i) = \frac{1 - \dfrac{\exp(-\alpha_{ABS} L_D)}{1 + \alpha_{ABS} L(u_i)}}{1 - \dfrac{\exp(-\alpha_{ABS} L_D)}{1 + \alpha_{ABS} L_{DIFF}}}, \qquad (10\text{-}19)$$

where α_{ABS} is the spectral absorption coefficient. Figure 4-2 (page 105) illustrated the absorption coefficient in bulk p-type silicon. The factor L_D is the depletion width and $L(u_i)$ is the frequency-dependent component of the diffusion length (L_{DIFF}) given by

$$L(u_i) = \frac{L_{DIFF}}{\sqrt{1 + (2\pi L_{DIFF} u_i)^2}}. \qquad (10\text{-}20)$$

The diffusion length typically ranges between 50 μm and 200 μm. The depletion width is approximately equal to the gate width. For short wavelengths ($\lambda < 0.6$ μm), α_{ABS} is large and lateral diffusion is negligible. Here, $MTF_{DIFFUSION}$ approaches unity. For the near IR ($\lambda > 0.8$ μm), the diffusion MTF may dominate the detector MTF (Figure 10-6). By symmetry, $MTF_{DIFFUSION}(u_i) = MTF_{DIFFUSION}(v_i)$ and $L(u_i) = L(v_i)$.

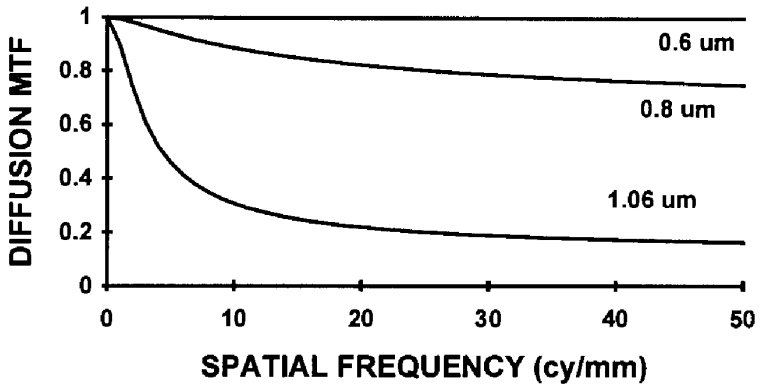


Figure 10-6. $MTF_{DIFFUSION}$ as a function of wavelength. The value L_D = 10 μm and L_{DIFF} = 100 μm. As the diffusion length increases, the MTF decreases. For comparison, a 20-μm detector will have a cutoff at 50 cycles/mm.

To account for the effects of lateral diffusion, Schumann and Lomheim[7] introduced a trapezoidal response approximation. This MTF only applies in the direction perpendicular to charge transport:

$$MTF_{DIFFUSION}(u_i) \approx sinc(d_{CCH}u_i)\, sinc[(d_{CCH} - \beta)u_i] \ , \qquad (10\text{-}21)$$

where β is the region over which the detector responsivity is flat (Figure 10-7). At the boundary between pixels, the trapezoidal response is 0.5 indicating equal probability of an electron going to either pixel.

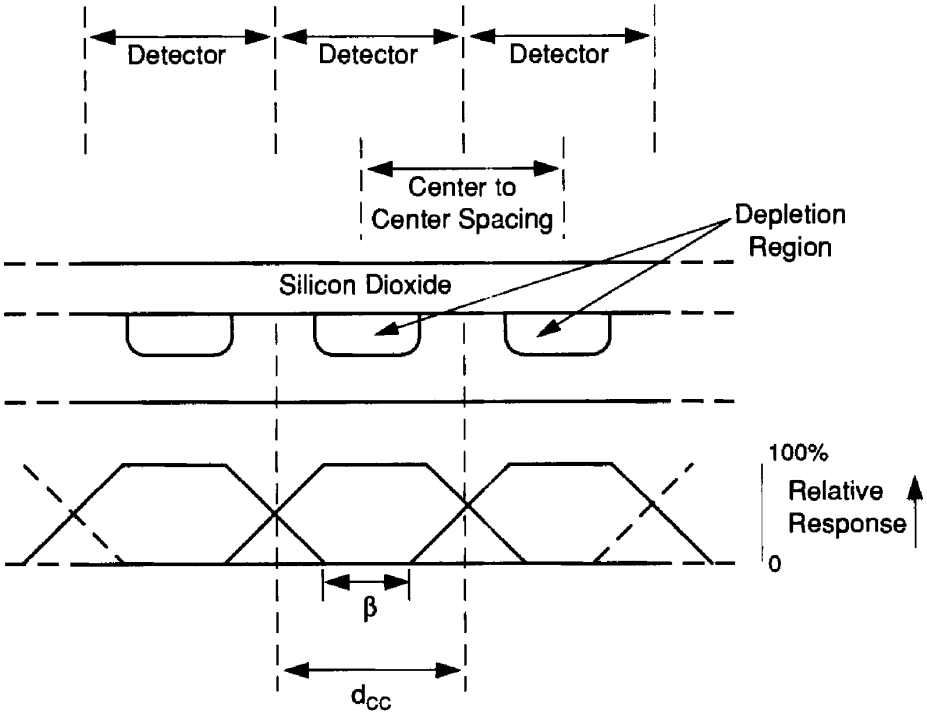


Figure 10-7. Trapezoidal approximation for long-wavelength photon absorption. Most of the charge goes to the charge well nearest to the photon absorption site.

10.3.2. CHARGE TRANSFER EFFICIENCY

CCD performance is characterized by the transfer efficiency and number of transfers (see Section 3.4., *Charge Transfer Efficiency*, page 74). Assuming vertical transfer, an MTF[8] that accounts for the incomplete transfer of electrons is

$$MTF_{CTE}(v_i) = \exp\left(-N_{TRANS}(1-\epsilon)\left[1-\cos\left(\frac{\pi v_i}{v_\epsilon}\right)\right]\right), \qquad (10\text{-}22)$$

where N_{TRANS} is the total number of charge transfers from a detector to the output amplifier and ϵ is the charge transfer efficiency for each transfer. It is the number of detectors multiplied by the number of CCD phases. When $N_{TRANS}(\epsilon - 1)$ is small, then $MTF(u_{iN}) \approx 1 - 2N_{TRANS}(1 - \epsilon)$.

This MTF depends upon the number of charge transfers. If the image is located next to the readout, the number of transfers is small. But if the image is at the extreme end of the array, the charge must be transferred across the entire array and through the serial readout register. For an average response, N_{TRANS} should be one-half the maximum number of transfers. This is mathematically equivalent to $(MTF_{CTE})^{1/2}$.

Transfers may be either in the vertical direction (column readout) or in the horizontal direction (row readout). Horizontal readout affects $MTF(u_i)$ and vertical readout affects $MTF(v_i)$. MTF_{CTE} only applies to the transfer readout direction. Figure 10-8 illustrates MTF_{CTE} at Nyquist frequency for several values of transfer efficiency. For consumer devices, CTE > 0.9999 and N_{TRANS} > 1500. For scientific applications, CTE > 0.999999 and N_{TRANS} can exceed 5000.

Example 10-1
Number of Transfers

What is the maximum number of transfers that exist in an array that contains 1000 × 1000 detector elements?

For a charge packet that is furthest from the sense node, the charge must be transferred down one column (1000 pixels) and across 1000 pixels for a total of 2000 pixels. The number of transfers is 4000, 6000, and 8000 for two-phase, three-phase, and four-phase devices, respectively.

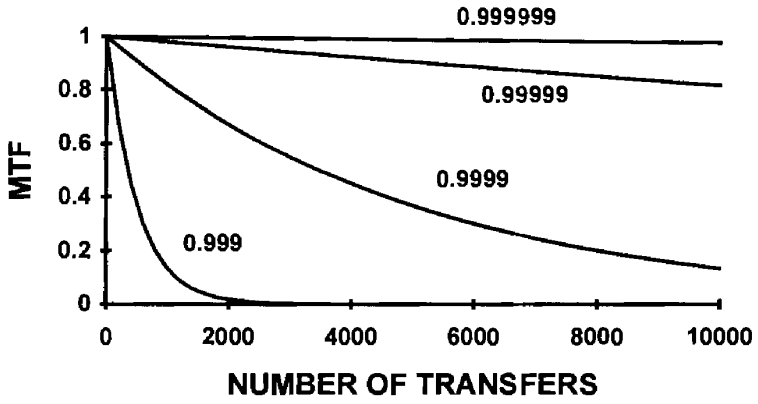


Figure 10-8. MTF_{CTE} at Nyquist frequency for several values of transfer efficiency. As the number of transfers increases, the efficiency must also increase to ensure that the MTF is not adversely affected.

10.3.3. TDI

TDI operation was described in Section 3.3.6., *Time Delay and Integration*, page 70. It is essential that the clock rate match the image velocity so that the photogenerated charge packet is always in sync with the image. Any mismatch will blur the image. Image rotation with respect to the array axes affects both the horizontal (TDI direction) and vertical (readout direction) MTFs simultaneously. For simplicity they are treated as approximately separable - $MTF(u_i,v_i) \approx MTF(u_i)MTF(v_i)$.

If the TDI direction is horizontal, velocity errors degrade[9] the detector MTF by

$$MTF_{TDI}(u_i) = \frac{\sin(\pi\, N_{TDI}\, d_{ERROR}\, u_i)}{N_{TDI} \sin(\pi\, d_{ERROR}\, u_i)} = \frac{sinc(N_{TDI}\, d_{ERROR}\, u_i)}{sinc(d_{ERROR}\, u_i)}, \quad (10\text{-}23)$$

where N_{TDI} is the number of TDI elements. The value d_{ERROR} is the difference between the expected image location and the actual location at the first pixel (Figure 10-9). After N_{TDI} elements, the image is displaced $N_{TDI}d_{ERROR}$ from the desired location. MTF_{TDI} is simply the MTF of an averaging filter for N_{TDI} samples displaced d_{ERROR} one relative to the next. As an averaging filter, the effective sampling rate is $1/d_{ERROR}$.

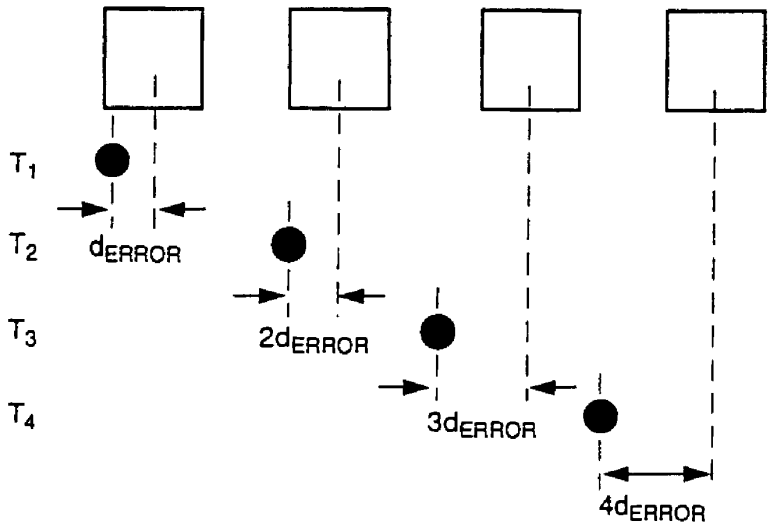


Figure 10-9. Definition of d_{ERROR}. With a velocity mismatch, the target falls further and further away from the desired location (on the center of the detector). After four TDI elements, the target is displaced from the detector center by $4d_{ERROR}$.

This is a one-dimensional MTF that apples in the TDI direction only. In image space

$$d_{ERROR} = |\Delta V| t_{INT} \quad mm \ , \tag{10-24}$$

where ΔV is the relative velocity error between the image motion and the charge packet "motion" or "velocity." The charge packet "velocity" is d_{CCH}/t_{INT} where t_{INT} is the integration time for each pixel.

Figure 10-10 portrays the MTF for two different relative velocity errors for 32 and 96 TDI stages. As the number of TDI stages increases, d_{ERROR} must decrease to maintain the MTF. Equivalently, the accuracy of knowing the target velocity must increase as N_{TDI} increases. Because the image is constantly moving, a slight image smear occurs[10] because the photogenerated charge is created at discrete times (e.g., at intervals of t_{CLOCK}). This linear motion MTF (discussed in Section 10.5.1., *Linear Motion*) is often small and therefore is usually neglected.

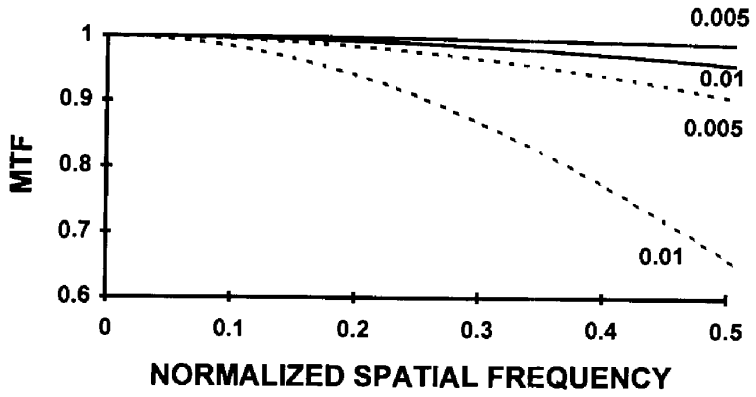


Figure 10-10. MTF degradation due to mismatch between the image velocity and the charge packet "velocity." The value d_{ERROR}/d_{CCH} equals 0.005 and 0.01. The spatial frequency axis is normalized to $d_{CCH}u_i$ and the MTF scale is expanded from 0.6 to 1.0. The solid lines represent $N_{TDI} = 32$ and the dashed lines are for $N_{TDI} = 96$.

TDI is also sensitive to image rotation. If the image motion subtends an angle θ with respect to the TDI rows (TDI direction), the image moves vertically $N_{TDI}d_{CCH}\tan(\theta)$ across the array. The MTF degradation in the vertical direction is

$$MTF_{TDI}(v_i) = \frac{\sin\left[\pi N_{TDI} d_{CCH} \tan(\theta)\, v_i\right]}{N_{TDI} \sin\left[\pi d_{CCH} \tan(\theta) v_i\right]}, \qquad (10\text{-}25)$$

where $MTF_{TDI}(v_i)$ is simply the MTF of an averaging filter for N_{TDI} samples displaced $d_{CCH}\tan(\theta)$ one relative to the next. Figure 10-11 illustrates the vertical MTF degradation due to image rotation for 32 and 96 stages. The spatial frequency is normalized to $d_{CCH}v_i$ where d_{CCH} is the *horizontal* detector pitch.

TDI offers the advantage that the signal-to-noise ratio increases by the square root of the number of TDI stages. This suggests that many TDI detectors should be used. The disadvantage is that the scan velocity must be tightly controlled as the number of TDI stages increases.

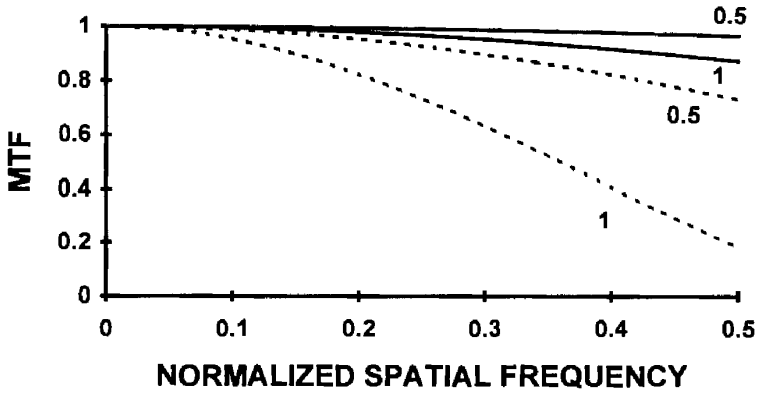


Figure 10-11. Vertical MTF degradation in the readout direction due to image rotation of 0.5 and 1 deg with respect to the array axis. The spatial frequency axis is normalized to $d_{CCH}v_i$. The solid lines represent $N_{TDI} = 32$ and the dashed lines are for $N_{TDI} = 96$.

10.3.4. OPTICAL ANTI-ALIAS FILTER

In color filter arrays, like-colored sensitive detector center-to-center spacings may be much larger than the detector pitch. This potentially increases aliasing (see Section 8.3.2., *Detector Array Nyquist Frequency*, page 242). The optical anti-alias filter blurs the image and effectively increases the optical area[11] of the detector. The filter, which consists of one or more birefringent crystals, is placed between the lens assembly and the detector array. Birefringent crystals break a beam into two components: the ordinary and the extraordinary. As illustrated in Figure 10-12, the detector collects light from a larger beam. Rays that would have missed the detector are refracted onto the detector. This makes the detector appear optically larger. While this changes the system MTF, the system sensitivity does not change. The light that is lost to adjoining areas is replaced by light refracted onto the detector.

The filter design depends upon the CFA design. If detectors sensitive to like colors are next to each other, the filter may not be required. If the detectors alternate, then an appropriately designed filter will make the detectors appear twice as large. Similarly, if the detectors are spaced three apart, then the filter will make the detector appear three times greater. This larger value (the effective detector size) is used in Equation 10-18 (page 275).

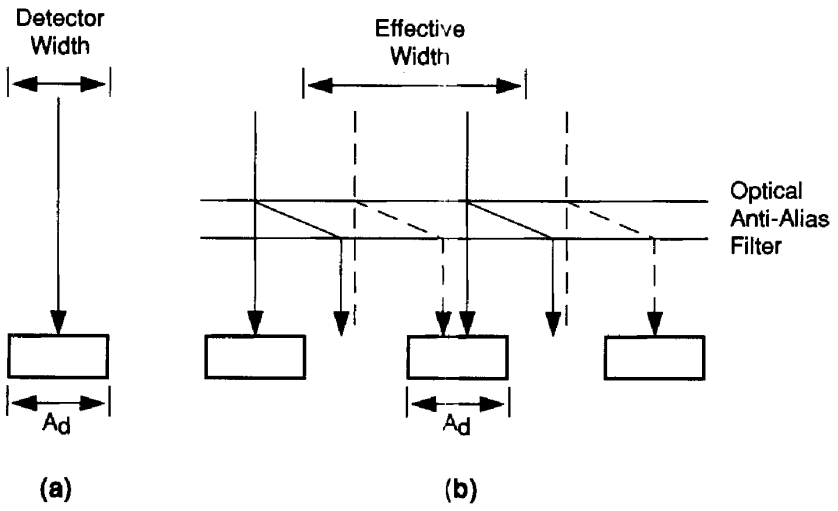


Figure 10-12. The birefringent filter increases the effective optical area of the detector. (a) No filter and (b) filter. Rays that would fall between detectors are refracted onto the detector.

Multiple crystals are used to change the effective detector size both vertically and horizontally. Because the spacing depends upon the CFA design, there is no unique anti-alias filter design. Clearly, if the detectors are unequally spaced, the Nyquist frequency for each color is different. Similarly, with different effective sizes, the MTFs are also different for each color. Complex algorithms are required to avoid color aliasing (see Example 5-1, page 167) and to equalize the MTFs. The anti-alias filter is essential for CFAs to reduce color moiré patterns and can be used in any camera to reduce aliasing.

Figure 10-13 illustrates how the detector MTF is modified by the birefringent crystal when the detector pitch is twice as large as the element size. While the filter reduces aliasing, it also reduces the overall system MTF. For scientific applications, this reduction may be too severe.

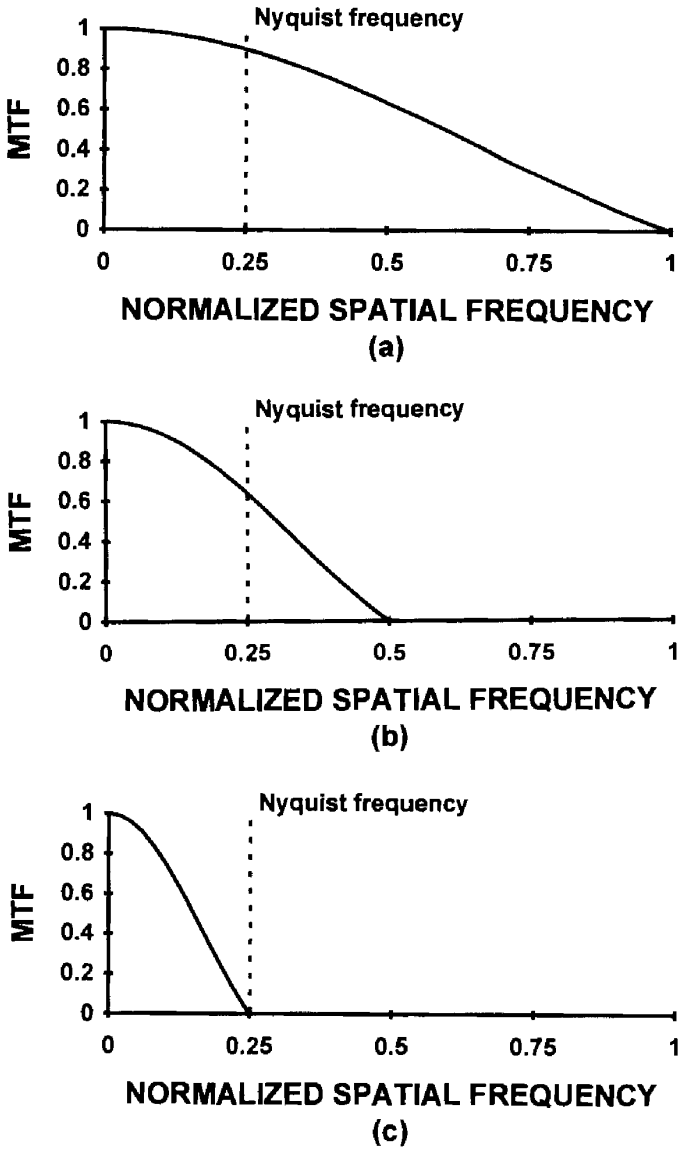


Figure 10-13. $MTF_{DETECTOR}$ modifications due to the anti-alias filter as a function of $d_H u_i$. The detector pitch is twice the detector element size. (a) No filter, (b) a filter that doubles the detector optical size, and (c) a filter that quadruples the effective detector size. The filter does not affect the array Nyquist frequency.

10.4. OPTICS-DETECTOR SUBSYSTEM

For many solid state cameras, the system MTF is dominated by the optics and detector MTFs. Here, the electronic MTFs maximize the signal. They are approximately unity over the spatial frequencies of interest. With electronic zoom, the effects of the display and observer MTFs can be minimized. Therefore, it is worthwhile to treat the optics and detector MTFs as a subsystem assembly and to examine this subsystem MTF.

When viewing a point source, diffraction-limited optics produces a diffraction pattern that consists of a bull's-eye pattern with concentric rings. The center is the Airy disk and its diameter is

$$d_{AIRY} = 2.44\frac{\lambda fl}{D_o} = 2.44\lambda F . \qquad (10\text{-}26)$$

Assume that the detector array has square detectors with 100% fill factor ($d_H = d_V = d_{CCV} = d_{CCH} = d$). When d_{AIRY} is larger than the detector size, the system is said to be optics-limited. Here, changes in the optics MTF (i.e., D_o or fl) significantly affect MTF_{SYSTEM}. If $d_{AIRY} < d$, the system is detector-limited and changes in the detector size affect MTF_{SYSTEM} at u_{iN}. Figure 10-14 illustrates $MTF_{OPTICS}MTF_{DETECTOR}$ at Nyquist frequency as a function of d/Fλ. It is the ratio of the optical cutoff to the detector cutoff: $u_{iC}/u_{iD} = d/F\lambda$.

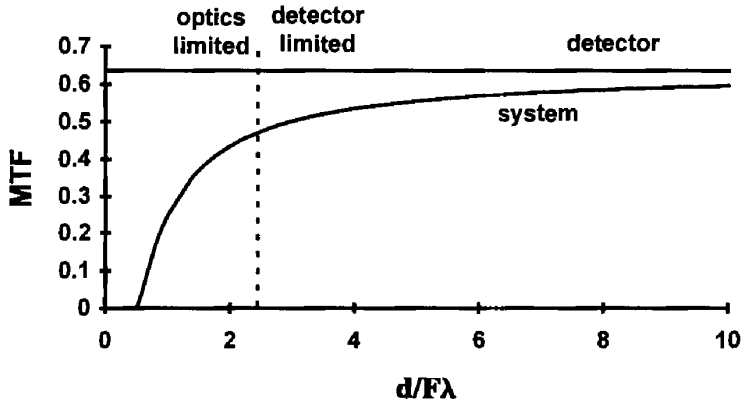


Figure 10-14. $MTF_{OPTICS}MTF_{DETECTOR}$ at Nyquist frequency as a function of d/Fλ. The fill factor is 100% ($d = d_H = d_V = d_{CCH} = d_{CCV}$). The vertical line indicates where the Airy disk diameter is equal to the detector size. The best MTF that can be achieved occurs when MTF_{OPTICS} is negligible compared to $MTF_{DETECTOR}$. Equivalently, $MTF_{OPTICS}MTF_{DETECTOR} \approx MTF_{DETECTOR} = 0.637$.

The MTF at Nyquist frequency is often used as a measure of performance. As the MTF increases, image quality should increase. Unavoidably, as the MTF increases, aliasing also increases[12] and image quality suffers. To avoid aliasing, the MTF at the Nyquist frequency must be zero. This requires an infinite f-number lens or an optical anti-alias filter (discussed in the previous section).

Smaller chips make smaller cameras (we live in a world were smaller is presumed more desirable). However, to maintain the MTF the f-number must decrease. For visible systems ($\lambda \approx 0.5\ \mu m$), the transition from the optics-limited to detector-limited case occurs when $F = d/1.22$. If $d = 10\ \mu m$, then F must be greater than 8.2 to enter the optics-limited condition (Figure 10-15).

For a small format chip, modest f-numbers provide an optics-limited camera system. For low illumination level imagery, the user will probably switch to a low f-number lens. If the camera enters the detector-limited region, pixelation becomes evident and image quality suffers. Large format chips are detector-limited for the more common f-number lenses. The transition from detector-limited to optics-limited was arbitrarily selected as $d = d_{AIRY}$. The transition is actually gradual.

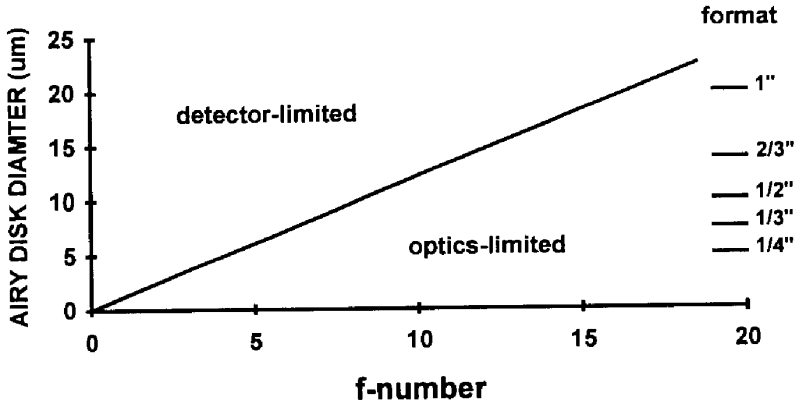


Figure 10-15. Airy disk diameter as a function of f-number when $\lambda = 0.5\ \mu m$. The nominal pixel sizes for the various video formats are from Table 3-3 (page 99).

With wet-film cameras, in most cases, more scene detail can be discerned by enlarging the print. This occurs because the silver granules in the film are very small compared to the Airy disk. That is, the camera system is almost always optics-limited. Enlarging the image provides more detail. With solid state cameras, this is not true. Electronic zoom (which is analogous to print enlargement) provides more detail only up to the point where individual pixels can be seen. There is no more detail available.

The output voltage (for square detectors) is given by the simple camera formula:

$$v_{CAMERA} = \frac{1}{4}\left(\frac{dD_o}{fl}\right)^2 \int_{\lambda_1}^{\lambda_2} R(\lambda)\, M_{illum}(\lambda)\, d\lambda \ . \qquad (10\text{-}27)$$

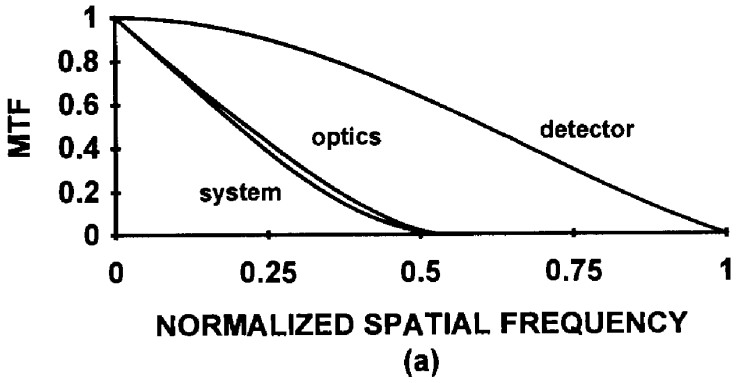
Decreasing the focal length, increases the MTF at u_{iN}. It also increases the camera output (improves sensitivity). But decreasing the focal length increases the scene spatial frequencies relative to the detector response. That is, the system's response moves from being detector-limited to being optics-limited. Thus, a tradeoff exists between sensitivity and image quality (as defined by the MTF).

While parametric analyses are convenient, absolute values are lost. The MTF at Nyquist frequency is important. However, it is even more important to know the relationship between the scene spatial content and the actual value of the Nyquist frequency. In object space, as the focal length decreases, the absolute value of the Nyquist frequency also decreases. It is instructive to see the effects of d/Fλ on computer-generated imagery. Details of the simulation are provided in Reference 13. Figure 10-16 illustrates the original scene.

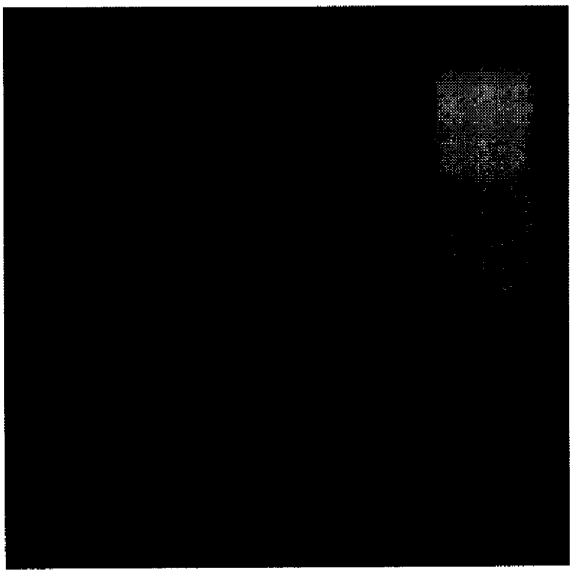


Figure 10-16. Image created by the *System Image Analyzer* software.[14]

When $d/F\lambda = 0.5$, $MTF(u_N) = 0$ and the optics have low-pass filtered the scene. Here, no aliasing can occur. Figure 10-17a provides the MTFs and Figure 10-17b illustrates the resultant imagery which includes a Butterworth post-reconstruction filter where N = 10 (discussed in Section 10.6.4., *Post-Reconstruction Filter*). While the low-pass filtering action of the optics removed all aliasing, it also significantly attenuated the in-band frequency amplitudes.



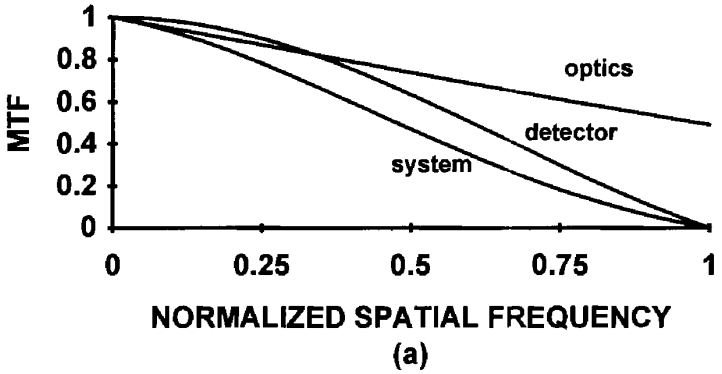
(a)

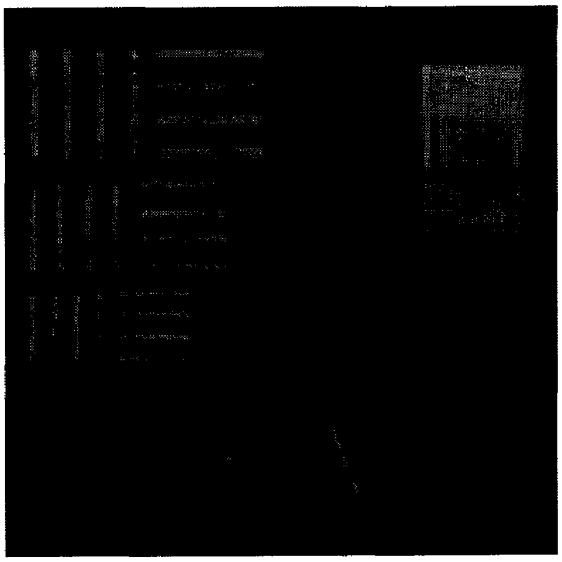


(b)

Figure 10-17. (a) MTF_{OPTICS} and $MTF_{DETECTOR}$ when $d/F\lambda = 0.5$ and (b) reconstructed image including a Butterworth filter where N = 10. The optics has significantly blurred the image and no aliasing exists. Created by the *System Image Analyzer* software.[14]

Figures 10-18 and 10-19 illustrate the cases where $d/F\lambda = 2.44$ and 10, respectively. Note that the MTFs illustrated in Figures 10-18a and 10-19a do not include the reconstruction filter whereas the imagery includes a 10th-order Butterworth reconstruction filter.

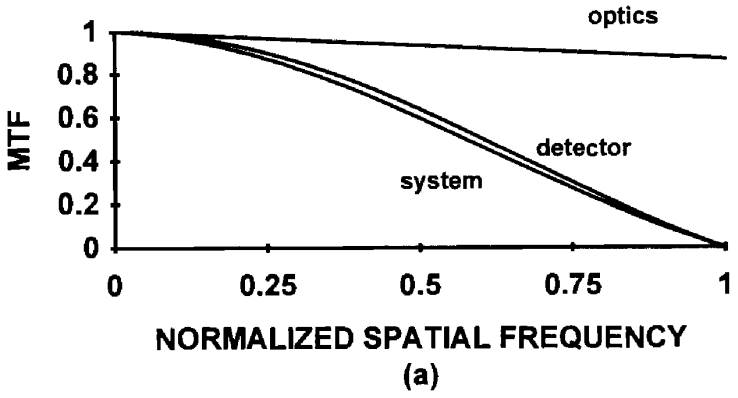




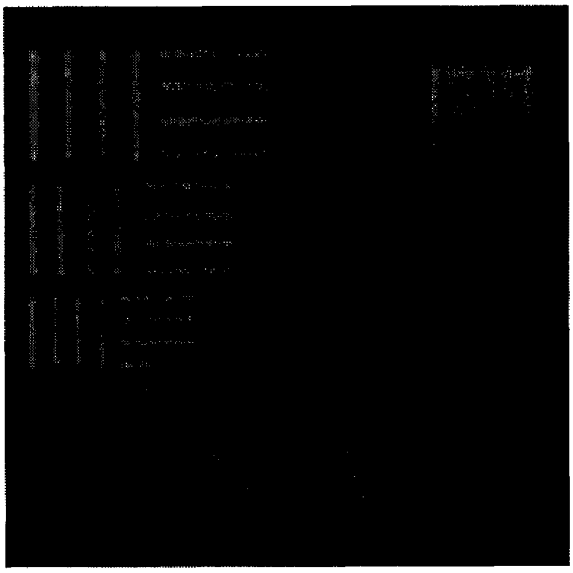
(b)

Figure 10-18. (a) MTF_{OPTICS} and $MTF_{DETECTOR}$ when $d/F\lambda = 2.44$ and (b) reconstructed image including a Butterworth filter where N = 10.

Careful examination of Figure 10-19b will reveal that the edges are sharper compared to Figure 10-18b but aliasing has increased. However, the effect is not dramatic when using a high order Butterworth reconstruction filter. At Nyquist frequency, $MTF_{OPTICS}MTF_{DETECTOR}$ increased from 0.472 to 0.592. In terms of imagery, whether $d/F\lambda = 10$ is better than $d/F\lambda = 2.44$ depends on the scene spectral content and the reconstruction filter used. The amount of aliased signal is scene-dependent and the amount of aliasing accepted depends on personal preference.



(a)



(b)

Figure 10-19. (a) MTF_{OPTICS} and $MTF_{DETECTOR}$ when $d/F\lambda = 10$ and (b) reconstructed image including a Butterworth filter where $N = 10$.

10.5. MOTION

Motion blurs imagery. When motion is fast compared to the detector integration time, details become blurred in a reproduced image. In real-time imagery, edges may appear fuzzy to the observer even though any one frame may provide a sharp image. The eye integration time blends many frames. The effects of motion during the entire integration and human interpretation process must be considered.

Linear motion includes both target movement (relative to the imaging system) and motion of the imaging system (stationary target). High frequency random motion is simply called jitter. Typically, an imaging system is subjected to linear and random motion simultaneously:

$$MTF_{MOTION} = MTF_{LINEAR}\, MTF_{RANDOM} \,. \tag{10-28}$$

In a laboratory, the system and test targets may be mounted on a vibration-isolated stabilized table. Here, no motion is expected so that $MTF_{MOTION} = 1$.

10.5.1. LINEAR MOTION

The OTF degradation due to horizontal linear motion is:

$$OTF_{LINEAR}(u) = sinc(a_L u) \,, \tag{10-29}$$

where a_L is the distance the target edge moved across the image plane. It is equal to $v_R \Delta t$ where v_R is the relative image velocity between the sensor and the target. For scientific and machine vision applications, the exposure time is equal to the detector integration time. But observer's eye blends many frames of data and the eye integration time should be used. Although the exact eye integration time is debatable, the values most often cited are between 0.1 and 0.2 s.

Figure 10-20 illustrates the OTF due to linear motion as a fraction of the detector size, d. Recall that the MTF is the magnitude of the OTF. Linear motion only affects the MTF in the direction of the motion. As a rule-of-thumb, when the linear motion causes an image shift less than about 20% of the detector size, it has minimal effect on system performance.

As the motion increases, a phase reversal occurs which is represented by a negative OTF. Here, periodic black bars appear white and periodic white bars appear black. Figure 10-21 illustrates a test pattern smeared by linear motion. At cutoff (where the system MTF approaches the first zero), the bar pattern cannot be resolved. Phase reversal occurs above cutoff.

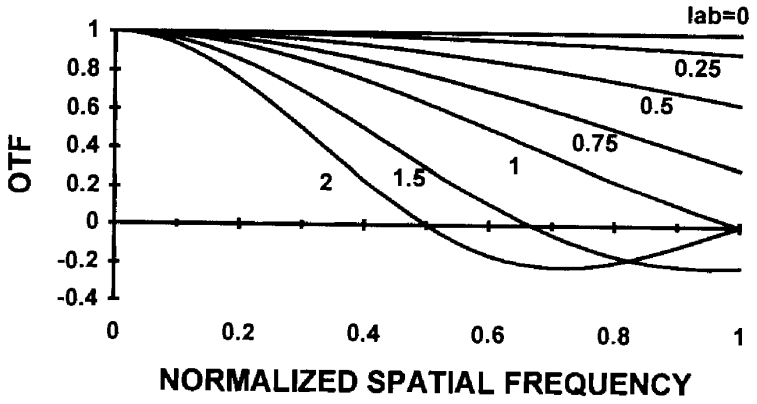


Figure 10-20. OTF_{LINEAR} as a function of normalized spatial frequency du_i. The curves represent values of a_L/d. In the laboratory a_L is usually zero. The negative OTF represents phase reversal. The MTF is always positive.

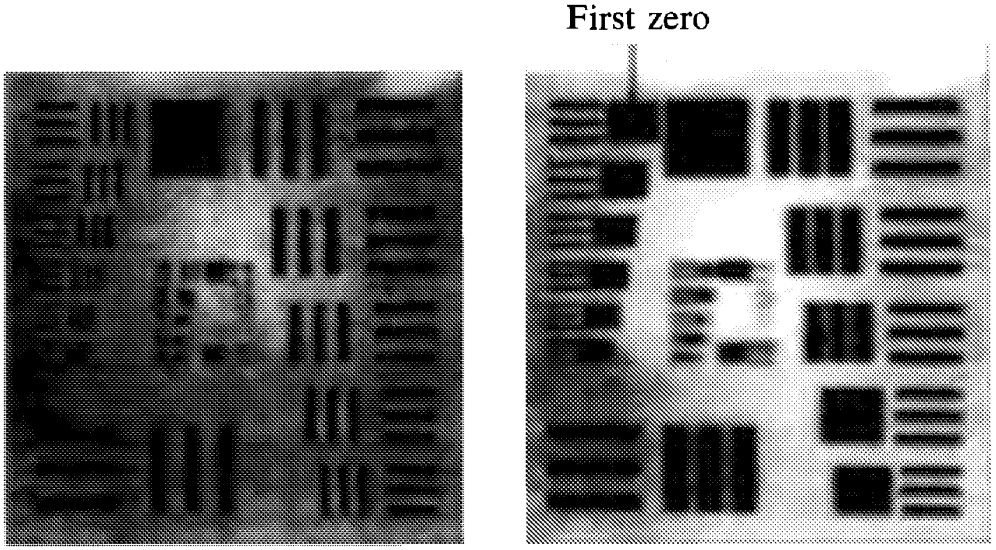


Figure 10-21. Linear motion smears imagery. Because the motion is horizontal, the vertical resolution is maintained. When the bar target frequency is equal to the first zero of OTF_{LINEAR}, the bars all blend together. Higher spatial frequency bars illustrate phase reversal: There appear to be two black bars on a gray background. (From Reference 15: by courtesy of G. L. Conrad).

10.5.2. RANDOM MOTION (JITTER)

With high frequency motion, it is assumed that the image has moved often during the integration time so that the central limit theorem is valid. The central limit theorem says that many random movements can be described by a Gaussian distribution. The Gaussian MTF is

$$MTF_{RANDOM}(u_i) = e^{-2\pi^2 \sigma_R^2 u_i^2}, \tag{10-30}$$

where σ_R is the rms random displacement in millimeter. Figure 10-22 illustrates the random motion MTF. As a rule-of-thumb, when the rms value of the random motion is less than about 10% of d (detector size), system performance is not significantly affected. Jitter is considered equal in all directions and is included in both the horizontal and vertical system MTFs. High frequency motion blurs imagery (Figure 10-23).

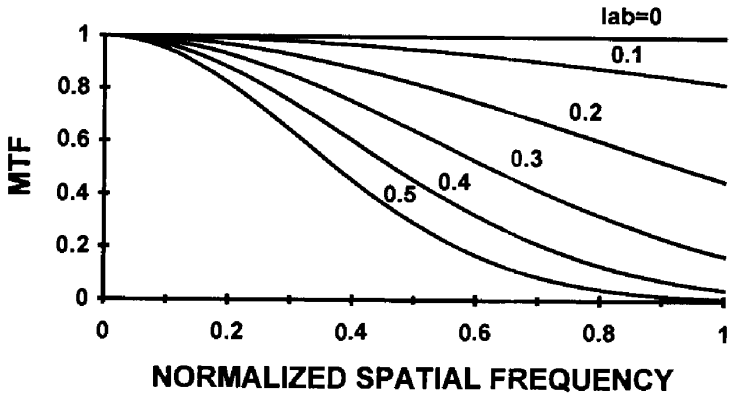
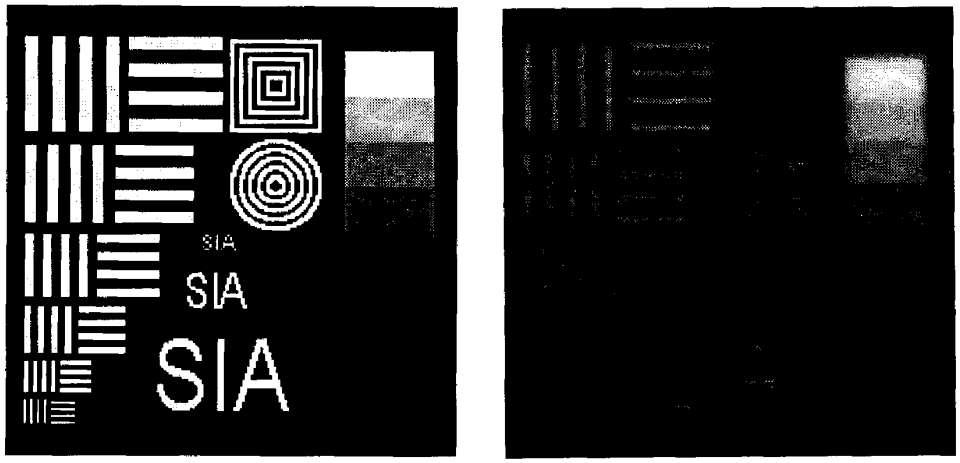


Figure 10-22. MTF degradation due to high frequency random (Gaussian) movement as a function of $\sigma_R u_i$. In the laboratory, σ_R is usually zero.



(a) (b)

Figure 10-23. Random motion blurs imagery. (a) Original image, (b) two-dimensional random motion. Generated[14] by SIA.

10.6. ELECTRONIC FILTERS

When filter response is provided as a function of electrical frequency, it is denoted by $H(f_e)$ or $H(f_v)$. When the electrical frequency is expressed in object space or image space units, the filter impulse response is labeled as an MTF. Boost filters may be used to enhance the signal at selected spatial frequencies. Both analog and digital filters can be used.

10.6.1. ANTI-ALIAS ANALOG FILTER

Ideally, $H(f_e)$ is a filter with MTF of unity up to the array Nyquist frequency and then drops to zero. This filter maximizes the SNR by attenuating out-of-band amplifier noise and passing the signal without attenuation. The ideal filter is unrealizable but can be approximated by N^{th}-order Butterworth filters:

$$H_{LOWPASS}(f_e) = \frac{1}{\sqrt{1 + \left(\frac{f_e}{f_{e3dB}}\right)^{2N}}}, \tag{10-31}$$

where f_{e3dB} is the frequency at which the power is one-half or the amplitude is 0.707. As $N \to \infty$, $H_{LOWPASS}(f_e)$ approaches the ideal filter response with the cutoff frequency of f_{e3dB} (Figure 10-24).

When f_{e3dB} is approximately equivalent to the array Nyquist frequency, the sampling theorem can be satisfied. However, square waves (bar targets) will appear as sinusoids. Thus, f_{e3dB} must be much higher to preserve the square-wave response.

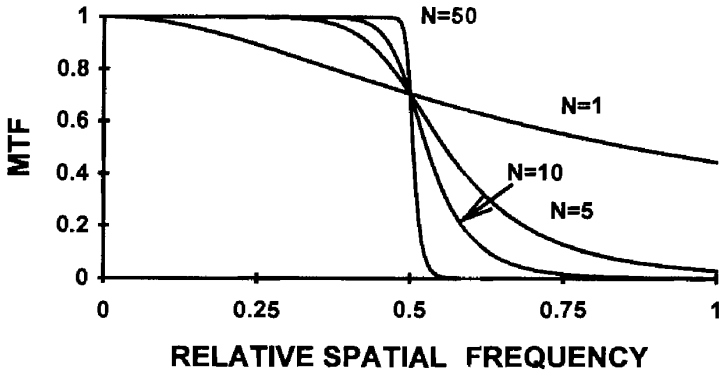


Figure 10-24. Butterworth filters for N = 1, 5, 10, and 50. The value $f_{e3dB} = 0.5$.

10.6.2. DIGITAL FILTERS

There are many available image processing algorithms. Only a few of these can be described mathematically in closed-form and only these can be included in an end-to-end system performance model. The performance of the remaining algorithms can be inferred only by viewing the system output for a few representative inputs. Because the system is not spatially invariant, predicting system performance when viewing any other target is pure conjecture.

The sampling process replicates the frequency spectrum at nf_{eS} (see Section 8.1., *Sampling Theorem*, page 234). Similarly, digital filter response is symmetrical about the Nyquist frequency and repeats at multiples of the sampling frequency. The highest frequency of interest is the Nyquist frequency.

Digital filters process data that reside in a memory. The units assigned to the filter match the units assigned to the data arrays. With one-to-one mapping of pixels to datels, the filter sampling frequency is the same as the array sampling frequency. With this mapping, each filter coefficient processes one pixel value. Digital filters can be two-dimensional.

There are two general classes of digital filters[16]: infinite impulse response (IIR) and finite impulse response (FIR). Both have advantages and disadvantages. The FIR has a linear phase shift whereas the IIR does not. IIR filters tend to have excellent amplitude response whereas FIR filters tend to have more ripple. FIR filters are typically symmetrical in that the weightings are symmetrical about the center sample. They are also the easiest to implement in hardware or software.

Figure 10-25 illustrates two FIR filters. The digital filter design software provides the coefficients, A_i. The central data point is replaced by the digital filter coefficients as they operate on the neighboring data points. The filter is then moved one data point and the process is repeated until the entire data set has been operated on. Edge effects exist with any digital filter. The filter illustrated in Figure 10-25a requires seven inputs before a valid output can be achieved. At the very beginning of the data set, there are insufficient data points to have a valid output at data point 1, 2, or 3. The user must be aware of edge effects at both the beginning and the end of his data record. In effect, this states that edges cannot be filtered.

The following MTF equations are only valid where there are no edge effects. For FIR filters where the multiplicative factors (weightings) are symmetrical about the center, the filter is mathematically represented by a cosine series (sometimes called a cosine filter). With its frequency response transposed to electrical frequency, an FIR filter with an odd number of samples (also called taps) provides

$$H_{DFILTER}(f_e) = \left| \sum_{k=0}^{\frac{N-1}{2}} A_k \cos\left(\frac{2\pi k f_e}{f_{eS}} \right) \right| . \qquad (10\text{-}32)$$

For an even number of samples,

$$H_{DFILTER}(f_e) = \left| A_o + \sum_{k=1}^{\frac{N}{2}} A_k \cos\left(\frac{2\pi (k-1) f_e}{f_{eS}} \right) \right| . \qquad (10\text{-}33)$$

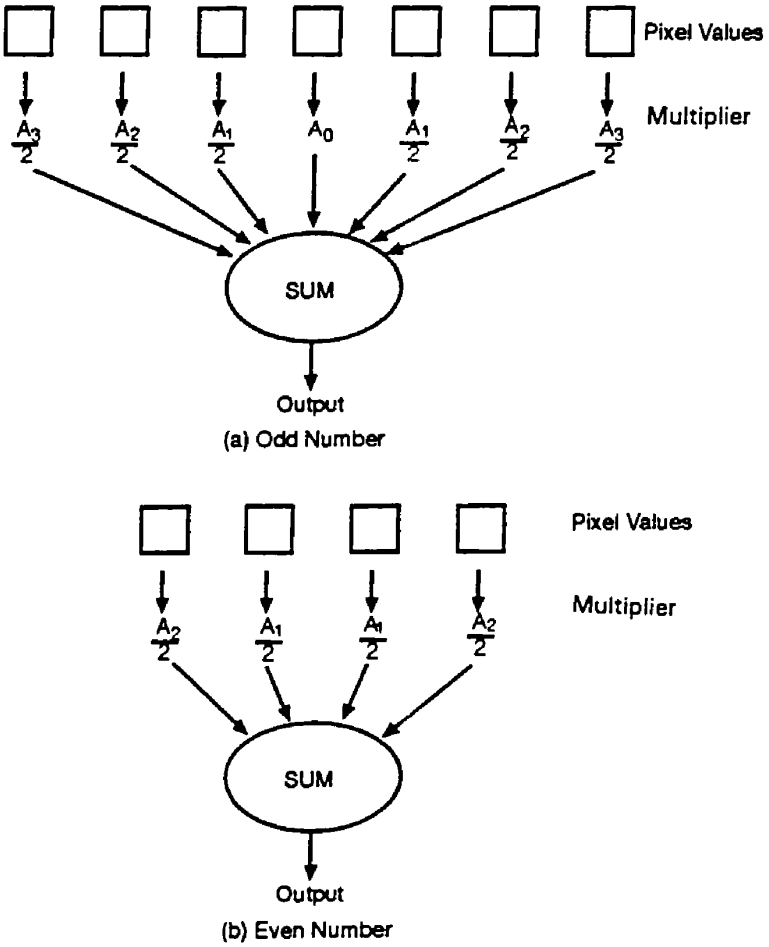


Figure 10-25. Symmetrical digital filters. (a) 7-tap (odd number) filter and (b) 4-tap (even number) filter.

The sum of the coefficients should equal unity so that the $H_{DFILTER}(f_e = 0)$ is one:

$$\sum A_k = 1 \ . \tag{10-34}$$

Although the above equations provide the filter response in closed form, the response of a real filter is limited by the ability to implement the coefficients. The smallest increment is the LSB.

With an averaging filter,[9] all the multipliers shown in Figure 10-25 are equal. When N_{AVE} datels are averaged, the equivalent MTF is

$$H_{AVE}(f_e) = \left| \frac{\sin\left(N_{AVE}\pi \frac{f_e}{f_{eS}}\right)}{N_{AVE}\sin\left(\pi \frac{f_e}{f_{eS}}\right)} \right| . \tag{10-35}$$

The first zero of this function occurs at f_{eS}/N_{AVE}.

Averaging samples together is called binning or super pixeling. It provides the same MTF as if the detector elements were proportionally larger. That is, averaging two samples together provides the same MTF as a single detector element that is twice as large. Cameras that operate in either the pseudo-interlace or the progressive scan modes will have a different vertical MTF for each mode. In the pseudo-interlace mode, two pixels are averaged together. If $d_H = d_{CCH}$, then

$$\begin{aligned} MTF_{DETECTOR}MTF_{DFILTER} &= sinc(d_H f_e)\frac{sinc\left(N_{AVE}\frac{f_e}{f_{eS}}\right)}{sinc\left(\frac{f_e}{f_{eS}}\right)} \\ &= sinc(N_{AVE}d_H f_e) . \end{aligned} \tag{10-36}$$

where the effective detector width is $N_{AVE}d_H$.

10.6.3. SAMPLE-AND-HOLD

After the digital-to-analog converter (DAC), the analog signal changes only at discrete times. The sample-and-hold circuitry within the DAC extends the data into a continuous analog signal. The MTF of a zero-order sample-and-hold when transposed into image space is:

$$MTF_{S\&H} = sinc\left(\frac{u_i}{u_{iS}}\right) , \tag{10-37}$$

where $u_{iS} = 1/d_{CCH}$. Figure 10-26 illustrates the sample-and-hold MTF as a function of normalized spatial frequency.

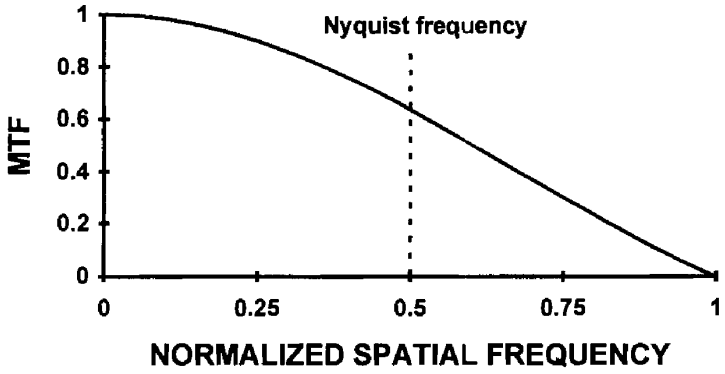


Figure 10-26. Zero-order sample-and-hold MTF normalized to $d_{CCH}u_i$. The sample-and-hold acts as a low-pass filter.

10.6.4. POST-RECONSTRUCTION FILTER

After the digital-to-analog conversion, the image still appears blocky due to the discrete nature of the conversion. The ideal post-reconstruction filter removes all the higher order frequencies (Figure 10-27) such that only the original smooth signal remains. The output is delayed but this is not noticeable on most imagery.

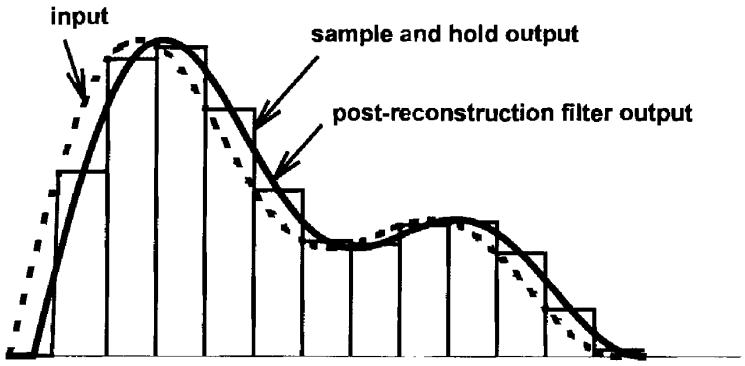


Figure 10-27. The post-reconstruction filter removes the blocky (stair-step) effect created by the sample-and-hold circuitry within the DAC.

Ideally, $H(f_v)$ is a filter with MTF of unity up to the array Nyquist frequency and then drops to zero. The ideal filter is unrealizable but can be approximated by N^{th}-order Butterworth filters:

$$H_{LOWPASS}(f_v) = \frac{1}{\sqrt{1 + \left(\frac{f_v}{f_{v3dB}}\right)^{2N}}}, \tag{10-38}$$

where f_{v3dB} is the frequency at which the power is one-half or the amplitude is 0.707. As $N \to \infty$, $H_{LOWPASS}(f_v)$ approaches the ideal filter response with the cutoff frequency of f_{v3dB}. Real filters will have some roll-off and f_{v3dB} should be sufficiently large so that it does not affect the in-band MTF. The post-reconstruction filter can be of the same functional form as the anti-alias filter (see Section 10.6.1., page 295) but serves a different purpose. It removes the spurious frequencies created by the sampling process.

For analog video output, A low-pass filter is used as a post-reconstruction filter. This filter affects only the horizontal signal. While the video bandwidth has been standardized (NTSC, PAL, and SECAM are 4.2, 5.5, and 6 MHz, respectively), the filter design has not. Thus, different cameras may have different post-reconstruction filters and therefore different horizontal MTFs even though they are built to the same video standard. No reconstruction filter is used in the vertical direction. Here, the display and human visual response provide the reconstruction. As a result of different detector sizes (d_V and d_H) and horizontal analog filters, the MTFs in the vertical and horizontal directions can be quite different.

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Example 10-2
POST-RECONSTRUCTION FILTER

What is the required spatial frequency cutoff for an ideal post-reconstruction filter if the desired output is EIA 170 and there are 640 horizontal detectors in the array?

For EIA 170, t_{LINE} is 52.09 μs. The Nyquist frequency in the video domain is

$$f_{VN} = \frac{1}{2}\frac{640}{52.09\times10^{-6}} = 6.14\ Mhz \qquad (10\text{-}39)$$

The bandwidth necessary to transmit the detector data must exceed 6.14 MHz to avoid roll-off effects. This is a greater bandwidth than allowed by the EIA 170 standard. However, the camera output only has to conform to EIA 170 timing so that the information can be displayed on a conventional monitor.

10.6.5. BOOST

MTF degradation caused by the various subsystems can be partially compensated with electronic boost filters. Boost filters also amplify noise so that the signal-to-noise ratio may degrade. For systems that are contrast-limited, boost may improve image quality. However, for noisy images, the advantages of boost are less obvious. As a result, these filters are used only in high contrast situations (typical of consumer applications) and are not used in scientific applications where low signal-to-noise situations are often encountered. Historically, each subsystem was called an "aperture." Therefore, boost provided "aperture correction." This should not be confused with the optics MTF where the optical diameter is the entrance aperture. "Aperture correction" has been used in video for years.

The boost amplifier can either be an analog or a digital circuit with peaking that compensates for any specified MTF roll-off. The MTF of a boost filter, by definition, exceeds one over a limited spatial frequency range. When used with all the other subsystem MTFs, the resultant MTF_{SYSTEM} is typically less than one for all spatial frequencies. Excessive boost can cause ringing at sharp edges. The boost algorithm should enhance signal amplitudes with frequencies below the Nyquist because reconstruction usually limits the response to the Nyquist frequency.

A variety of boost circuits are available.[17] One example is the tuned circuit with response

$$H_{BOOST}(f_v) = \frac{1}{\sqrt{\left(1 - \left(\frac{f_v}{f_{BOOST}}\right)^2\right)^2 + \left(\frac{f_v}{Qf_{BOOST}}\right)^2}}, \quad (10\text{-}40)$$

where Q is the quality factor and equal to boost amplitude when $f_v = f_{BOOST}$.

Although illustrated in the video domain, boost can be placed in any part of the circuit where a serial stream of data exists. By appropriate selection of coefficients, digital filters can also provide boost. MTF_{BOOST} can also approximate the inverse of MTF_{SYSTEM} (without boost). The combination of MTF_{BOOST} and MTF_{SYSTEM} can provide unity MTF over spatial frequencies of interest. This suggests that the reproduced image will precisely match the scene in every spatial detail.

10.7. CRT-BASED DISPLAY

For most electronic imaging systems, the display medium acts as a reconstruction filter. Displays do not completely attenuate the replicated frequency amplitudes created by the sampling process. The HVS further reduces the sampling remnants so that the perceived image appears continuous with minimal sampling artifacts. Therefore, displays cannot be analyzed in isolation but must be considered as part of the display/observer system.

The display MTF is a composite that includes both the internal amplifier and the CRT responses. Implicit in the MTF is the conversion from input voltage to output display brightness. Although not explicitly stated, the equation implies radial symmetry and the MTFs are the same in both the vertical and horizontal directions. That is, the MTF is considered separable and $MTF_{CRT}(u_d, v_d) = MTF_{CRT}(u_d)MTF_{CRT}(v_d)$ and $MTF_{CRT}(v_d) = MTF_{CRT}(u_d)$. While this may not be precisely true, the assumption is adequate for most calculations.

The amplifier bandwidth is not a number that is often useful to the user. We must assume that the manufacturer selected an adequate bandwidth to provide the display resolution. For example, a 1600 × 1200-disel display must have a wider bandwidth than a 1280 × 1024-disel display by a factor of approximately $1600/1280 = 1.25$. MTF_{CRT} includes both the electronics MTF and spot diameter. For an infinitesimal input, the spot diameter is affected by the video bandwidth. That is, the minimum spot diameter is the equivalent point spread function.

It is reasonable to assume that the resultant spot is Gaussian (see Section 7.3., *Spot Size*, page 210). Then,

$$MTF_{CRT}(u_d) \approx e^{-2\pi^2 \sigma_{SPOT}^2 u_d^2} = e^{-2\pi^2 \left(\frac{S}{2.35} u_d\right)^2}, \tag{10-41}$$

where σ_{SPOT} is the standard deviation of the Gaussian beam profile and S is the spot diameter at FWHM. These parameters must have units of millimeters because the frequency has units of cycles/mm. The spot diameter is

$$S = \sqrt{8\ln(2)}\ \sigma_{SPOT} = 2.35\,\sigma_{SPOT}\ . \tag{10-42}$$

If the spot size is not specified, then σ_{SPOT} can be estimated from the TV limiting resolution. With the TV limiting resolution test, an observer views a wedge pattern and selects that spatial frequency at which the converging bar pattern can no longer be seen. The display industry has standardized the bar spacing to $2.35\sigma_{SPOT}$.

If N_{TV}/PH is the TV limiting resolution and N_{TV} lines are displayed on a monitor, then $H_{MONITOR} \approx 2.35\sigma_{SPOT}N_{TV}$. When transposed to image space,

$$MTF_{CRT}(u_i) \approx e^{-2\pi^2 \left(\frac{VFOVfl}{2.35 N_{TV}} u_i\right)^2}\ . \tag{10-43}$$

For staring arrays with N_V displayed vertical lines,

$$MTF_{CRT}(u_i) = e^{-2\pi^2 \left(\frac{(N_V - 1) d_{CCV} + d_V}{2.35 N_{TV}} u_i\right)^2}\ . \tag{10-44}$$

Figure 10-28 illustrates $MTF_{DETECTOR}$ and $MTF_{DISPLAY}$. The display spot size is independent of the detector size and the display resolution is independent of the number of detector elements. Matching the display resolution (number of pixels) to the number of detector elements does not uniquely specify the display MTF as suggested by Equation 10-44. For example, suppose an array contained 1000 elements horizontally. A monitor that can resolve 1000 pixels may not provide good imagery if the resolution/addressability ratio (RAR) is large. Equation 10-44 is only valid when RAR $\approx$ 1. The RAR was described in Section 7.6., *Addressability* (page 222).

Many consumer CCD cameras match the number of vertical detectors to the number of active video lines. With consumer televisions, $N_{TV} \approx 0.7N_V$. Thus, the video standard uniquely defines the CRT MTF. For 100% fill factor arrays,

$$MTF_{CRT}(u_i) \approx e^{-2\pi^2 \left(\frac{d_{CCV}}{1.645} u_i\right)^2}\ . \tag{10-45}$$

At Nyquist frequency, $MTF_{CRT} = 0.161$. That is, the "standard" design effectively reduces sampling effects by attenuating the amplitudes above u_{iN}. However, the in-band amplitudes are unavoidably attenuated also.

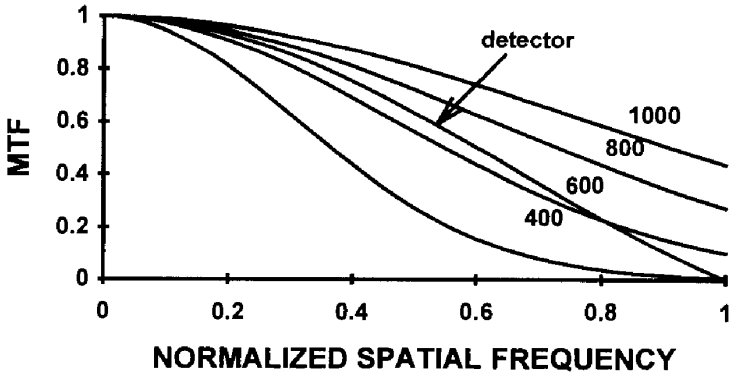


Figure 10-28. $MTF_{DISPLAY}$ as a function of $d_{CCV}v_i$ for four different TV limiting resolutions when $N_V = 480$. The display MTF limits most systems. The Nyquist frequency (not shown) is at $d_{CCV}v_i = 0.5$.

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Example 10-3
DISPLAY MTF

What should the display resolution be to maximize the system MTF?

Equations 10-43 or 10-44 are used to calculate image MTF when the input is a sinusoid. The Nyquist frequency is used most often when specifying system response. For EIA 170, $N_V = 485$. Inserting $d_V u_i = 0.5$ into Equation 10-45 provides

$$MTF_{CRT}(u_{iN}) = e^{-2\pi^2\left(\frac{0.5}{2.35}\frac{485}{N_{TV}}\right)^2} . \qquad (10\text{-}46)$$

For a 100% fill factor array, the detector MTF is 0.63 at u_{iN}. Figure 10-29 illustrates the detector and display MTF at Nyquist frequency. The display resolution must increase to 1400 TVL/PH for display MTF to be 0.90 at the Nyquist frequency. This suggests that most imaging systems are display resolution limited. This result is based upon the assumption that the beam profile is Gaussian. A different shaped beam (i.e., flat-topped), will provide a different relationship between TV limiting resolution and MTF.

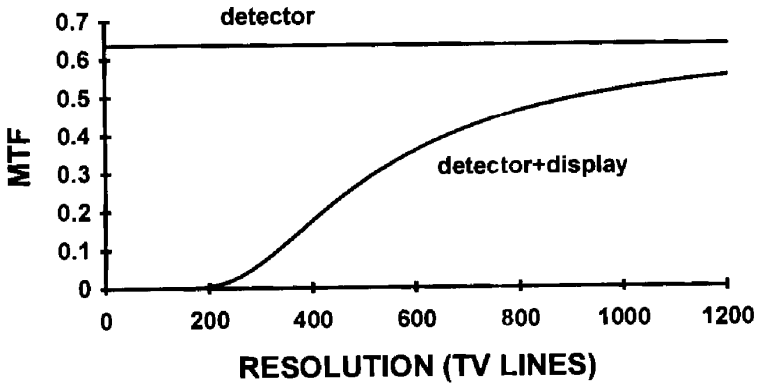


Figure 10-29. $MTF_{DETECTOR}MTF_{DISPLAY}$ at Nyquist frequency as a function of TV liming resolution. The detectors are contiguous so that the center-to-center spacing is equal to the detector element size. The value $N_V = 485$. All other MTFs are assumed to be unity at u_{iN}.

10.8. HUMAN VISUAL RESPONSE

The observer processes imagery to create a perceived MTF:

$$MTF_{PERCEIVED} = MTF_{SYS}\, MTF_{HVS} \,. \tag{10-47}$$

The HVS MTF should only be used to understand the relationship between the imaging system MTF and the eye response. It is not used to describe sensor performance. When $MTF_{PERCEIVED}$ is combined with system noise, system responsivity, and the eye integration capabilities, it is possible to predict the minimum resolvable contrast (described in Chapter 12, *Minimum Resolvable Contrast*). The eye's contrast sensitivity is also included in all image quality metrics (discussed in Chapter 11, *Image Quality*).

The sine wave response is used as an approximation to the eye-brain MTF. It is sometimes called the human visual system MTF or HVS-MTF. The sine wave response depends on diffraction by the pupil, aberrations of the lens, finite size of the photoreceptors, ocular tremor, and neural interconnections within the retina and brain. Diffraction and aberrations vary with ambient luminance, monitor brightness, and chromatic composition of the light. Because the retina is composed of rods and cones of varying densities, the location and size of the object with respect to the fovea significantly affect the sine wave response.

The sine wave response ignores spatial noise, background luminance, angular orientation and exposure time. Each of these parameters significantly affects the interpretation of image visibility. The MTF in the purest sense is noise independent but the human eye's response is very sensitive to spatial and temporal noise. Therefore, the sine wave response is only an approximation to the true response. Furthermore, the overall population exhibits large variations in response. Any MTF approximation used for the HVS therefore is only a crude approximation and probably represents the largest uncertainty in the overall MTF analysis approach. Factors that affect observer performance include monitor viewing ratio (usually selected to reduce raster effects), target size, and observation time. Visual psychophysical data can be found in Farrell and Booth's[18] and Biberman's[19] books.

The usual measurement is to determine the minimum modulation required to just perceive a sinusoidal target. The modulation is

$$M_t = \frac{L_{MAX} - L_{MIN}}{L_{MAX} + L_{MIN}}, \tag{10-48}$$

where L_{MAX} and L_{MIN} are the maximum and minimum luminances, respectively. The eye's detection capability depends upon the visual angle subtended by the target size at the observer. As shown in Figure 10-30, in the absence of noise, the eye's modulation threshold (minimum perceivable modulation) is characteristically J-shaped. It is labeled as M_t in the visual psychophysical literature. The eye is most sensitive to spatial frequencies[20] that range between 3 and 5 cycles/deg at typical ambient lighting levels.

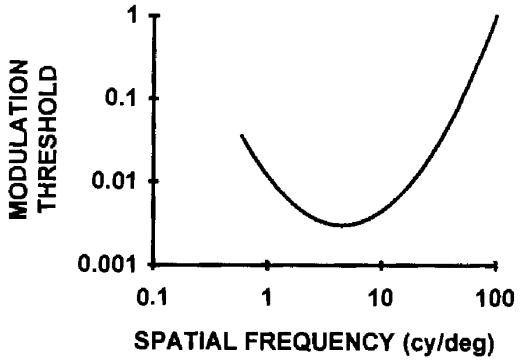


Figure 10-30. A representative modulation threshold function.

The increase in threshold at low frequencies is due to the eye's inhibitory signal processing component. The contrast sensitivity is the inverse of the modulation threshold curve. When normalized to one, the contrast sensitivity or sine wave response is called the HVS MTF. By convention, the MTF is defined to be one at zero spatial frequency and to be a monotonically decreasing function. The way to include the inhibitory response as an MTF component is not clear.

Nevertheless, various researchers modeled the normalized contrast sensitivity and labeled it as the HVS MTF (Figure 10-31). Nill[21] recommended

$$MTF_{HVS}(f_{eye}) = 2.71\left[0.19 + 0.81\left(\frac{f_{eye}}{f_{PEAK}}\right)\right] e^{-\left(\frac{f_{eye}}{f_{PEAK}}\right)} . \qquad (10\text{-}49)$$

Schulze[22] recommended

$$MTF_{HVS}(f_{eye}) = 2.71\left(e^{-0.1138 f_{eye}} - e^{-0.325 f_{eye}}\right) . \qquad (10\text{-}50)$$

Campbell and Robson's high luminance data[23] can be approximated by

$$MTF_{HVS}(f_{eye}) = 10^{-1.4 \log_{10}\left(\frac{f_{eye}}{f_{PEAK}}\right)^2} . \qquad (10\text{-}51)$$

deJong and Bakker[24] used

$$MTF_{HVS}(f_{eye}) = \sin^2\left[\frac{\pi}{2}\left(\frac{f_{eye}}{f_{PEAK}}\right)^{1/3}\right] . \qquad (10\text{-}52)$$

Neglecting the low frequency inhibitory response, Kornfeld and Lawson[25] suggested that

$$MTF_{HVS}(f_{eye}) = e^{-\Gamma \frac{f_{eye}}{17.45}} \qquad (10\text{-}53)$$

where Γ is a light-level-dependent eye response factor that was presented in tabular form[26] by Ratches et al. A third order polynomial fit provides

$$\Gamma = 1.444 - 0.344 \log(B) + 0.0395 \log^2(B) + 0.00197 \log^3(B) , \qquad (10\text{-}54)$$

where B is the monitor brightness in foot-Lamberts.

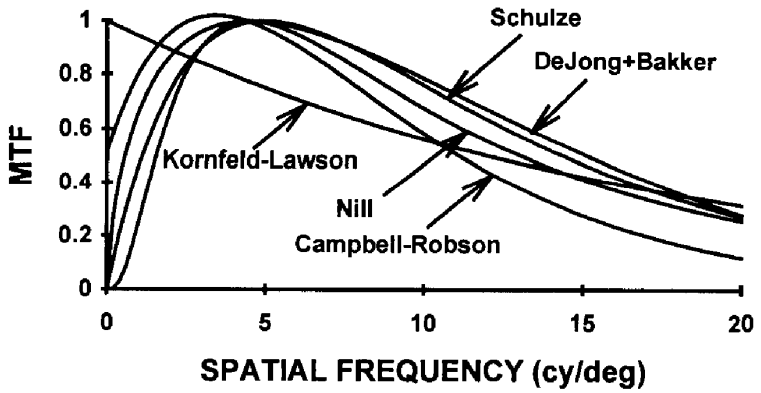


Figure 10-31. Various mathematical equations that approximate the HVS MTF.

Considering the large variation in observer responses, these curves have a similar shape when $f_{eye} > f_{PEAK}$. The original U.S. Army Night Vision Laboratory's static performance model[26] and FLIR92[27] use the Kornfeld-Lawson eye model. These models were validated by the U.S. Army when detecting tank-sized targets at modest ranges. This translates into modest spatial frequencies. The Kornfeld-Lawson model appears to follow all other models (to within a multiplicative factor) for mid-range spatial frequencies. This multiplicative factor becomes a normalization issue for the MRC (discussed in Chapter 12, *Minimum Resolvable Contrast*).

Insufficient data exist to say with certainty which eye model is best. Because of this uncertainty, *all analyses, no matter which eye model is used, must only be used for comparative performance purposes.*

Two scenarios are possible: (1) the observer is allowed to move his head and (2) the head is fixed in space. Because the eye's detection capability depends upon the angular subtense of the target, head movement may provide different results than if the head is fixed. In laboratory testing, the distance to the monitor is not usually specified nor limited in any way. To maximize detection capability (stay on the minimum of the contrast threshold curve), an observer subconsciously moves toward the monitor to perceive small targets and further away to see larger targets.

By allowing the observer to adjust the viewing distance, several interrelated detection criteria are optimized that include striving for apparent edge sharpness and maximizing perceived signal-to-noise ratio. This apparently results in an

equal detection capability for all spatial frequencies such that the eye's contrast sensitivity approaches a constant. This results in a nearly constant MTF that is called the "non-limiting eye MTF" or $MTF_{HVS} = 1$. Equation 10-53 is used in those situations where the head is fixed, such as when a pilot is strapped into a cockpit seat.

10.9. INTENSIFIED CCD

The intensified CCD (ICCD) is more difficult to analyze. The MTF of an image intensifier tube (IIT) varies with tube type,[28] manufacturing precision,[29] and materials used. Figure 10-32 illustrates a possible range of MTFs. The MTF should be obtained from the manufacturer before proceeding with system analysis. It can be approximated by a simple Gaussian expression:

$$MTF_{INTENSIFIER}(u) = e^{-2\pi^2\sigma_{IIT}^2 u^2} . \qquad (10\text{-}55)$$

MTF theory will provide an optimistic result of fiber optic coupled ICCDs. It does not include the CCD mismatch or the chicken wire effects. The MTF associated with lens coupling is probably more accurate. The MTF of an ICCD is $MTF_{INTENSIFIER}$ multiplied by the appropriate MTFs presented in this chapter.

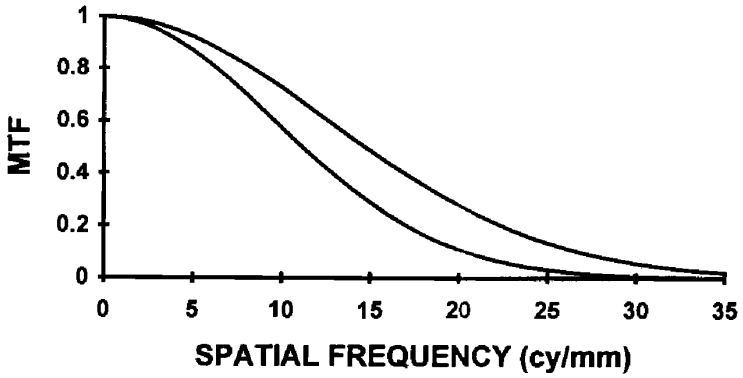


Figure 10-32. Range of MTFs for GenII image intensifier (From Reference 29).

10.10. SAMPLING EFFECTS

For a sampled-data system, a wide range of MTF values is possible[30-34] for any given spatial frequency (see Section 8.3.3., *Image Distortion*, page 245). To account for this variation, a sample-scene MTF may be included. The detector spatial frequency response is represented by $MTF_{DETECTOR}MTF_{PHASE}$. This MTF provides an average performance response that may be used to calculate the system response general imagery.

In general, the "MTF" is[35]

$$MTF_{PHASE}(u) \approx \cos\left(\frac{u_i}{u_{iN}}\,\theta\right), \tag{10-56}$$

where θ is the phase angle between the target and the sampling lattice. For example, when $u_i = u_{iN}$, the MTF is a maximum when $\theta = 0$ (in-phase) and a zero when $\theta = \pi/2$ (out-of-phase).

To approximate a median value for phasing, θ is set to $\pi/4$. Here, approximately one-half of the time the MTF will be higher and one-half of the time the MTF will be lower. The median sampling MTF is

$$MTF_{MEDIAN}(u) \approx \cos\left(\frac{\pi}{2}\frac{u_i}{u_{iS}}\right). \tag{10-57}$$

At Nyquist frequency, MTF_{PHASE} is 0.707. This is the Kell factor so often reported when specifying the resolution of monitors. An MTF averaged over all phases is represented by

$$MTF_{AVERAGE}(u_i) \approx sinc\left(\frac{u_i}{u_{iS}}\right). \tag{10-58}$$

Figure 10-33 illustrates the difference between the two equations. Because these are approximations, they may be considered roughly equal over the range of interest (zero to the Nyquist frequency). MTF_{PHASE} can be applied to both the vertical and horizontal MTFs.

Sampling effects are phase-dependent and, as a result, have no unique MTF. For system modeling purposes, average MTFs were assigned for some more common image processing algorithms. Because average MTFs are used, only an average system performance can be predicted. Performance can vary dramatically depending upon the target phase with respect to the sampling lattice. For laboratory measurements, it is common practice to "peak-up" the target (in-phase relationship) and then $MTF_{PHASE} = 1$. This is done to get repeatable results.

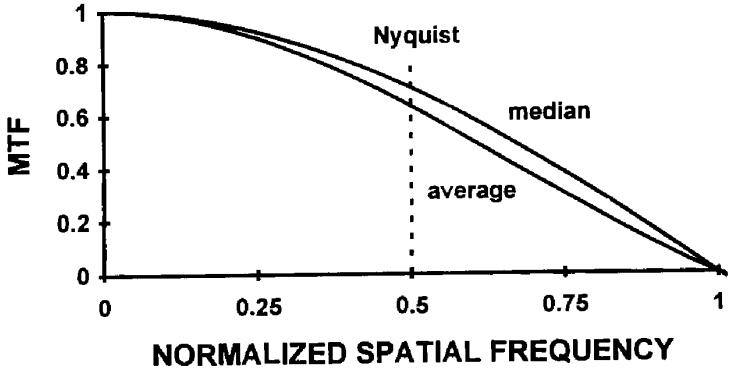


Figure 10-33. Average and median scene-sample phase MTFs normalized to u/u_S. The MTF is defined only up to the Nyquist frequency.

Frequencies above u_{iN} are aliased down to lower frequencies. Signal aliasing is ignored in most analyses and has been ignored here. A complete end-to-end analysis should include both aliased noise and aliased signal[36]. These aliased components limit[37] the extent to which a sampled image can be sharpened. Image reconstruction may include data removal (decimation) or data expansion (interpolation). The effective sampling frequency and aliasing can appear to change using different image processing algorithms.[38-40]

10.11. REFERENCES

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11

IMAGE QUALITY

Our perception of good image quality is based upon the real-world experiences of seeing all colors, all intensities, and textures. An imaging system has a limited field-of-view, limited temporal and spatial resolutions, and presents a two-dimensional view of a three-dimensional world. In the real-world our eyes scan the entire scene. Not all of the available information is captured by an imaging system. Furthermore, an imaging system introduces noise and the loss of image quality due to noise can only be estimated. Cameras sensitive to wavelengths less than 0.4 μm and greater than 0.7 μm provide imagery that we cannot directly perceive. The quality of the ultraviolet or infrared imagery can only be estimated because we do not know how it really appears.

Image quality is a subjective impression ranging from poor to excellent. It is a somewhat learned ability. It is a perceptual one, accomplished by the brain, affected by and incorporating inputs from other sensory systems, emotions, learning, and memory. The relationships are many and are still not well understood. Perceptual quality of the same scene varies between individuals and temporally for the same individual. Large variations exist in an observer's judgment as to the correct rank ordering of image quality from poor to best and therefore image quality cannot be placed on an absolute scale. Visual psychophysical investigations have not measured all the properties relevant to imaging systems.

Many formulas exist for predicting image quality. Each is appropriate under a particular set of viewing conditions. These expressions are typically obtained from empirical data in which multiple observers view many images with a known amount of degradation. The observers rank the imagery from worst to best and then an equation is derived which relates the ranking scale to the amount of degradation.

If the only metric for image quality was resolution, then we would attempt to maximize resolution in our system design. Many tests have provided insight into image quality metrics. In general, images with higher MTFs and less noise are judged as having *better* image quality. There is no single *ideal* MTF shape that provides best image quality. For example, Kusaka[1] showed that the MTF that produced the most aesthetically pleasing images depended on the scene content.

The metrics suggested by Granger and Cupery, Shade, and Barten offer[2-6] additional insight on how to optimize an imaging system. Granger and Cupery developed the Subjective Quality Factor (SQF): an empirically derived relationship using individuals' responses when viewing many photographs. Shade used photographs and included high quality TV images. Barten's approach is more comprehensive in that it includes a variety of display parameters. It now includes[7] contrast, luminance, viewing ratio, number of scan lines, and noise.

While Barten has incorporated the sampling effects of flat panel displays,[7] no model includes the sampling (and associated aliasing) that takes place at the detector. Until this aliasing is quantified, no metric will predict image quality for sampled data systems. Only an end-to-end system approach can infer overall image quality.

There are potentially two different system design requirements: (1) good image quality and (2) performing a specific task. Sometimes these are equivalent, other times they are not. All image quality metrics incorporate some form of the system MTF. The underlying assumption is that the image spectrum is limited by the system MTF. Equivalently, it is assumed that the scene contains all spatial frequencies and that the displayed image is limited by system MTF - a reasonable assumption for general imagery. While good image quality is always desired, a military system is designed to detect and recognize specific targets (discussed in Chapter 12, *Minimum Resolvable Contrast*). Optimized military systems will have high MTF at the (assumed) target frequencies and other spatial frequencies are considered less important. Computer monitors are usually designed for alphanumeric legibility.

Often, the display is the limiting factor in terms of image quality and resolution. No matter how good the electronic imaging system is, if the display resolution is poor, then the overall system resolution is poor. If the system is optics-limited, then a high resolution display does not offer any "extra" system resolution. A high resolution display just ensures that all the information available is displayed. System resolution may be limited by the HVS. If the observer is too far from the screen, not all of the image detail can be discerned.

The HVS appears to operate as a tuned spatial-temporal filter where the tuning varies according to the task at hand. Because the HVS approximates an optimum filter, no system performance improvement is expected by *precisely* matching the image spectrum to the HVS preferred spectrum. Rather, if the displayed spectrum is within the limits of the eye spectrum, the HVS will automatically tune to the image. Clearly, the overall system magnification should be set such that the frequency of the maximum interest coincides with the peak

frequency of the HVS's contrast sensitivity. Although this implies a specific frequency, the range of optimization is broad.

A large number of metrics are related to image quality. Most are based on monochrome imagery such as resolution, MTF, and minimum resolvable contrast. CRT resolution was presented in Section 7.5., *Resolution* (page 218). Color reproduction and tonal transfer issues, which are very important to color cameras, are not covered here.

The symbols used in this book are summarized in the *Symbol List* (page xviii) which appears after the *Table of Contents*.

11.1. RESOLUTION METRICS

An overwhelming majority of image quality discussions center on resolution. Resolution has been in use so long that it is thought to be fundamental and that it uniquely determines system performance. There are four different types of resolution: (1) temporal, which is the ability to separate events in time; (2) gray scale, which is determined by the analog-to-digital converter design, noise floor; or the monitor capability, (3) spectral; and (4) spatial. An imaging system operating at 30 Hz frame rate has a temporal resolution of 1/30 sec. Gray-scale resolution is a measure of the dynamic range. The spectral resolution is simply the spectral band pass (e.g., UV, visible, or near infrared) of the system. This section covers spatial resolution.

Resolution provides valuable information regarding the finest spatial detail that can be discerned. A large variety of resolution measures exist[8] and the various definitions may not be interchangeable. An electronic imaging system is composed of many subsystems and each has its own metric for resolution (Table 11-1). These can also be divided into analog (Table 11-2) and sampled-data resolution metrics (Table 11-3).

A single measure of spatial resolution cannot be satisfactorily used to compare all sensor systems. Spatial resolution does not provide information about total imaging capability or contrast sensitivity. The minimum resolvable contrast simultaneously provides contrast sensitivity information and resolution information for monochrome systems. Resolution does not include the effects of system noise and is not related to sensitivity.

Table 11-1
SUBSYSTEM MEASURES of RESOLUTION

SUBSYSTEM	RESOLUTION METRIC
Optics	Rayleigh criterion Airy disk diameter Blur diameter
Detectors	Detector-angular-subtense Instantaneous-field-of-view Effective-instantaneous-field-of-view Detector pitch Pixel-angular-subtense
Electronics	Bandwidth
Electronic imaging system (MTF approach)	Limiting resolution Nyquist frequency
Displays	TV limiting resolution

Table 11-2
RESOLUTION MEASURES for ANALOG SYSTEMS

RESOLUTION	DESCRIPTION
Rayleigh criterion	Ability to distinguish two adjacent point sources
Airy disk	Diffraction-limited diameter produced by a point source
Blur diameter	Actual minimum diameter produced by a point source
Limiting Resolution	Spatial frequency at which MTF= 0.02 to 0.10
TV limiting resolution	Number of resolved lines per picture height
Ground resolved distance	The smallest test target (1 cycle) that a photointerpreter can distinguish
Ground resolution	An estimate of the limiting feature size seen by a photointerpreter
Resel	Smallest region that contains unique information

Table 11-3
RESOLUTION MEASURES for SAMPLED DATA SYSTEMS

RESOLUTION	DESCRIPTION
Detector angular subtense	Angle subtended by one detector element
Instantaneous field-of-view	Angular region over which the detector senses radiation
Nyquist frequency	One-half of the sampling frequency
Detector pitch	Center-to-center spacing
Effective-instantaneous-field-of-view	One-half of the reciprocal of the object-space spatial frequency at which the MTF is 0.5
Pixels, datels, and disels	Number of detector elements or number of digital data points

When resolution is defined as the inverse of the system cutoff in angular space (typical for military applications), the back-of-the-envelope approximation provides the range at which the target can be "detected":

$$Range \approx \frac{target\ size}{resolution} . \qquad (11\text{-}1)$$

This is the maximum range at which a periodic target can be faithfully reproduced.

Analog measures of spatial resolution may be determined by: (1) the width of a point source image, (2) the minimum detectable separation of two point sources, (3) the spatial frequency at which the MTF drops to a defined level, or (4) the smallest detail resolved by an observer. These measures assume that the system output image is a replica of the input scene (a linear-shift-invariant system).

As imaging systems are incorporated into new disciplines, resolution must be specified in terms used by those industries. For example, photointerpreters use the ground resolved distance (GRD) when evaluating reconnaissance imagery captured on film. But as solid state imaging systems replace the wet film process, the GRD, by default, becomes an imaging system resolution measure.

When viewing aerial imagery that contains a test pattern (such as the U.S. Air Force 1951 standard 3-bar target), an image analyst determines the smallest discernible cycle on the ground. This cycle width (bar plus space) is the GRD. It includes the system MTF and possible degradation by the atmosphere and is

a function of altitude. The GRD is related[9,10] to the 10-point Imagery Interpretability Rating Scale (IIRS). The National Imagery Interpretability Rating Scale (NIIRS) has replaced the IIRS.[11-14]

The smallest elements that can be created by a digital subsystem are the pixel, datel, and disel. These are created by the detector array, ADC, and the display media, respectively. The resel is the smallest element that can be created by an analog system. The optics, analog electronics, and video standard (or transmission link) each have their own resel. System resolution is a convolution of all "-els."

Complex systems cannot be characterized by a single number (for example, an "-el"). Nevertheless, this chapter discusses various measures because they have been in existence so long. They were developed to describe the resolution of specific subsystems and do not provide an end-to-end performance metric. Nor do they include aliasing. Aliasing effects are discussed in Reference 15.

11.2. OPTICAL RESOLUTION METRICS

Table 11-4 provides various optical resolutions. As analog metrics, these are various definitions of a resel. Diffraction measures include the Rayleigh criterion and the Airy disk diameter. The Airy disk is the bright center of the diffraction pattern produced by an ideal optical system. In the focal plane of the lens, the Airy disk diameter is

$$d_{AIRY} = 2.44\frac{\lambda}{D_o}fl = 2.44\lambda F \ . \qquad (11\text{-}2)$$

The Rayleigh criterion is a measure of the ability to distinguish two closely spaced objects when the objects are point sources. Optical aberrations and focus limitations increase the diffraction-limited spot diameter to the blur diameter. Optical designers use ray tracing programs to calculate the blur diameter. The blur diameter size is dependent on how it is specified (i.e., the fraction of encircled energy[16]). den Dekker and van den Bos provide[17] an in-depth review of optical resolution metrics.

Considerable literature[18] has been written on the image forming capability of lens systems. Image quality metrics include aberrations, Strehl ratio, and blur or spot diagrams. These metrics, in one form or another, compare the actual blur diagram to diffraction-limited spot size. As the blur diameter increases, image quality decreases and edges become fuzzy. The ability to see this

degradation requires a high resolution sensor. Both the human eye and photographic film visually have this resolution. However, with electronic imaging systems, the detectors are often too large to see the degradation because the detectors are often larger than the blur diameter.

Table 11-4
OPTICAL RESOLUTION METRICS (in image space)

RESOLUTION	DESCRIPTION	DEFINITION (usual units)
Rayleigh criterion	Ability to distinguish two adjacent point sources	$x_{RES} = 1.22 \lambda F$ (Calculated: mm)
Airy disk	Diffraction-limited diameter produced by a point source	$x_{RES} = 2.44 \lambda F$ (Calculated: mm)
Blur diameter	Actual minimum diameter produced by a point source	Calculated from ray tracing (mm)

11.3. DETECTOR RESOLUTION

Considering the Airy disk, the wavelength dependence suggests that the resolution increases as the wavelength decreases (smaller is better). However, this is only true when the detector size is much smaller than the Airy disk size. For most electronic imaging systems the reverse is true. The detector is the same size or larger than the disk diameter (see Section 10.4., *Optics-Detector Subsystem*, page 286). This means that the Airy disk is not adequately sampled and therefore the resolution afforded by the optics cannot be exploited. Systems designed for star detection are usually optics-limited (optical resel larger than a pixel), whereas for general imagery the systems are usually detector-limited (pixel larger than the optical resel)

Detector arrays are often specified by the number of pixels and detector pitch. These are not meaningful until an optical system is placed in front of the array. Table 11-5 provides the most common resolution metrics expressed in object-space units. The detector-angular-subtense (DAS) is often used by the military to describe the resolution of systems when the detector is the limiting subsystem. If the detector's element horizontal and vertical dimensions are different, then the DAS in the two directions is different. Note that the PAS is different than the DAS (see Section 1.5., *Pixels, Datels, Disels, and Resels*, page 14). Only with 100% fill factor arrays are they the same. Spatial sampling rates are determined by the pitch in image space or the PAS in object space.

Table 11-5
DETECTOR ELEMENT RESOLUTION MEASURES (in object space)

RESOLUTION	DESCRIPTION	DEFINITION (usual units)
Detector-angular-subtense	Angle subtended by one detector element	d/fl (Calculated: mrad)
Instantaneous-field-of-view	Angular region over which the detector senses radiation	Measured width at 50% amplitude (mrad)
Pixel-angular-subtense	Angle subtended by one pixel	d_{cc}/fl (Calculated: mrad)
Effective-instantaneous-field-of-view	One-half of the reciprocal of the object-space spatial frequency at which the MTF is 0 5	Measured or calculated (mrad)
Ground sampled distance	Projection of detector pitch onto the ground	d_{cc}R/fl (calculated: inches)
Nyquist frequency	One-half of the angle subtended by detector pitch	d_{cc}/2fl (calculated: mrad)

If resolution is defined by the DAS, then a vanishingly small detector is desired. Simultaneously, the f-number must approach zero so the system is not optics-limited (see Figure 10-15, page 287). Although any detector size, optical aperture, and focal length can be chosen to select the resolution limit, the same parameters affect the sensitivity (see Equation 10-27, page 288). With practical optical systems, the minimum f-number is about 1.0 with a theoretical limit of 0.5. Resolution and sensitivity factors are coupled into a single figure of merit: the minimum resolvable contrast (discussed in Chapter 12, *Minimum Resolvable Contrast*).

The instantaneous-field-of-view (IFOV) is the linear angle from which a single detector element senses radiation. It is a summary measure that includes both the optical and detector responses. The IFOV is typically a measured quantity. Here, a point source transverses the detector element and the detector output is graphed as a function of angle. The IFOV is the full-width, one-half maximum amplitude of the resultant signal. For detector-limited systems (large $d/F\lambda$), the IFOV is approximately equal to the DAS. Equivalently, if the optical blur diameter is small compared to the DAS, then they are approximately equal.

The detector horizontal cutoff is $u_{oD} = fl/d_H = 1/DAS$ in object space. With detector arrays, signal fidelity is limited to the Nyquist frequency. Here, the effective-instantaneous-field-of-view (EIFOV) offers an alternate measure of resolution (Figure 11-1). The value u_{EIFOV} is the spatial frequency at which the MTF is 0.5. Calling 1/DAS the cutoff provides a misleading representation. Recall that the detector can respond to frequencies above 1/DAS (see Figure 8-9, page 241).

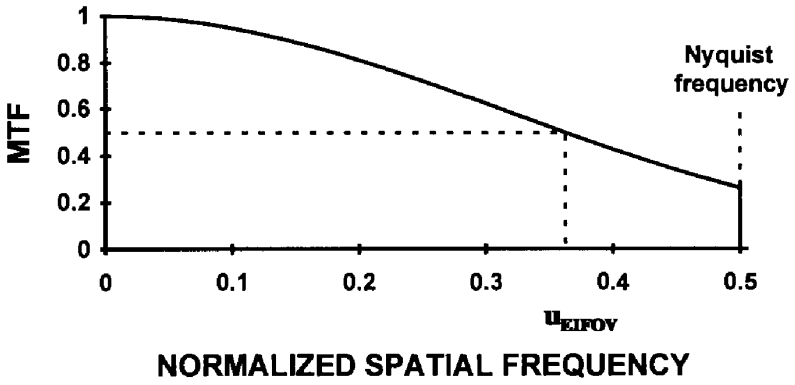


Figure 11-1. Definition of effective-instantaneous-field-of-view for an undersampled system. The spatial frequency has been normalized to the Nyquist frequency, f_N. EIFOV $= 1/(2\,u_{EIFOV})$.

11.4. ELECTRICAL RESOLUTION METRIC

For high data rate systems such as line-scanners, the electronic bandwidth may limit system response. For electronic circuits, resolution is implied by its bandwidth. The minimum pulse width is approximately

$$\tau_{MINIMUM} \approx \frac{1}{2\,BW}, \tag{11-3}$$

where $\tau_{MINIMUM}$ is measured in seconds and BW is measured in Hertz. The 3-dB point (half-power frequency) is often called the bandwidth. With this minimum value the output signal *looks* like the input. Other expressions (e.g., $\tau_{MINIMUM} = 1/BW$) simply imply there is a measurable output without any inference about signal fidelity.

11.5. MTF-BASED RESOLUTION

Usually systems are designed to have high MTF, and Figure 10-14 (page 286) illustrated the MTF at Nyquist frequency. However, the value of Nyquist frequency is a measure of resolution; 100% fill factor staring arrays have the highest Nyquist frequency.

11.5.1. LIMITING RESOLUTION

Other measures also exist such as the limiting resolution. This is the spatial frequency at which the MTF is, say, 5%. Figure 11-2 illustrates two systems that have the same limiting resolution. Which system is selected depends on the specific application. System A is better at high spatial frequencies, and system B is better at low spatial frequencies. Equivalently, if the scene contains mostly low frequencies (large objects), then system B should be used. If edge detection is important (high spatial frequencies), then system A should be considered. This clearly indicates the difficulty encountered when using resolution exclusively as a measure of system performance.

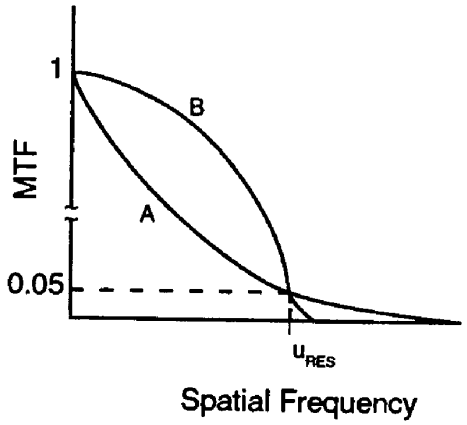


Figure 11-2. The MTFs of two different imaging systems with the same limiting resolution, u_{RES}.

11.5.2. MTF/TM RESOLUTION

Early resolution measures were based on wet-film camera characteristics. The intersection of the system MTF and film threshold modulation (TM) provided a measure of camera system performance (Figure 11-3). TM is the minimum modulation required at a given spatial frequency to discern a difference. The value u_{RES} is the limiting spatial frequency or intersection frequency.

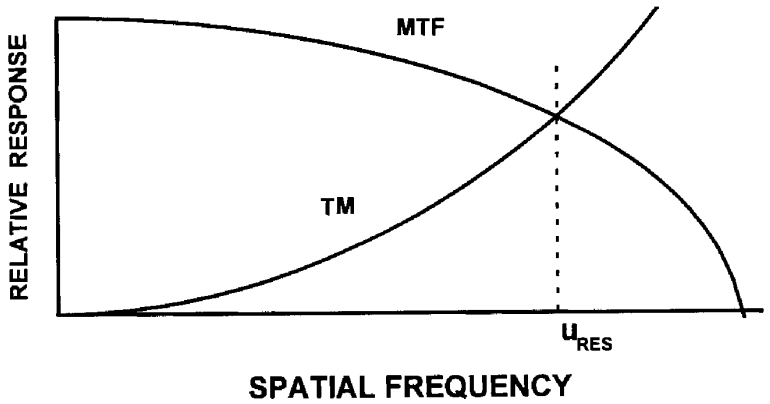


Figure 11-3. The spatial frequency of the intersection of the film threshold modulation and MTF_{SYSTEM} is a measure of resolution.

Conceptually, for spatial frequencies above u_{RES}, the film requires more modulation than that provided by the system. Below u_{RES} the film can easily discern the scene modulation. Because many measures were in support of aerial imagery, the intersection was also called the aerial image modulation (AIM). With the advent of electronic imaging systems, the film TM was replaced with the HVS's threshold modulation (discussed in Section 11.7., *MTFA*).

11.5.3. SHADE'S EQUIVALENT RESOLUTION

Shade[3] equated apparent image sharpness of a television picture to an equivalent pass band:

$$N_e = \int_0^\infty [MTF(f)]^2 \, df \, . \qquad (11\text{-}4)$$

As reported by Lloyd,[19] Sendall modified Shade's equivalent resolution such that

$$R_{EQ} = \frac{1}{2N_e} = \frac{1}{2\int_0^{\infty} [MTF_{SYS}(u)]^2 \, du} . \tag{11-5}$$

The value R_{EQ} cannot be directly measured and is a mathematical construct that expresses overall performance. As R_{EQ} decreases, the resolution "improves" (smaller is better). As an approximation, the system resolution, $R_{EQ\text{-}SYS}$, may be estimated from the component equivalent resolutions, R_i, by

$$R_{EQ\text{-}SYS} \approx \sqrt{R_1^2 + R_2^2 + \ldots + R_n^2} . \tag{11-6}$$

Shade's approach using the square of the MTF emphasized those spatial frequencies at which the MTF is relatively high. It appears to be a good measure for classical systems in which the MTF is decreasing (such as a Gaussian distribution). The equivalent resolution approach assumes that the system is completely analog and it ignores sampling effects. Therefore, R_{EQ} becomes a resel. It probably should not be used (nor should any other image quality metric) to compare systems with significantly different MTFs. Nor should it be used with systems that can create significant aliasing.

As a summary metric, $R_{EQ\text{-}SYS}$ provides a better indication of system performance than just a single metric such as the DAS. $R_{EQ\text{-}SYS}$ probably should be used in Equation 11-1 (page 319) to obtain a more realistic measure of range performance. The value R_{EQ} cannot be evaluated in closed form for all subsystems such as boost, defocused optics, or Chebyshev filters. For these subsystems, Equation 11-6 must be evaluated numerically. If a subsystem MTF is essentially unity over the spatial frequency region of interest, then that subsystem R_{EQ} can be ignored (e.g., $R_{EQ} = 0$). Table 11-6 provides the equivalent resolution for several common MTFs.

Table 11-6
ONE-DIMENSIONAL EQUIVALENT RESOLUTIONS

SUBSYSTEM	MTF	R_{EQ}
Optics	$\frac{2}{\pi}\left(\cos^{-1}\left(\frac{u_l}{u_{iC}}\right)-\frac{u_l}{u_{iC}}\sqrt{1-\left(\frac{u_l}{u_{iC}}\right)^2}\right)$	$1.845\,\lambda F$
Rectangular detector	$sinc(d\,u_l)$	d
N^{th}-order low-pass filter	$\frac{1}{\sqrt{1+\left(\frac{f_e}{f_{e3dB}}\right)^{2N}}}$	$\frac{1}{\pi f_{e3dB}}$ *when* $N = 1$ $\frac{1}{2f_{e3dB}}$ *when* $N \to \infty$
CRT-based display	$e^{-2\pi^2\sigma_{SPOT}^2 u_d^2}$	$2\sqrt{\pi}\,\sigma_{SPOT}$

If the electronics provides adequate bandwidth, it is instructive to see the relationship between the Airy disk diameter and the detector size. Using the same parameters as Figure 10-14 (page 286), x = d/(Fλ), for a system with resolution limited by the optics/detector combination,

$$R_{EQ\text{-}SYS} = d\sqrt{\left(\frac{1.845}{x}\right)^2 + 1}\ . \qquad (11\text{-}7)$$

The equation is graphed in Figure 11-4. As x increases, $R_{EQ\text{-}SYS}$ approaches d. For small values of x, the system becomes optics-limited and the equivalent resolution increases. When $x = 2.44$, $R_{EQ\text{-}SYS} = 1.25d$ and when $x = 4$, $R_{EQ\text{-}SYS} = 1.10d$. Matching the Airy disk to the detector size creates an equivalent resolution 25% larger than the actual detector size.

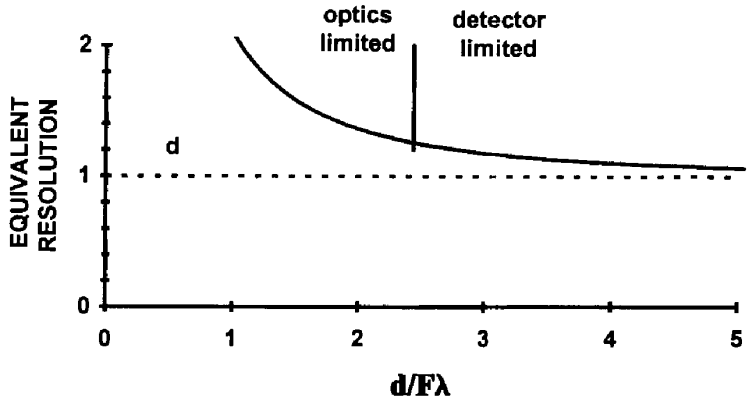


Figure 11-4. Equivalent resolution normalized to d as a function of d/Fλ. The vertical line indicates where the Airy disk diameter is equal to the detector size. The best resolution occurs when d/Fλ approaches infinity. Here the optics MTF approaches unity.

11.6. SYSTEM RESOLUTION EXAMPLES

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Example 11-1
PIXELS and DATELS

An imaging system consists of 512 × 512 detector elements. Assume that the fill factor is 100% and the camera's analog output is digitized at either 1024 samples/line or 2048 samples/line. What is the resolution?

The external analog-to-digital converter creates either two or four datels for each pixel. In both cases, the pixel size remains the same. Increasing the sampling rate does not change the system's resolution but improves the repeatability of all measurements by reducing phasing effects that might occur in the analog-to-digital converter. Any image processing algorithm that operates on this higher number must consider the sensor resolution.

Cameras with a standard video output may not have the resolution suggested by the video standard. For example, a camera containing an array of 320 × 240 pixels may have its output formatted into EIA 170 timing. The signal may be digitized by a frame grabber that creates 640 × 480 datels. The image size is still 320 × 240 pixels.

Example 11-2
DISELS and PIXELS

A staring array consists of 512 × 512 detectors. Using 4× electronic zoom it is presented on a digital monitor that displays 1024 × 1024 disels. What is the system resolution?

Each pixel is mapped onto four datels that are then mapped one-to-one onto disels. Here, the imaging system determines the system resolution, not the number of datels or disels. High quality monitors only ensure that the image quality is not degraded. Electronic zoom cannot increase resolution. But decimation or minifying may reduce resolution. Because image processing is performed on datels, the image analyst must be made aware of the system resolution.

Example 11-3
SYSTEM EQUIVALENT RESOLUTION

A CCD camera has an analog output digitized by a frame grabber. What is the apparent system resolution for image processing and what is the resolution displayed on a CRT-based monitor?

This CCD camera contains 480 horizontal detectors. Each detector is 15 μm on 15 μm centers (100% fill factor). The optical aperture is 1 inch and the focal length is 5.6 inches (F = 5.6). The analog electronics is wideband and it does not significantly affect the resolution. Camera output is in the standard EIA 170 format with a bandwidth of 4.2 MHz and $t_{VIDEO\text{-}LINE}$ = 52.45 μs. The frame grabber provides 640 horizontal samples and a standard consumer CRT-based monitor is used.

Assuming $\lambda_{AVE} \approx 0.5\,\mu m$, R_{EQ} for the optics is $1.845\lambda_{AVE}/D_o = 0.0363$ mrad. The DAS is d/fl or 0.105 mrad. Here, $d/(F\lambda) = \alpha D_o/\lambda = 5.33$. That is, the optical/detector subsystem is detector-limited. The HFOV is

$$HFOV = \frac{N_H d_H}{fl} = \frac{480\,(15\times10^{-6}m)}{(5.6\,in)\left(25.4\times10^{-3}\frac{m}{in}\right)} = 50.6\,mrad\,. \quad (11\text{-}8)$$

With an active line time of 52.45 μs, the video bandwidth in object space is

$$f_{o\text{-}VIDEO} = \frac{t_{VIDEO\text{-}LINE}}{HFOV}BW = \frac{52.45\times10^{-6}}{50.6\times10^{-3}}4.2\times10^{6} = 4.35\,\frac{cycles}{mrad}\,. \quad (11\text{-}9)$$

Assuming a sharp cutoff, $R_{EQ} \approx 1/2f_{3dB} = 0.115$ mrad. The system equivalent resolution is

$$R_{EQ\text{-}SYS} = \sqrt{0.0363^2 + 0.105^2 + 0.115^2} = 0.160\,mrad\,. \quad (11\text{-}10)$$

Here, the EIA 170 bandwidth significantly affects the resolution. Neglecting phasing effects, each frame grabber datel represents approximately (0.159)(480)/640 = 0.119 mrad. These are overlapping resolution elements where the center-to-center spacing is (0.105)(480)/640 = 0.0787 mrad.

The CRT equivalent resolution is

$$R_{EQ} = 2\sqrt{\pi}\,\sigma_o = 2\sqrt{\pi}\left(\frac{d_{CC}}{1.645\cdot fl}\right) = 0.227\,mrad\,. \quad (11\text{-}11)$$

The display significantly degrades the resolution. But this is necessary to suppress the raster and sampling artifacts. Each disel represents overlapping resolution elements with apparent size

$$R_{EQ\text{-}SYS} = \sqrt{0.159^2 + 0.227^2} = 0.277\,mrad\,. \quad (11\text{-}12)$$

Numerical integration of Equation 11-5 provides $R_{EQ\text{-}SYS} = 0.263$. For this example, Equations 11-5 and 11-6 provided similar results.

11.7. MTFA

The area bounded by the system MTF and the HVS's modulation threshold (M_t) is called the modulation transfer function area (MTFA) (Figure 11-5a). As the MTFA increases, the perceived image quality appears to increase. The spatial frequency at which the MTF and M_t intersect is a measure of the overall resolution. However, the resolution is not unique because M_t depends on the display viewing distance. The HVS's inhibitory response (see Figure 10-31, page 309) is omitted from the MTFA approach. Mathematically,

$$MTFA = \int_0^{f_o} [MTF(f) - M_t(f)]\, df \,. \qquad (11\text{-}13)$$

where f_o is the limiting spatial frequency or intersection frequency. The value M_t is also called the aerial image modulation and demand modulation function. It is the minimum modulation required at a given spatial frequency to discern a difference.

According to Snyder,[20] the MTFA appears to correspond well with performance in military detection tasks where the targets are embedded in noise. The noise elevates the HVS's modulation threshold so that the MTFA decreases with increasing noise (Figure 11-5b).

For low noise, general imagery, the HVS's contrast sensitivity has little effect on the MTFA. The integrand in Equation 11-13 can be replaced with just the system MTF. Here, the high spatial frequencies are weighted too heavily compared to the low spatial frequencies and Shade's approach appears better.

From an analyst's viewpoint, the convolution theorem states that MTFs should be multiplied. The contrast sensitivity is proportional to the HVS MTF. Therefore, the system MTF should be multiplied by the contrast sensitivity or divided by the inverse (modulation threshold). However, the intersection frequency can be used as a measure of limiting resolution of the system. It can be used, for example, to calculate the GRD.

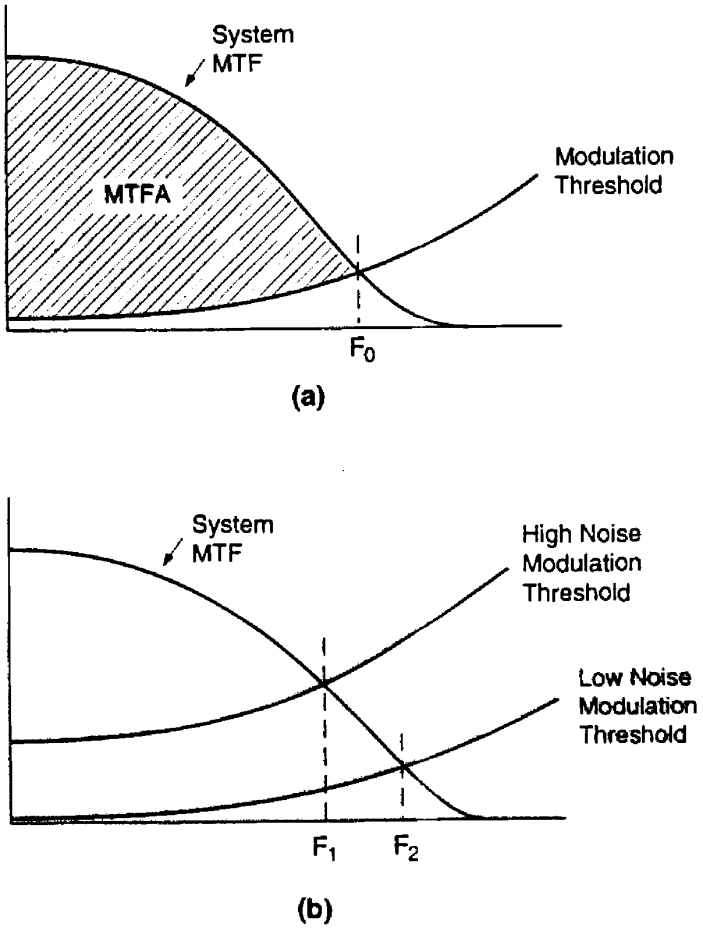


Figure 11-5. MTFA. The area between system MTF and M_t up to the intersection is a measure of image quality. The spatial frequency at the intersection is a measure of limiting resolution. The area and limiting resolution depend on the noise level within the imagery. (a) Low noise and (b) elevated noise.

11.8. SUBJECTIVE QUALITY FACTOR

According to Granger and Cupery,[2] the spatial frequency range important to image quality is in the region from just below the peak to three times the peak sensitivity of the eye. The Campbell-Robson high luminance data, and the HVS models of Nill, Schultz, and deJong and Bakker support Granger and Cupery's approach whereas the Kornfeld-Lawson HVS model does not (see Section 10.8., *Human Visual Response*, page 306). Recall that the Kornfeld-Lawson model is considered only applicable for spatial frequencies greater than f_{PEAK}.

In logarithmic units, the normalized subjective quality factor (SQF) is:

$$SQF = K \int_{\log(3)}^{\log(12)} MTF_{SYS}(f_{eye})\, d[\log(f_{eye})] \,, \qquad (11\text{-}14)$$

where K is a normalization constant. In the SQF approach, only those frequencies that are very important to the eye are included. The spatial frequency presented to the eye depends on the image size on the display, the distance to the display, and electronic zoom. Table 11-7 provides Granger and Cupery's interpretation of the SQF. These results are based on many observers viewing noiseless photographs with known MTF degradation.

The SQF is an adequate image quality metric for low noise imagery when the illumination is fixed at a moderate level. As with the MTFA and Shade's equivalent pass band, the SQF is intended for general imagery only. It cannot be used for specific applications such as the legibility of alphanumeric characters.

Table 11-7
SUBJECTIVE QUALITY FACTOR

SQF	SUBJECTIVE IMAGE QUALITY
0.92	Excellent
0.80	Good
0.75	Acceptable
0.50	Unsatisfactory
0.25	Unusable

11.9. SQUARE-ROOT INTEGRAL

Barten[4-7] introduced the square-root integral (SQRI) as a measure of image quality. The SQRI is

$$SQRI = \frac{1}{\ln(2)} \int_{f_{min}}^{f_{max}} \sqrt{MTF_{SYS}(f_{eye})\, CSF_{EYE}(f_{eye})}\, \frac{df_{eye}}{f_{eye}} . \quad (11\text{-}15)$$

The multiplication overcomes the theoretical objection raised with the MTFA where the CSF was subtracted from the MTF. MTF_{SYS} includes all the subsystem MTFs up to and including the display. Barten modeled the contrast sensitivity function as

$$CSF(f_{eye}) = \frac{1}{M_t} = a f_{eye} e^{-bf_{eye}} \sqrt{1 + c e^{bf_{eye}}} , \quad (11\text{-}16)$$

where

$$a = \frac{540\left(1 + \frac{0.7}{L_{AVE}}\right)^{-0.2}}{1 + \frac{12}{w\left(1 + \frac{f_{eye}}{3}\right)^2}} , \quad (11\text{-}17a)$$

$$b = 0.3\left(1 + \frac{100}{L_{AVE}}\right)^{0.15} , \quad (11\text{-}17b)$$

and

$$c = 0.06 , \quad (11\text{-}17c)$$

where f_{eye} has units of cycles/degree, L_{AVE} is the average luminance in candelas per square meter, and w is the angular display size as seen by the observer. The factor 1/ln(2) allows SQRI to be expressed in just-noticeable-difference (JND) units. Both average luminance level and display size affect the CSF. This CSF is a good approximation over five orders of magnitude of luminance levels and for angular display sizes ranging from 0.5° to 60°.

This model includes the effects of various display parameters such as viewing ratio, luminance, resolution, contrast, addressability, and noise. Display viewing ratio and average luminance are incorporated in the HVS's CSF (via w and L_{AVE} in the CSF equation). Display resolution (display MTF) is included in MTF_{SYS}.

Contrast loss due to reflected ambient lighting effectively reduces the display MTF. If ΔL is the additional luminance due to reflected ambient light, then the modulation depth is reduced by the factor:

$$\eta_{DISPLAY} = \frac{L_{AVE}}{L_{AVE} + \Delta L} . \qquad (11\text{-}18)$$

This factor is the same for all spatial frequencies of interest and the perceived effect on image quality is incorporated into the SQRI by multiplying MTF_{SYS} by $\sqrt{\eta_{DISPLAY}}$.

The display parameters dictate the limits of integration. The value f_{MIN} is that spatial frequency that provides one-half cycle across the display and f_{MAX} is the maximum spatial frequency of the display and this is related to display addressability (see Section 7.6., *Addressability*, page 222). For example, if the number of active lines is N_{ACTIVE}, then

$$f_{MAX} = \frac{(Kell\,factor)\ N_{ACTIVE}}{2} D_{FOV} . \qquad (11\text{-}19)$$

The small angle approximation was used to calculate field-of-view, D_{FOV}, subtended by the observer. It is the display height, $H_{MONITOR}$, divided by the viewing distance, D.

Noise increases the contrast sensitivity function. Because the SQRI must decrease with noise, Barten added noise as an additional factor to the HVS MTF:

$$MTF_{t\text{-}noise}(f_{eye}) = \sqrt{MTF^2_{eye}(f_{eye}) + (k_{noise} M_n)^2} . \qquad (11\text{-}20)$$

The value M_n can be calculated from the noise power spectral density presented to the eye.[5] Barten predicted the quality of imagery when both static (pattern noise) and dynamic (temporally varying) noise are present. He considered both one-dimensional and two-dimensional noise sources. His approach encompasses actual sensor operation where different noise components may exist in the horizontal and vertical directions. As such, he considered some of the three-dimensional noise components used for military applications (discussed in Section 12.2., *Three-Dimensional Noise Model*).

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12

MINIMUM RESOLVABLE CONTRAST

Most image quality metrics were developed for high contrast imagery. Here, image quality is closely linked with the MTF. High MTF cameras provide better image quality and therefore provide better resolution under optimum conditions. While most resolution metrics are applicable to high contrast targets, the relative rating of systems may change for low contrast scenes. A high MTF system with excessive noise will not permit detection of low contrast targets.

The military is interested in detecting and recognizing targets at the greatest possible range. This is achieved by increasing the system gain until noise is apparent and the imagery is "snowy." Because the distinction between target and background is measured by contrast, the signal threshold is expressed as the minimum resolvable contrast (MRC). MRC applies to monochrome systems only. It is a measure of an observer's ability to detect a 3-bar target embedded in noise. The Johnson criterion relates real targets to equivalent bar chart targets. Thus, the link between real targets and the MRC is the spatial frequency of the equivalent 3-bar target.

By providing an angular resolution, it is simple to determine the range: R = (target size)/(resolution). Therefore, for MRC calculations, object-space spatial frequency is used. The MTFs provided in Chapter 10 were specified in the image-space spatial frequency domain. The conversion is $u_{ob} = fl\, u_i$ and $v_{ob} = fl\, v_i$, where fl is the effective optical focal length.

In the 1950s, Shade[1] modeled the resolution of photographic film and TV sensors as a function of light level. His approach is the framework of all models used today. In the 1970s, Rosell and Willson[2] applied Shade's results to thermal imaging systems and low light level televisions. Since then, most modeling efforts have concentrated on infrared imaging systems. However, the same modeling equations apply to all imaging systems. Different forms exist to accommodate the terminology associated with different technologies (scanning versus staring, visible versus thermal imaging systems, etc.).

MRC was originally developed for vidicons and low light level televisions. The approach taken here extends the thermal imaging system performance model (popularly called FLIR92) methodology[3] to visible systems. FLIR92 calculates the minimum resolvable temperature (MRT) where the target-background

radiance difference is characterized by a differential temperature. FLIR92 methodology and the three-dimensional noise model[4] are reformatted for solid state cameras. The 3-D noise model was developed to describe the various noise sources present in thermal imaging systems. These same noises exist in lesser amounts within solid state cameras.

The MRC approach uses terminology that characterizes human perceptual capability. The observer does not see the same contrast at the display as that presented by the target to the camera. Both the displayed contrast and brightness can be adjusted on the display so the observed contrast may be significantly different from what is present at the entrance aperture of the imaging system. Observer threshold is expressed as the perceived signal-to-noise ratio rather than the perceived contrast.

Within the real world, there is a probability associated with every parameter. The target contrast is not one number but a range of values that follow a diurnal cycle. The atmospheric transmittance is not fixed but can change in minutes. There appear to be an overwhelming set of combinations and permutations. Therefore, only a few representative target contrasts and a few representative atmospheric conditions are selected and the performance range is calculated for these conditions.

The Nyquist frequency limits the highest frequency that can be reproduced. The specific manner that the Nyquist frequency is included in the model greatly affects range performance. This is a result of the assumptions used and is not necessarily representative of actual system performance. While no model is perfect, models are still excellent for comparative analyses.

The symbols used in this book are summarized in the *Symbol List* (page xviii) which appears after the *Table of Contents*.

12.1. THE OBSERVER

The original Night Vision Laboratory static performance model[5] and FLIR92 use the Kornfeld-Lawson eye model (see Section 10.8., *Human Visual Response*, page 306). These models were validated by the U.S. Army when detecting tank-sized targets at modest ranges. Insufficient data exist to say with certainty which of the eye models available is best. Because of this and other model uncertainties, range predictions cannot be placed on an absolute scale. *All analyses, no matter which eye model is used, must be used only for comparative performance purposes.*

12.1.1. PERCEIVED SIGNAL-TO-NOISE RATIO

The human visual system "filters" enhance the displayed SNR. The perceived signal-to-noise ratio, referred back to the array output, is

$$SNR_P = k\frac{MTF_{SYS}\,\Delta n_{pe}}{\langle n_{SYS}\rangle}\,\frac{1}{(eye\ spatial\ filter)(eye\ temporal filter)}\ . \quad (12\text{-}1)$$

MTF_{SYS} includes the camera, electronics, display, and HVS MTFs (see Chapter 10, *System MTF*, page 267). All calculations are performed with object-space units (e.g., cycles/mrad). The value Δn_{pe} is the difference in the number of photoelectrons generated by the target and its immediate background. The value k depends on the optical aperture diameter, focal length, detector spectral quantum efficiency, etc.

This approach differs from the camera signal-to-noise ratio presented in Section 6.1.2. (page 186). There, the target was considered very large so the system MTF did not affect the signal strength. The rationale for using the MTF here, is that observer metrics (i.e., MRC) are based on the visibility of high frequency bar targets.

Although the HVS's modulation threshold is reported as a J-shaped curve (see Figure 10-30, page 307), the actual shape depends on the noise power spectral density.[6-8] If the noise is restricted to certain spatial frequencies, then the detection of targets of comparable spatial frequencies becomes more difficult. The observer's ability to see a specific spatial frequency target depends on the noise content in the neighborhood of that spatial frequency (Figure 12-1). Low spatial frequency noise components will interfere with detecting low frequency targets (large objects). Mid-spatial frequency noise increases the modulation threshold curve at mid-frequencies and so on. These noise factors are included in the MRC model via the three-dimensional noise model. As such, they are not included in the HVS MTF.

For nearly all imaging systems, square waves (bar targets) are used for system characterization. Using the CTF_{SYS} (See Section 9.5., *Contrast Transfer Function*, page 263), the perceived signal-to-noise ratio is

$$SNR_P = k'\,\frac{CTF_{SYS}\,\Delta n_{pe}}{\langle n_{SYS}\rangle(eye\ spatial\ filter)(eye\ temporal\ filter)}\ , \quad (12\text{-}2)$$

where k′ is a constant that includes k and the conversion from MTF to CTF.

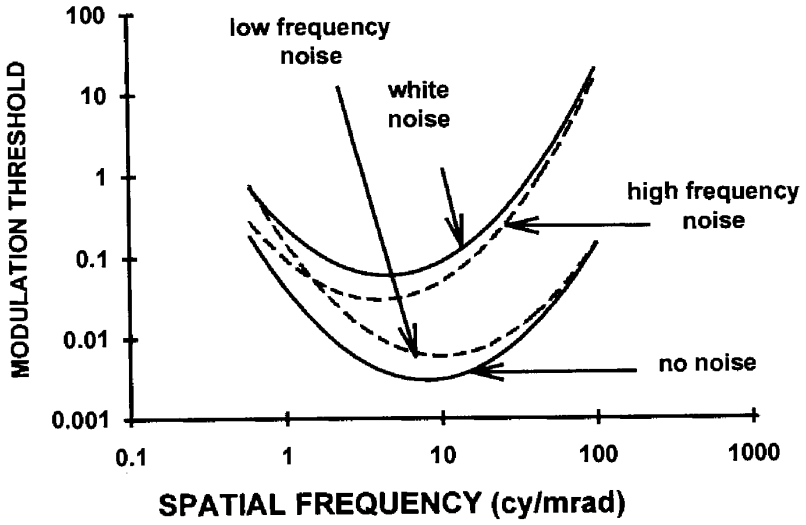


Figure 12-1. Effects of spectral noise on the HVS's modulation threshold. The MRC should approximately follow the shape of the modulation threshold curve.

Selecting a threshold value that is required to just perceive a target and inverting Equation 12-2 provide a minimum detectable target to background difference:

$$\Delta n_{MINIMUM} = SNR_{TH} \frac{\langle n_{SYS} \rangle (eye\,spatial\,filter)(eye\,temporal\,filter)}{k' CTF_{SYS}} \quad . \quad (12\text{-}3)$$

The system noise may consist of many components and the HVS may integrate each component differently. The function β_i is the "filter" that interprets noise source $\langle n_i \rangle$:

$$\Delta n_{MINIMUM} = SNR_{TH} \frac{\sqrt{\langle n_1^2 \rangle \beta_1 + ... + \langle n_m^2 \rangle \beta_m}}{k' CTF_{SYS}} \quad (12\text{-}4)$$

or

$$\Delta n_{MINIMUM} = SNR_{TH} \frac{\langle n_1 \rangle}{k' CTF_{SYS}} \sqrt{\beta_1 + ... + \frac{\langle n_m^2 \rangle}{\langle n_1^2 \rangle} \beta_m} \quad . \quad (12\text{-}5)$$

A test bar target is approximated by a square wave of infinite extent. If the system is band-limited, then only the fundamental of the square wave has sufficient amplitude to contribute to the response (valid for high frequencies). The fundamental's amplitude is $4/\pi$ times the square wave amplitude. The HVS is sensitive to the average value of the first harmonic and the average value of a half-cycle sine wave is $2/\pi$. Therefore, the conversion from a square wave (CTF_{SYS}) to a sinusoid (MTF_{SYS}) requires a factor of $8/\pi^2$ when viewed by an observer:

$$\Delta n_{MINIMUM} = SNR_{TH} \frac{\pi^2}{8} \frac{\langle n_1 \rangle}{k\, MTF_{SYS}} \sqrt{\beta_1^2 + \ldots + \frac{\langle n_m^2 \rangle}{\langle n_1^2 \rangle} \beta_m^2} \quad . \qquad (12\text{-}6)$$

Following FLIR92 terminology,[3] $\langle n_1 \rangle$ is the shot noise. The other noise terms represent all other noise sources. The three-dimensional noise model quantifies each $\langle n_i^2 \rangle$.

In Section 6.2.1., *Camera SNR* (page 186), a target SNR was calculated. The background light level was assumed to be zero so that the photon shot noise was associated with the target only. For target detection, the target exists on a positive background. Both the target and the background regions provide photons that the camera converts to photoelectrons. Let $n_{pe\text{-}T}$ and $n_{pe\text{-}B}$ be the number of photoelectrons associated with the target and background, respectively. There is shot noise associated with both. The "average" shot noise variance is

$$\langle n_1^2 \rangle = \langle n_{SHOT}^2 \rangle \approx \frac{n_{pe-T} + n_{pe-B}}{2} \quad . \qquad (12\text{-}7)$$

A variety of definitions exist for contrast. The contrast, as defined in the original MRC derivation, is the target luminance minus the background luminance divided by the background luminance. Because both the target and background are assumed to be illuminated by the same source (sun, moon, etc.), the contrast depends on reflectances:

$$C_o = \frac{|L_T - L_B|}{L_B} = \frac{|\rho_T - \rho_B|}{\rho_B} \quad . \qquad (12\text{-}8)$$

Historically, the target was always considered darker than the background. However, the target can be brighter than the background and there does not appear to be any difference between the detectability of objects that are of negative or positive contrast.

Substituting Equations 12-7 and 12-8 into Equation 12-6 and calling the minimum detectable contrast the MRC, provides

$$MRC = SNR_{TH}\frac{\pi^2}{8}\frac{1}{k\,MTF_{SYS}}\sqrt{\frac{MRC+2}{2n_{pe-B}}}\sqrt{\beta_1+\ldots+\frac{\langle n_m^2\rangle}{\langle n_{SHOT}^2\rangle}\beta_m}\ . \quad (12\text{-}9)$$

Because MRC appears on both sides of the equation, it can be solved either iteratively or as a quadratic equation. The MRC is a family of curves dependent on the background level (Figure 12-2). MRC approaches a maximum value of unity as the system MTF approaches zero. Thus, MRC is linked to MTF but the resolution (i.e., the spatial frequency where the contrast approaches one) depends on the background.

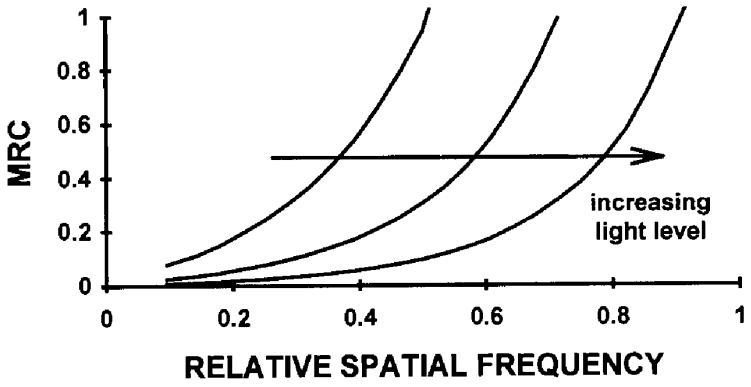


Figure 12-2. MRC is a family of curves that depends on the background light level.

12.1.2. PERCEIVED RESOLUTION

Perceived resolution depends on the size of the target, ambient lighting, and target-to-background contrast. These issues were not considered when discussing display resolution because they are relatively constant.

For signals embedded in noise, the situation is different. The HVS is then very sensitive to the signal-to-noise ratio. Slight variations affect target visibility. As illustrated in Figure 12-3, the signal increases faster than the accompanying photon shot noise. Given a threshold of perceptibility, as the SNR increases, more detail can be seen because more signals rise above the threshold. Thus, camera "resolution" depends on background light level. This "resolution" is strictly due to the HVS's response and is not related to hardware performance. In contrast, hardware resolution is typically specified as that spatial frequency where the hardware MTF is, say, 10% and is measured under relatively high signal-to-noise ratio conditions.

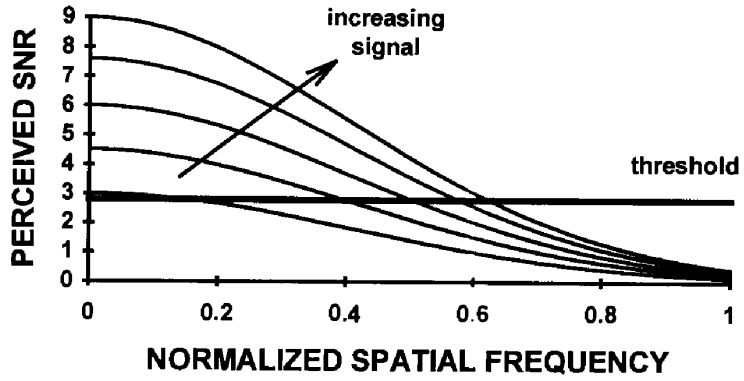


Figure 12-3. As the target signal increases, the SNR increases. For a fixed threshold, increasing the signal appears to increase the resolution.

Figure 12-4 illustrates the perceived resolution as a function of light level. The apparent resolution increases with light level. Because the SNR is proportional to contrast, the "resolution" is also a function of contrast. High contrast targets produce higher resolution. Again, this is strictly due to the HVS's response and is not related to hardware limitations.

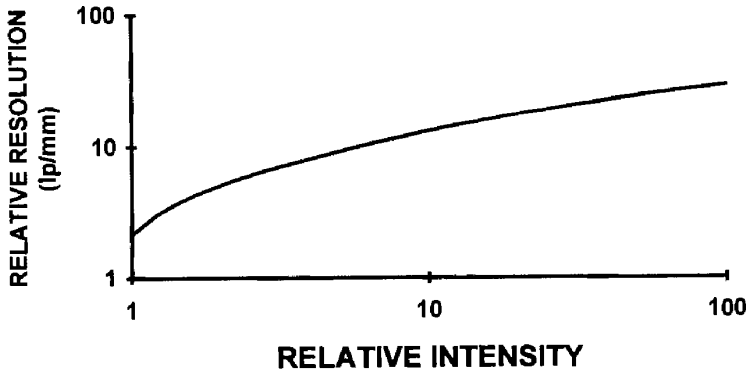


Figure 12-4. Perceived resolution as a function of light level.

12.1.3. THE HVS "FILTER"

The HVS system is probably the most difficult system to model. Although many models exist, the two most often employed are the matched filter and the synchronous integrator model. With the matched filter, the HVS acts like a tuned circuit. Here, the perceived SNR is affected only by spatial frequencies that are near the target's spatial frequency. All other spatial frequencies are ignored. This is not a filter in the usual sense because the signal and noise are "filtered" by it. Rather, visual psychophysical data suggest that the HVS acts as if it were a filter that can be described mathematically by a filter function. With the synchronous integrator model, the HVS integrates over an angular region defined by the target edges.

Scott and D'Agostino state[9] *The most frequently encountered methods...describe the eye/brain spatial integration using either a matched filter or a synchronous integrator model ... they yield virtually identical ... predictions ... Any potential difference ... will be lost in the inherent error of the .... measurements. For these reasons, and because ... a synchronous integrator is somewhat simpler ...., FLIR92 has been written as a synchronous integrator model.* Russell and Willson[2] used the synchronous integrator model for television systems and their approach is presented in this chapter.

12.2. THREE-DIMENSIONAL NOISE MODEL

The three-dimensional noise model[4] provides the basic framework for analyzing various noise sources. It was developed to describe the noise in thermal imaging systems. However, the methodology also applies to solid state cameras.

The noise is divided into a set of eight components that relate temporal and spatial noise to a three-dimensional coordinate system (Figure 12-5). This approach allows full characterization of all noise sources including random noise, pattern noise, streaks, rain, 1/f noise, and any other artifact. Analyzing the noise in this manner has the advantage of simplifying the understanding of complex phenomena by breaking it down into a manageable set of components. The method simplifies the incorporation of complex noise factors into model formulations.

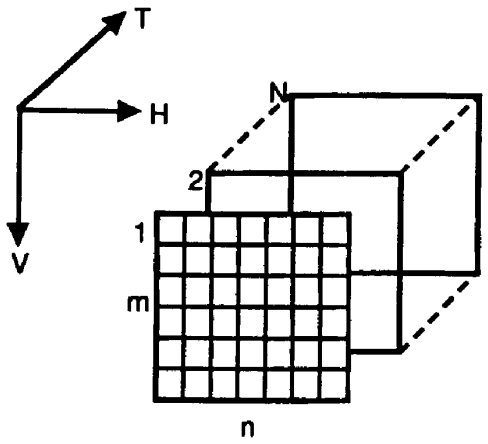


Figure 12-5. Three-dimensional noise model coordinate system illustrating data set N_{TVH}.

The T-dimension is the temporal dimension representing the video framing sequence. The other two dimensions (horizontal and vertical) provide spatial information. For a staring array, n and m indicate detector element locations in the horizontal and vertical directions, respectively.

Table 12-1 describes the three-dimensional noise components. The subscripts describe the noise "direction." The value σ_{TVH} represents the rms noise of the three-dimensional data set $m \times n \times N$. The value σ_{VH} is the rms noise after averaging in the T-direction. Its data set contains $m \times n$ elements. And so on.

Table 12-1
THREE-DIMENSIONAL NOISE DESCRIPTORS

3-D NOISE COMPONENT	DESCRIPTION
σ_{TVH}	Random 3-D noise
σ_{VH}	Spatial noise that does not change from frame-to-frame
σ_{TH}	Variations in column averages that change from frame-to-frame (rain)
σ_{TV}	Variations in row averages that change from frame-to-frame (streaking)
σ_{V}	Variations in row averages that are fixed in time (horizontal lines or bands)
σ_{H}	Variations in column averages that are fixed in time (vertical lines)
σ_{T}	Frame-to-frame intensity variations (flicker)

Depending on the system design and operation, any one of these noise components can dominate. The origins of these components are significantly different and the existence and manifestation depend on the specific design of the imaging system. Not all of the noise components may be present in every imaging system.

Assuming the noise components are independent, the total system noise is

$$\sigma_{SYS} = \sqrt{\sigma^2_{TVH} + \sigma^2_{TH} + \sigma^2_{TV} + \sigma^2_{VH} + \sigma^2_{H} + \sigma^2_{V} + \sigma^2_{T}} \ . \qquad (12\text{-}10)$$

Independence was a fundamental assumption during the development of the three-dimensional noise model. For nearly all systems, σ_T is considered negligible compared to σ_{TVH} and therefore is omitted from the data set. The value σ_{TVH} consists of the shot noise and the noise floor. Pattern noise is incorporated though σ_{VH}, σ_V, and σ_H. Currently, only σ_{TVH} is predicted and the remaining noise components must be determined from measurements or estimates. Figures 12-6 through 12-8, generated by the *System Image Analyzer*,[10] illustrate the effect of these noise sources. Figure 12-6 is the basic image. In Figure 12-7, FPN, PRNU, and random noise appear similar in a single frame. Random noise changes from frame-to-frame whereas pattern noise does not. Figure 12-8 illustrates how σ_{TV} or σ_V affect the visibility of horizontal bars. Scanning systems often exhibit this type of noise. Pixels will always have different responsivities. When the row-average responsivities are different in TDI sensors, banding occurs.[11]



Figure 12-6. Ideal image with $\sigma_{SYS} = 0$. Generated by *System Image Analyzer* software.[10]

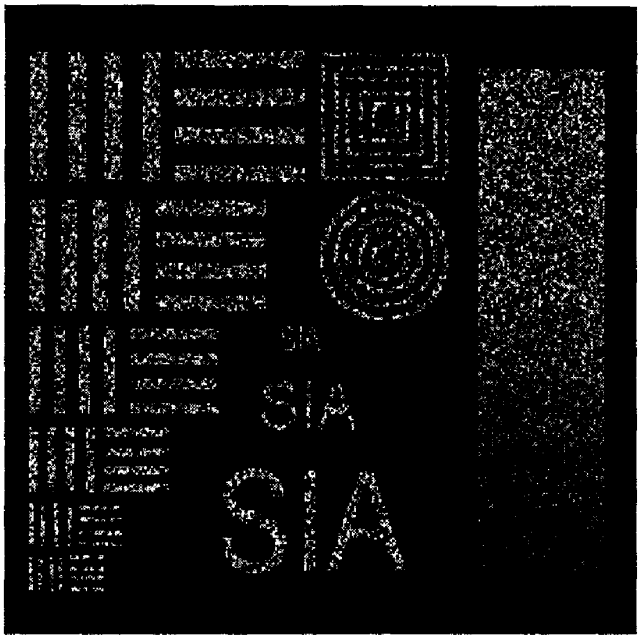


Figure 12-7. Image with random, FPN, or PRNU noise.

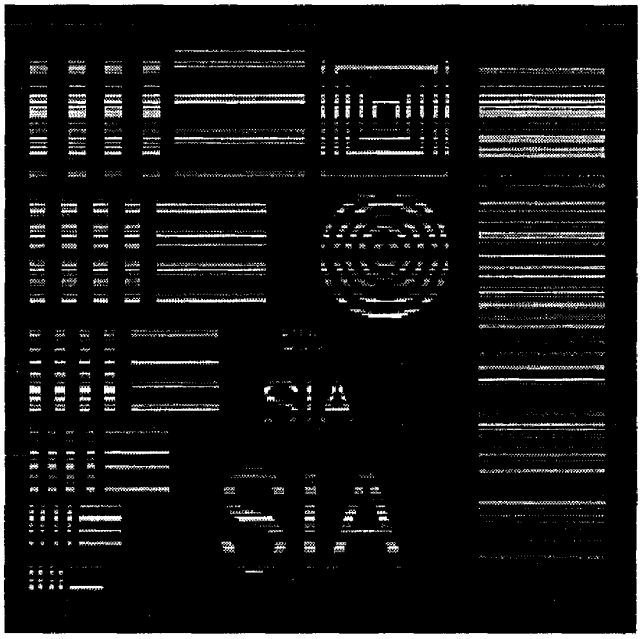


Figure 12-8. Image with dominant horizontal banding (high σ_{TV} or σ_V).

While the three-dimensional noise model was created to describe noise sources in thermal imaging systems, many of the same noises exist in all imaging systems. The FLIR92 default values should apply to all imaging systems built to similar designs.

With all systems, the most prevalent noise source is assumed to be temporal noise (σ_{TVH}). For staring arrays, the next most important noise source is σ_{VH}. Table 12-2 lists the FLIR92 recommended[3] values for PtSi staring arrays operating in the 3 to 5 μm range. Other systems using different detectors may perform differently. These values were obtained empirically.

For scanning systems, temporal row noise (σ_{TV}) and fixed row noise (σ_{V}) are the important contributors. Table 12-3 lists the FLIR92 default values appropriate for scanning systems with HgCdTe detectors operating in the 8 to 12 μm region. These values apply to all linear arrays (vertically oriented) with horizontal scanning.

Table 12-2
DEFAULT VALUES for STARING SYSTEMS

RELATIVE NOISE	DEFAULT VALUE
σ_{VH}/σ_{TVH}	0.40
σ_{TV}/σ_{TVH}	0
σ_{V}/σ_{TVH}	0
σ_{TH}/σ_{TVH}	0
σ_{H}/σ_{TVH}	0

Table 12-3
DEFAULT VALUES for SCANNING SYSTEMS

RELATIVE NOISE	DEFAULT VALUES
σ_{VH}/σ_{TVH}	0
σ_{TV}/σ_{TVH}	0.25
σ_{V}/σ_{TVH}	0.25
σ_{TH}/σ_{TVH}	0
σ_{H}/σ_{TVH}	0

12.3. THE MRC MODEL

The MRC is a measure of an observer's ability to detect a signal embedded in noise. The MRC model is a so-called *static* model in that the target is stationary and no search is required (or at least the observer knows where to look). The observer has an unlimited amount of time for target discrimination. As with most models, the system is assumed to be linear-shift-invariant.

This section applies the FLIR92 methodology to solid state camera performance. The fundamental difference between the MRC and MRT is the method by which the target is characterized. In the infrared spectral region, the target-to- background differential signal is specified by a temperature difference. In the visible spectral region, the differential signal is specified by the contrast. The MRT derivation can be found in the literature.[5,12-15]

Following FLIR92 methodology, the horizontal and vertical MRCs are

$$MRC_H(u_{ob}) = SNR_{TH} \frac{\pi^2}{8} \frac{1}{k\,MTF_H(u_{ob})} \sqrt{\frac{MRC + 2}{2n_{pe-B}}}\, K_H(u_{ob}) \quad (12\text{-}11)$$

and

$$MRC_V(v_{ob}) = SNR_{TH} \frac{\pi^2}{8} \frac{1}{k\,MTF_V(v_{ob})} \sqrt{\frac{MRC + 2}{2n_{pe-B}}}\, K_V(v_{ob}) \,. \quad (12\text{-}12)$$

The functions $K_H(u_{ob})$ and $K_V(v_{ob})$ are summary noise factors that combine the three-dimensional noise model components with the HVS's spatial and temporal integration capabilities. The variable $MTF_H(u_{ob})$ is the product of all the horizontal MTFs and $MTF_V(v_{ob})$ is the product of all the vertical MTFs (see Chapter 10, *System MTF*, page 267). In the original development of the MRC model, only the HVS spatial and temporal integration factors were considered. Later models included the HVS MTF.

The summary noise factors are

$$K_H(u_{ob}) = \left(E_T E_V E_H + \frac{\sigma^2_{VH}}{\sigma^2_{TVH}} E_V E_H + \frac{\sigma^2_{TH}}{\sigma^2_{TVH}} E_T E_H + \frac{\sigma^2_{H}}{\sigma^2_{TVH}} E_H \right)^{\frac{1}{2}} \quad (12\text{-}13)$$

and

$$K_V(v_{ob}) = \left(E_T E_V E_H + \frac{\sigma^2_{VH}}{\sigma^2_{TVH}} E_V E_H + \frac{\sigma^2_{TV}}{\sigma^2_{TVH}} E_T E_V + \frac{\sigma^2_{V}}{\sigma^2_{TVH}} E_V \right)^{\frac{1}{2}} . \quad (12\text{-}14)$$

For staring systems, the default (see Table 12-2) MRCs become

$$MRC_H(u_{ob}) = \frac{\pi^2}{8} \frac{SNR_{TH}}{k\,MTF_H(u_{ob})} \sqrt{\frac{MRC + 2}{2 n_{pe\text{-}B}}} \sqrt{E_V E_H \left(E_T + \frac{4}{10} \right)} \quad (12\text{-}15)$$

and

$$MRC_V(v_{ob}) = \frac{\pi^2}{8} \frac{SNR_{TH}}{k\,MTF_V(v_{ob})} \sqrt{\frac{MRC + 2}{2 n_{pe\text{-}B}}} \sqrt{E_V E_H \left(E_T + \frac{4}{10} \right)} . \quad (12\text{-}16)$$

For scanning systems (applies to linear arrays) the default (see Table 12-3) MRCs are

$$MRC_H(u_{ob}) = \frac{\pi^2}{8} \frac{SNR_{TH}}{k\,MTF_H(u_{ob})} \sqrt{\frac{MRC + 2}{2 n_{pe\text{-}B}}} \sqrt{E_T E_V E_H} \quad (12\text{-}17)$$

and

$$MRC_V(v_{ob}) = \frac{\pi^2}{8} \frac{SNR_{TH}}{k\,MTF_V(v_{ob})} \sqrt{\frac{MRC + 2}{2 n_{pe\text{-}B}}} \sqrt{E_V \left(E_T E_H + \frac{1}{4} E_T + \frac{1}{4} \right)} . \quad (12\text{-}18)$$

The values E_T, E_H, and E_V, respectively, represent the temporal, horizontal spatial and vertical spatial integration afforded by the HVS interpreter. The model assumes that the HVS temporally integrates perfectly and continuously over the HVS integration time. The noise is considered uncorrelated from frame-to-frame so that it adds in quadrature. When the information update rate, F_R, is high enough, and if there is signal correlation between adjacent frames:

$$E_T = \frac{1}{F_R t_e} . \qquad (12\text{-}19)$$

A 5:1 aspect ratio 3-bar target ($T_{ASPECT} = 5$) is used to measure the MRC, whereas a 7:1 aspect ratio 4-bar target is typically used for MRT measurements. The bars are oriented vertically for horizontal measurements and horizontally for vertical measurements. Thus, the equations used depend on the bar orientation. A vertical and horizontal MRC exists for each bar orientation. Table 12-4 lists the nomenclature. Before the two-dimensional MRC approach, only $E_{H\text{-}H}$ was used for horizontal MRC measurements. Similarly, only $E_{V\text{-}V}$ was used for vertical MRC measurements. The additional components, $E_{V\text{-}H}$ and $E_{H\text{-}V}$, are used in the two-dimensional MRC (discussed in Section 12.5., *Two-dimensional MRC*).

Table 12-4
MRC EQUATION NOMENCLATURE

MEASUREMENT	BAR ORIENTATION	MODEL NOMENCLATURE
Horizontal MRC	Vertical	Horizontal MRC: $E_{H\text{-}H}$ Vertical MRC: $E_{V\text{-}H}$
Vertical MRC	Horizontal	Horizontal MRC: $E_{H\text{-}V}$ Vertical MRC: $E_{V\text{-}V}$

The noise filters and noise power spectrum were described in Section 6.2.1., *Camera SNR* (page 186). The noise spectrum is modified by the electronic filters that occur after the insertion of noise. Because noise is assumed to originate in the detector, MTF_{OPTICS}, MTF_{MOTION}, and $MTF_{DETECTOR}$ are not part of the noise filters. As appropriate, the remaining MTFs provided in Chapter 10, *System MTF* (page 267), are components of the noise filters. For equation brevity, the horizontal and vertical noise filters are listed as $H_{NF\text{-}H}(u_{ob})$ and $H_{NF\text{-}V}(v_{ob})$, respectively. As appropriate, f_e, f_v, and u_d are expressed in equivalent object-space units (u_{ob}). Because electrical signals are typically read out in a serial data

stream (consistent with video standard timing), the noise appears in the horizontal direction only. The variable v_{ob} is the transposed variable v_d and also the vertical digital filter response if present.

For horizontal MRC, the bars are oriented vertically and the bar aspect ratio, T_{ASPECT}, appears in the vertical summary noise factors. For a bar target with fundamental spatial frequency u_o, the summary noise factors are

$$E_{H\text{-}H}(u_o) = \frac{d_{CCH}}{fl}\int_0^{\infty} S(u_{ob})\,|H_{NF\text{-}H}(u_{ob})|^2\, sinc^2\left(\frac{u_{ob}}{2u_o}\right) du_{ob} \quad (12\text{-}20)$$

and

$$E_{V\text{-}H}(u_o) = \frac{d_{CCV}}{fl}\int_0^{\infty} |H_{NF\text{-}V}(v_{ob})|^2\, sinc^2\left(\frac{T_{ASPECT}v_{ob}}{2u_o}\right) dv_{ob}\ . \quad (12\text{-}21)$$

For the vertical MRC, the bar aspect ratio is in the horizontal summary noise factor:

$$E_{H\text{-}V}(u_o) = \frac{d_{CCH}}{fl}\int_0^{\infty} S(u_{ob})\,|H_{NF\text{-}H}(u_{ob})|^2\, sinc^2\left(\frac{T_{ASPECT}u_{ob}}{2u_o}\right) du_{ob} \quad (12\text{-}22)$$

and

$$E_{V\text{-}V}(u_o) = \frac{d_{CCV}}{fl}\int_0^{\infty} |H_{NF\text{-}V}(v_{ob})|^2\, sinc^2\left(\frac{v_{ob}}{2u_o}\right) dv_{ob}\ . \quad (12\text{-}23)$$

In the early literature, only the horizontal MRC was calculated and only random temporal noise was modeled. With no other noise sources,

$$MRC_H(u_{ob}) = \frac{\pi^2}{8}\frac{SNR_{TH}}{k\,MTF_H(u_{ob})}\sqrt{\frac{MRC+2}{2n_{pe\text{-}B}}}\sqrt{E_V E_H E_T}, \quad (12\text{-}24)$$

where E_T, E_H, and E_V are given by Equations 12-19, 12-20, and 12-21, respectively.

If MTFs are near unity and the noise is white [$S(u_{ob}) \approx 1$] over the spatial frequencies of interest, then

$$E_H = E_{H\text{-}H}(u_o) \approx \frac{d_{CCH}}{fl} \frac{u_o}{T_{ASPECT}} \tag{12-25}$$

and

$$E_V = E_{V\text{-}H}(u_o) \approx \frac{d_{CCV}}{fl} u_o \ . \tag{12-26}$$

Then

$$MRC(u_o) = \frac{\pi^2}{8} \frac{SNR_{TH}}{k\, MTF(u_o)} \sqrt{\frac{MRC + 2}{2 n_{pe\text{-}B}}} \sqrt{\frac{1}{F_R t_e}} \sqrt{\frac{d_{CCH} d_{CCV}}{fl^2 T_{ASPECT}} u_o^2} \ . \tag{12-27}$$

The original SNR formulation[16] contained an $(a/A)^{1/2}$ factor where "a" is the target area at the image plane and "A" is the effective area of the photosensitive device. The MRC is the inverse of the SNR and therefore should contain $(A/a)^{1/2}$. This is identical to the last square-root term in Equation 12-27. "A" is the photosensitive area that contributes to noise. With vidicons, the "A" represented the entire image surface. With solid state arrays, it is the effective pixel size, $d_{CCH}d_{CCV}/fl^2$. The target size is $(1/u_o)(T_{ASPECT}/u_o)$. Equation 12-27 reduces to the basic MRC equation used by most researchers[17,18] prior to the introduction of the three-dimensional noise model.

12.4. SNR_{TH} and t_e

The FLIR92 documentation[19] states: *SNR_{TH} and the eye integration time, t_e, are most often the model parameters used to "tune" an MRTD prediction to a set of measurements.* These values are treated as constants that are adjusted so that the predicted values match laboratory data.

The 1975 NVL model documentation[20] states: ... *unfortunately, universal values for these constants do not exist. The values recommended at this time are $SNR_{TH} = 2.25$ and $t_e = 0.2$.*

FLIR92 documentation continues[19] *The luminances associated with about a 0.1 second eye integration time agrees well with the display experiments*

conducted in 1988 ... (darkened room and optimal viewing) ... In higher ambient light levels conditions, such as may be encountered with fielded systems, greater display luminances can be expected and thus a faster eye integration time may be appropriate... NVESD recommends setting SNR_{TH} equal to 2.5 ... Though psychophysical data show that SNR_{TH} is a function of target frequency, a value of 2.5 represents a reasonable average

The value t_e is somewhat nebulous and its value depends on the specific task at hand and ambient light level. FLIR92 recommends changing t_e according to the available light level (Figure 12-9).

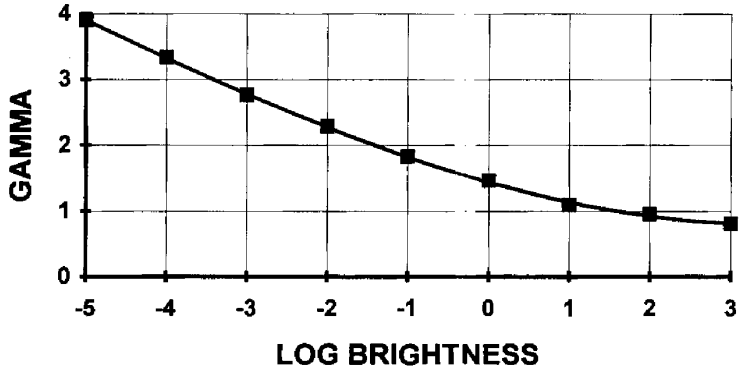
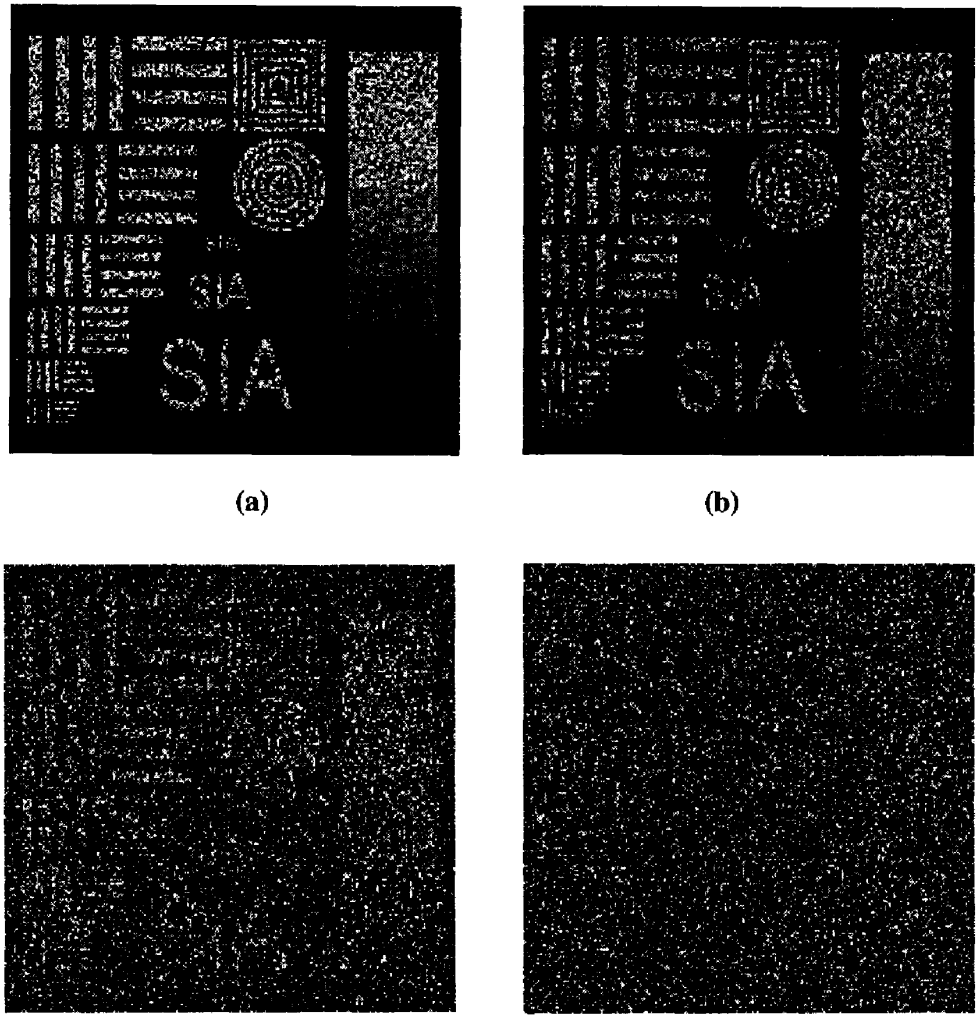


Figure 12-9. HVS integration values as a function of light level. FLIR92 documentation recommends using t_e = 0.1 s for laboratory MRT predictions. The same technique can be applied to MRC.

While many arguments exist for selecting the "correct" values, SNR_{TH} and t_e are simply constants. Both SNR_{TH} and t_e have a range of acceptable values. No matter what value is selected for t_e, consistency throughout the model must be maintained. The value t_e is also used in the linear motion MTF (see Section 10.5.1., *Linear Motion*, page 292).

A word of clarification is necessary here. SNR_{TH} is approximately the signal-to-noise value that the HVS perceives the image to be at threshold. It includes, in part, both temporal and spatial integration effects. It is *not* the signal-to-noise ratio of the video signal nor the SNR of the luminance on the display. Depending on the noise characteristics and the target characteristics, the HVS can detect[21] signals with video SNR as low as 0.05. Figure 12-10 provides an example of the HVS spatial integration capability.



(a) (b)

(c) (d)

Figure 12-10. Variations in the signal-to-noise ratio, (a) SNR = 2, (b) SNR = 1, (c) SNR = 0.75, and (d) SNR = 0.5. The imagery was computer generated with the SNRs listed. The tonal transfer characteristics of the laser printer (to create the hard copy) and halftone (to print the image) may have affected the final SNR. The actual SNRs in this printed copy have not been measured. These images should be considered as representative of the ability to perceive low SNR imagery.

The ability to perceive targets embedded in noise depends on the target spatial extent with respect to the noise spatial frequencies. Large bars are easier to perceive compared to small targets that "disappear" into the noise. Figure 12-10 only illustrates the HVS's spatial integration capabilities. With live video, the random noise is changing from frame to frame and the HVS's temporal integration provides an additional enhancement of $F_R t_e$. For EIA 170 timing, this is about a factor of three to six.

12.5. TWO-DIMENSIONAL MRC

Although FLIR92 is called two-*dimensional*, it is a two-*directional* model. That is, the threshold is predicted along two orthogonal axes, taken as the vertical and horizontal directions. With unequal MTFs, the predicted MRC will be different in the two directions. The two directional values are brought together with a two-dimensional spatial frequency that approximates the response of an equivalent radially symmetric system.

As with the MRTs, the two-dimensional MRC is created by taking the geometric average of the horizontal and vertical MRC frequencies at each contrast value (Figure 12-11):

$$f_{2D} = \sqrt{u_1 v_1} \ . \tag{12-28}$$

In this manner, the two-dimensional MRC is forced to approach asymptotically the mean values of the vertical and horizontal cutoff frequencies. The two-dimensional MRC is a mathematical construct that is used for range performance predictions. It cannot be measured because f_{2D} does not exist.

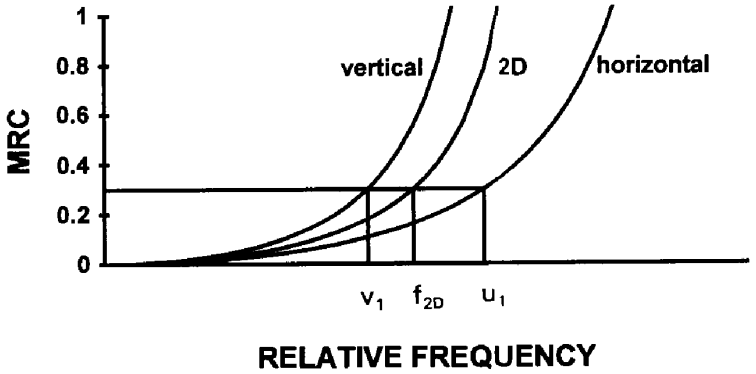


Figure 12-11. The two-dimensional MRC is mathematically created from the horizontal and vertical MRCs. It is really a two-*directional* MRC.

12.6. RANGE PREDICTIONS

Performance modeling assumes that the target is a single spatial frequency. This is an approximation because real targets consist of a complex superposition of spatial frequencies. Targets are actually a continuum of spatial frequencies from zero on up. The system MTF limits the target spatial frequencies that can be displayed. This section provides an overview of the range prediction methodology. A detailed discussion of system range performance is available.[22]

The Johnson criterion provides the link between the target angular subtense and the spatial frequency scale on the MRC graph. The target's inherent contrast, C_O, is modified by the atmospheric conditions (attenuation and path radiance). When the target contrast is reduced to the MRC curve, the performance range is obtained. Depending on the Johnson criterion selected, this becomes the detection, recognition, or identification range.

12.6.1. CONTRAST TRANSMITTANCE

Intuitively, it seems that any phenomena that prevent us from visually perceiving an object will affect all imagery the same way. During a hazy day, light scattered into the HVS (path radiance) reduces the visual contrast. Here, objects that are far away appear as a neutral white and we are unable to distinguish any features. While the HVS acts in this manner, imaging systems do not. Imaging systems simply respond to radiance differences.

However, real systems have automatic gain circuitry that may be activated by the path radiance signal. If so, the effect is to reduce system gain. Path radiance will partially fill the charge wells.

For most applications, the target and background are illuminated by the same source (sun, moon, etc.). The apparent contrast, C_R, is the inherent contrast modified by the atmosphere. Dropping the wavelength notation for equation brevity,

$$C_O = \frac{\Delta L}{L} = \frac{e^{-\sigma_{ATM}R}\left[\rho_T - \rho_B\right] L_{SCENE}}{e^{-\sigma_{ATM}R}\rho_B L_{SCENE} + L_{ATM}} = C_o \frac{1}{1 + \dfrac{L_{ATM}}{\rho_b L_{SCENE}} e^{\sigma_{ATM}R}}, \quad (12\text{-}29)$$

where L_{SCENE} is the ambient illumination that irradiates the target and background.

It is the sky, sun, or moon modified by the intervening atmospheric transmittance. The value σ_{ATM} is the atmospheric scattering cross section and $\exp(-\sigma_{ATM}R)$ is the atmospheric transmittance. The path radiance, L_{ATM}, is due to light scattered into the line-of-sight and the total amount received is an integral over the path length.[23] When only scattering is present (a reasonable approximation for the visible spectral band), $L_{ATM} \approx [1 - \exp(-\sigma_{ATM}R)]L_{SKY}$. The value L_{SKY} depends on the viewing direction and the location of the sun. The value $\rho_B L_{SCENE}$ is the background luminance. For convenience, the $L_{SKY}/\rho_B L_{SCENE}$ is called the sky-to-ground ratio (SGR):

$$C_R = C_O \frac{1}{1 + SGR\left(e^{\sigma_{ATM}R} - 1\right)} . \tag{12-30}$$

The SGR is approximately $0.2/\rho_B$ for a clear day ($L_{SKY}/L_{SCENE} \approx 0.2$) and $1/\rho_B$ for an overcast day ($L_{SKY}/L_{SCENE} \approx 1$). When the SGR is one, the received contrast is simply the inherent contrast reduced by the atmospheric transmittance:

$$C_R = C_O e^{-\sigma_{ATM}R} . \tag{12-31}$$

Meteorological range is defined quantitatively by the Koschmieder formula[24]:

$$R_{VIS} = \frac{1}{\sigma_{ATM}} \ln\left(\frac{1}{C_{TH}}\right) , \tag{12-32}$$

where C_{TH} is the modulation threshold at which 50% of the observers would see the target. The use of the scattering cross section in this definition rather than the extinction coefficient implies that absorption of particles at visual wavelengths is small enough to ignore. This view is probably justified except in cases of polluted air. Koschmieder set C_{TH} to 0.02 and evaluated σ_{ATM} at $\lambda = 0.555$ μm. Then

$$Transmittance = T_{ATM} = e^{-\sigma_{ATM}R} = e^{-\frac{3.912}{R_{VIS}}R} . \tag{12-33}$$

Table 12-5 lists σ_{ATM} as a function of standard weather conditions. However, σ_{ATM} decreases with increasing wavelength. For visibilities less than 6 km, σ_{ATM} can be approximated by

$$\sigma_{ATM}(\lambda) \approx \left(\frac{3.912}{R_{VIS}}\right)\left(\frac{0.55}{\lambda}\right)^{0.585(R_{VIS})^{1/3}} . \qquad (12\text{-}34)$$

For much greater visibilities,

$$\sigma_{ATM}(\lambda) \approx \left(\frac{3.912}{R_{VIS}}\right)\left(\frac{0.55}{\lambda}\right)^{0.5(R_{VIS})^{1/3}} . \qquad (12\text{-}35)$$

Table 12-5
INTERNATIONAL VISIBILITY CODE

DESIGNATION	VISIBILITY	SCATTERING COEFFICIENT, σ_{ATM}
Dense fog	0 - 50 m	$> 78.2\ km^{-1}$
Thick fog	50 - 200 m	$19.6 - 78.2\ km^{-1}$
Moderate fog	200 - 500 m	$7.82 - 19.6\ km^{-1}$
Light fog	500 - 1 km	$3.92 - 7.82\ km^{-1}$
Thin fog	1 - 2 km	$1.96 - 3.92\ km^{-1}$
Haze	2 - 4 km	$0.978 - 1.96\ km^{-1}$
Light haze	4 - 10 km	$0.391 - 0.978\ km^{-1}$
Clear	10 - 20 km	$0.196 - 0.391\ km^{-1}$
Very clear	20 - 50 km	$0.0782 - 0.196\ km^{-1}$
Exceptionally clear	> 50 km	$< 0.0782\ km^{-1}$

12.6.2. JOHNSON CRITERIA

The Johnson[25] methodology has become known as the equivalent bar pattern approach. Observers viewed military targets through image intensifiers and were asked to detect, decide the orientation, recognize, and identify the targets. Air Force tri-bar charts with bars the same contrast as the scaled models were also viewed and the maximum resolvable bar pattern frequency was determined. The number of bars per critical object dimension was increased until the bars could just be individually resolved. In this way, detectability was correlated with the sensor's threshold bar pattern resolution (Table 12-6). These results became the foundation for the discrimination methodology used today. *Critical* dimension refers to the target dimension that must be discerned for detection, recognition, or identification. In the early literature, the minimum dimension was called the critical dimension.

Table 12-6
JOHNSON'S RESULTS
(From Reference 25)

DISCRIMINATION LEVEL	MEANING	CYCLES ACROSS CRITICAL TARGET DIMENSION
Detection	An object is present (object versus noise).	1.0 ± 0.025
Orientation	The object is approximately symmetrical or unsymmetrical and its orientation may be discerned (side view versus front view).	1.4 ± 0.35
Recognition	The class to which the object belongs (e.g., tank, truck, man).	4.0 ± 0.80
Identification	The object is discerned with sufficient clarity to specify the type (e.g., T-52 tank, friendly jeep).	6.4 ± 1.50

Although Johnson used 6.4 cycles across the critical target dimension for identification, studies with thermal imaging systems at the Night Vision Laboratory suggested that eight cycles were more appropriate for identification. Orientation is a less popular discrimination level. Because today's standards are based on Johnson's work, they are labeled as the Johnson criteria though they are not the precise values recommended by him.

The original Johnson methodology was validated using common module thermal imaging systems. Those systems typically had a 2:1 difference in horizontal to vertical resolution. The vertical resolution was limited by the detector pitch Nyquist frequency. For validation purposes, military vehicles were used and the critical dimension tended to be in the vertical direction although the predictions were based on horizontal performance. Converting to a two-dimension model requires removing the directional bias imposed by the one-dimensional model. This is achieved by reducing all values by 25%, or equivalently, multiplying[26] all discrimination values by 0.75. This adjustment then provides the same range performance predictions whether predicted by the one-dimensional or two-dimensional model. Table 12-7 provides the commonly used discrimination levels. By convention, each 50% probability is labeled as N_{50} (e.g., in one-dimension, N_{50} is 1, 4, or 8 cycles for detection, recognition, or identification, respectively).

Table 12-7
COMMON DISCRIMINATION LEVELS

TASK	DESCRIPTION	One-dimension N_{50}	Two-dimension N_{50}
Detection	The blob has a reasonable probability of being an object being sought.	1.0	0.75
Classical recognition	Object discerned with sufficient clarity that its specific class can be differentiated.	4.0	3.0
Identification	Object discerned with sufficient clarity to specify the type within the class.	8.0	6.0

12.6.3. TARGET TRANSFER PROBABILITY FUNCTION

The results of threshold experiments, such as Johnson's, provide an approximate measure of the 50% probability of discrimination level. Results of several field tests[20] provided the cumulative probability of discrimination or target transfer probability function (TTPF) (Table 12-8). The TTPF can be used for all discrimination tasks by simply multiplying the 50% probability of performing the task by the TTPF multiplier. For example, from Tables 12-7 and 12-8, the probability of 95% recognition is $2N_{50} = 2(4) = 8$ cycles across the target's critical dimension.

Table 12-8
DISCRIMINATION CUMULATIVE PROBABILITY

PROBABILITY of DISCRIMINATION	MULTIPLIER
1.00	3.0
0.95	2.0
0.80	1.5
0.50	1.0
0.30	0.75
0.10	0.50
0.02	0.25
0	0

An empirical fit[27] to the data provides

$$P(N) = \frac{\left(\frac{N}{N_{50}}\right)^E}{1 + \left(\frac{N}{N_{50}}\right)^E}, \tag{12-36}$$

where

$$E = 2.7 + 0.7\left(\frac{N}{N_{50}}\right). \tag{12-37}$$

Figure 12-12 illustrates the full TTPF for the three levels of discrimination as identified by Johnson. Because of the variability in the population, some people can only detect the target, others will recognize it, and still a smaller portion will identify the target. This leads to the wide variations seen in field test results.

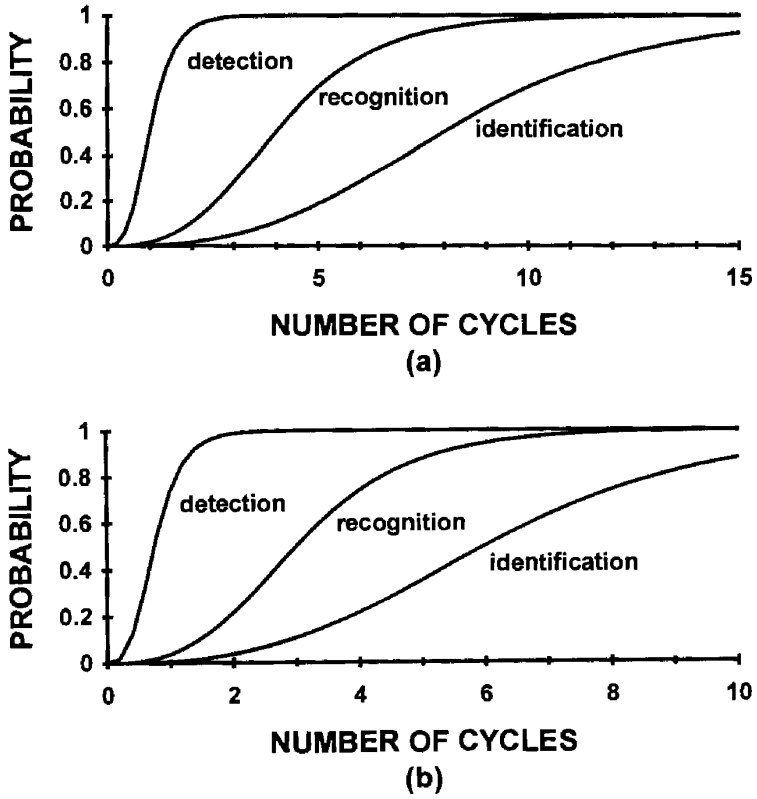


Figure 12-12. Target transfer probability function for detection, recognition, and identification. (a) one-dimensional and (b) two-dimensional. The curves overlap so that when only a small portion of the population can identify the target, a larger portion will recognize the target and an even larger portion will detect the target.

12.6.4. RANGE PREDICTION METHODOLOGY

The MRC abscissa is converted into a range scale using a target discrimination value. With the two-dimensional model, the critical dimension, h_c, is the square root of the target area, A_{TARGET}. For rectangular targets, $h_c = (HW)^{1/2}$ where H and W are the target's height and width, respectively. The number of equivalent cycles across the target is

$$N_T = \frac{\sqrt{A_{TARGET}}}{R} f_{2D} = \frac{h_c}{R} f_{2D} . \qquad (12\text{-}38)$$

Consider a target that is 2 × 8 m and six cycles are required across the critical dimension. Then the conversion from spatial frequency to range is

$$R = \frac{\sqrt{2 \cdot 8}}{6} f_{2D} = \frac{4}{6} f_{2D}, \tag{12-39}$$

where six cycles represent 95% probability of recognition for the two-dimensional model. The intersection of the MRC curve and the target apparent contrast, C_R (using Equation 12-31, page 360), versus range curve is the range at which the target can be discerned according to the discrimination level selected (Figure 12-13).

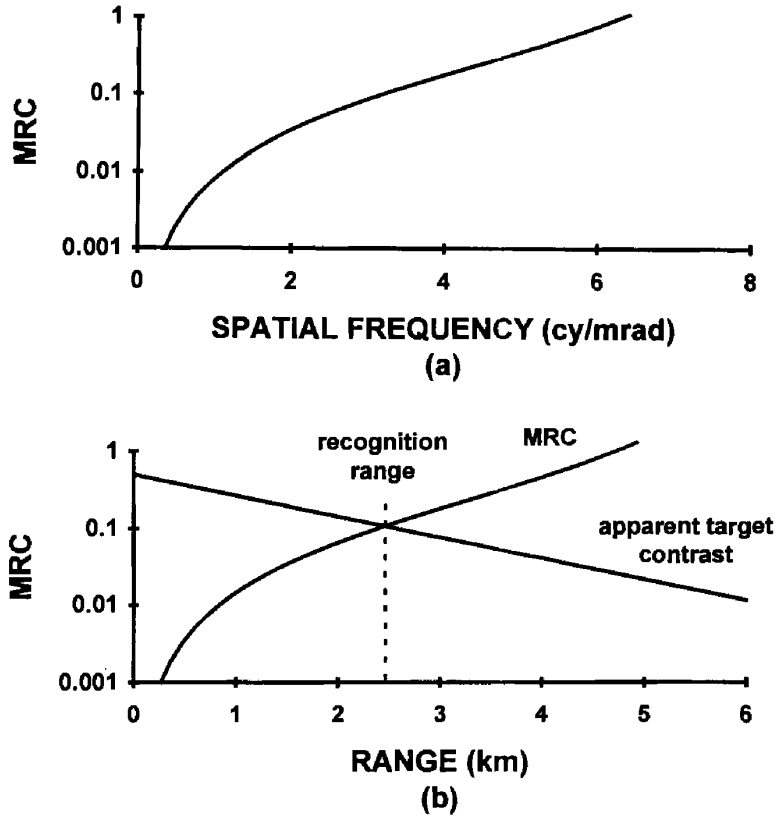


Figure 12-13. Graphical method to obtain the recognition range. (a) Two-dimensional MRC and (b) conversion of spatial frequency into range. The values $N_{50} = 3$, $h_c = 4$ m, and $C_O = 0.5$. The value C_R is a straight line when plotted in semi-logarithmic coordinates. The visibility is 6.2 km. The two-dimensional 50% probability recognition range is approximately 2.5 km.

The target transfer probability function is used to predict the probability of range performance. Here, a range is selected and C_R is calculated. This value intersects the MRC curve at what is called the critical frequency. Multiplying the angular subtense by the critical frequency provides the number of cycles across the target. Referring to the TTPF (see Figure 12-12), the probability is determined for that particular range. Then a new range is selected and the process is repeated until the entire probability function is determined (Figure 12-14).

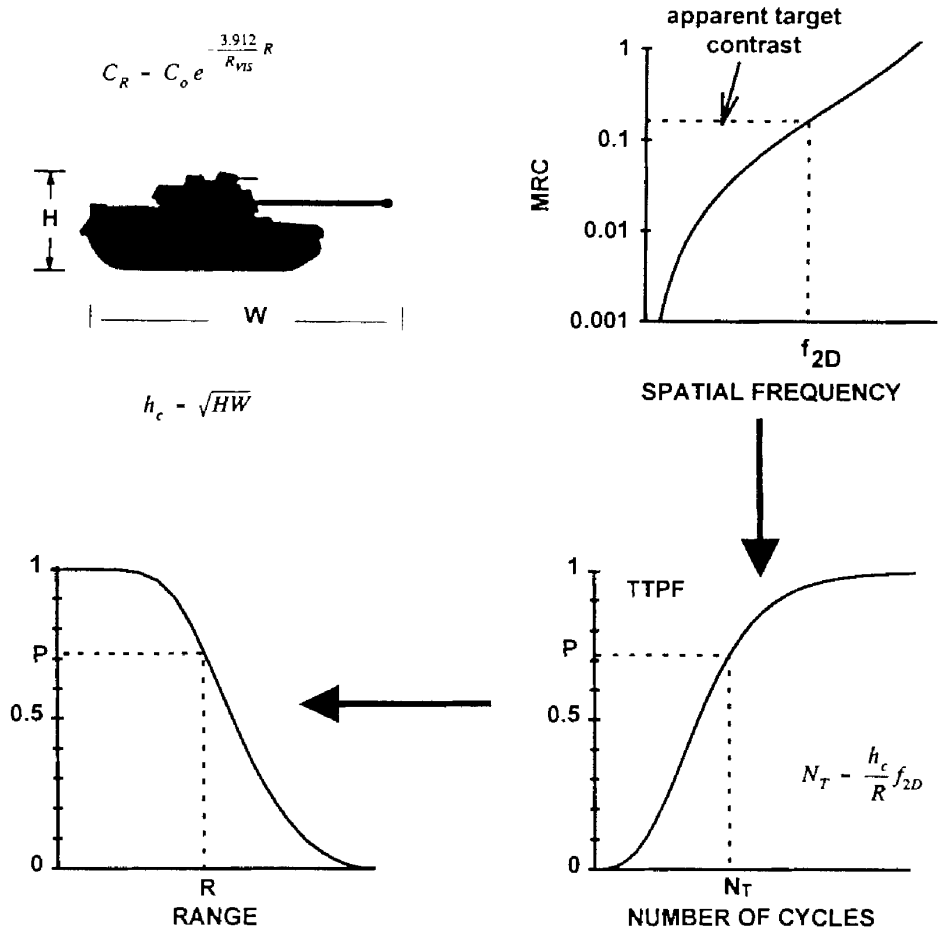


Figure 12-14. Methodology to determine range performance probability.

12.6.5. SAMPLING EFFECTS

In Chapter 8, *Sampling Theory*, page 231, it was stated that the highest frequency that could be faithfully reproduced is the Nyquist frequency. Solid state cameras are undersampled systems and are limited to a spatial frequency dictated by the detector center-to-center spacing. In the development of the MRC equation, sampling effects were ignored.

Because no frequency can exist above the Nyquist frequency, many researchers represent the MTF as zero above the Nyquist frequency. This forces the MRC to approach one at the Nyquist frequency (Figure 12-15). When the probability of detection is calculated using the target transfer probability function, the Nyquist limit reduces the range (Figure 12-16).

This range reduction is an artifact of the model. It is real when trying to discriminate sinusoids or bar targets. Real targets, however, are composed of many spatial frequencies ranging from zero and on up. Target features that have spatial frequencies above Nyquist will be distorted. No data exist on the detection or recognition of distorted imagery and it is, therefore, unwise at this juncture to extend the MRC model past the Nyquist frequency. The analyst must recognize that the Nyquist frequency limit may have an overly severe impact on target discrimination range. The specific manner in which the Nyquist frequency is included in the model has a dramatic effect on range performance. This is a result of the assumptions used and is not necessarily representative of actual system performance.

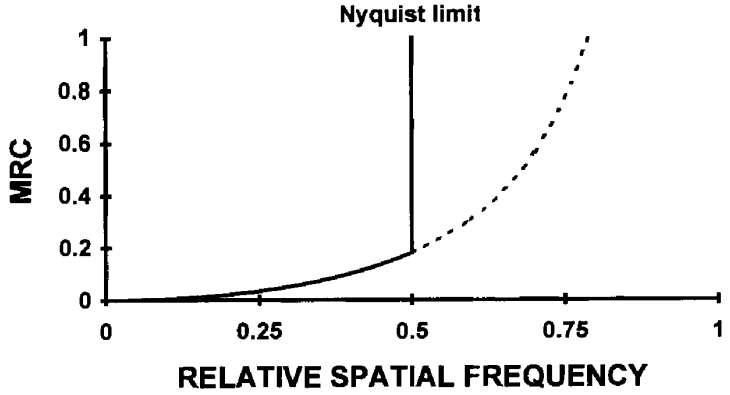


Figure 12-15. Representative MRC for a staring array sensor. At Nyquist frequency, the MRC is assumed to be one. The abrupt increase at Nyquist frequency is used by some researchers.

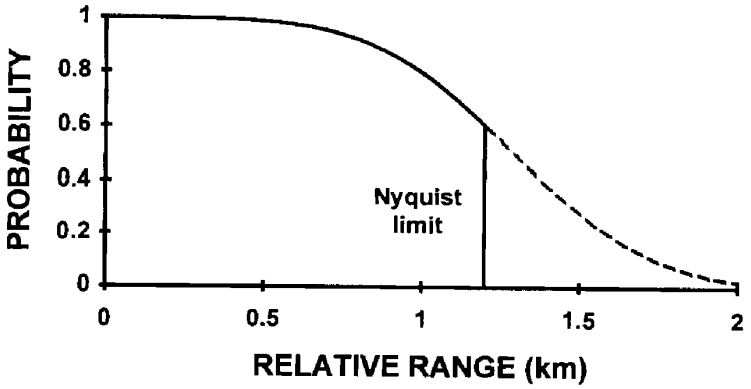


Figure 12-16. Probability of detection versus range for a staring array. The shapes of the curves depend on the MRC, contrast, atmospheric transmittance, and N_{50}. Because the MTF is forced to zero at the Nyquist frequency, the range hits a brick wall at Nyquist frequency. This is an artifact created by the model assumptions. Targets can be seen at longer ranges but aliasing will distort edges.

12.7. REFERENCES

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APPENDIX

A.1. EFFECTIVE FOCAL LENGTH

Most optical systems are composed of many individual lenses and mirrors. Each element may have a different refractive index and shape to minimize the system aberrations. The optical design can be considered as a single thick element (Figure A-1). For modeling purposes, it is treated as a single thin element with an effective focal length (Figure 2-6, page 23). The clear aperture is not necessarily the diameter of an optical element. The clear aperture limits the amount of scene radiation reaching the detector and is determined by the optical design.

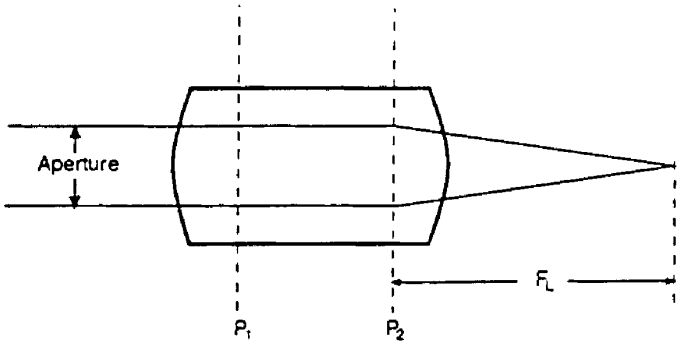


Figure A-1. The optical system can be considered as a single thick lens. P_1 and P_2 are the principal surfaces. The effective focal length is measured from the second principal surface. The clear aperture limits the amount of scene radiation reaching the detector. Although shown as planes, the principal surfaces are typically spherical.

A.2. f-NUMBER

The radiometric equations were derived from plane geometry and paraxial ray approximations. When using solid angles, the image incidance is proportional to $\sin^2(U')$ where U' is the maximum angle subtended by the lens. For paraxial rays, the principal surface is considered a plane. This representation is shown in most textbooks.

Lens design theory[1] assumes that the principal surface is spherical - every point on the surface is exactly a focal-length distance away (Figure A-2). This "sine corrected" lens has zero spherical aberration. Thus, $\sin^2(U')$ is equal to $1/(4F^2)$. The numerical aperture is another measure of the energy collected by the optical system. When the image is in air (refractive index of unity) the numerical aperture is

$$NA = \sin U' = \frac{1}{2F} . \qquad \text{(A-1)}$$

Since the largest angle is $\pi/2$, the smallest theoretical value for F is ½. This theoretical limit on F is not obvious from the radiometric equation.

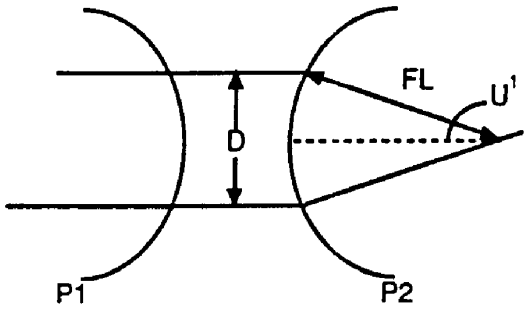


Figure A-2. Principal planes are typically spherical. Sin(U') = D/2fl = 1/2F (in air).

Not all optical systems have spherical principal planes. Often we assume the principal plane is flat. For hand-drawn optical layouts, the lenses are approximated by thin lenses and paraxial rays are used (large f-numbers). Here, $\sin(\theta) \approx \theta$ and Equation A-1 reduces to F = fl/D. Then $\sin^2(U')$ is $1/(4F^2+ 1)$. Whether $1/(4F^2+ 1)$ or $1/4F^2$ is used in the radiometric equations depends upon the f-number definition. If the analyst calculates the f-number from the effective lens diameter and focal length, then $1/(4F^2+ 1)$ should be used. If the optical designer provides the f-number, then the analyst must consult with him to ensure that the appropriate factor is used. For large f-numbers, the factors are approximately equal.

A.3. REFERENCE

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EXHIBIT 1026

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
TEXARKANA DIVISION

MAXELL LTD.,	§	
	§	
Plaintiff,	§	
	§	CIVIL ACTION NO. 5:19-CV-00036-RWS
v.	§	
	§	
APPLE INC,	§	
	§	
Defendant.	§	

CLAIM CONSTRUCTION MEMORANDUM AND ORDER

On January 8, 2020, the Court held an oral hearing to construe the disputed claim terms of the patents-in-suit. Having considered the parties' claim-construction briefing and based on the intrinsic and extrinsic evidence, the Court construes the disputed terms in this Memorandum and Order as detailed below. *See Teva Pharm. USA, Inc. v. Sandoz, Inc.*, 574 U.S. 318 (2015); *Phillips v. AWH Corp.*, 415 F.3d 1303, 1314 (Fed. Cir. 2005).

BACKGROUND

Plaintiff Maxell brings suit alleging that Apple infringes the following ten patents: U.S. Patent Nos. 6,748,317 (the " '317 patent); 6,580,999 (the " '999 patent"); 6,430,498 (the " '498 patent"); 8,339,493 (the " '493 patent"); 6,329,794 (the " '794 patent"); 6,408,193 (the " '193 patent"); 6,928,306 (the " '306 patent"); 10,084,991 (the " '991 patent"); 7,116,438 (the " '438 patent"); and 10,212,586 (the " '586 patent). Eight of the asserted patents contain disputed terms.

Maxell previously asserted five of the patents (the '438 patent, the '317 patent, the '493 patent, the '193 patent and the '794 patent) against other defendants in prior litigation—*Maxell Ltd. v. Huawei Device USA, Inc.*, 297 F. Supp. 3d 668 (E.D. Tex. 2018). However, the Court has not construed any of the presently disputed terms.

APPLICABLE LAW

"It is a 'bedrock principle' of patent law that 'the claims of a patent define the invention to which the patentee is entitled the right to exclude.' " *Phillips*, 415 F.3d 1303 at 1312 (en banc) (quoting *Innova/Pure Water Inc. v. Safari Water Filtration Sys., Inc.*, 381 F.3d 1111, 1115 (Fed. Cir. 2004)). The Court first examines a patent's intrinsic evidence to define the patented invention's scope. *Id.* at 1313–14; *Bell Atl. Network Servs., Inc. v. Covad Commc'ns Group, Inc.*, 262 F.3d 1258, 1267 (Fed. Cir. 2001). Intrinsic evidence includes the claims themselves, the specification and the prosecution history. *Phillips*, 415 F.3d at 1312–13; *C.R. Bard, Inc. v. U.S. Surgical Corp.*, 388 F.3d 858, 861 (Fed. Cir. 2004). . The general rule—subject to certain specific exceptions discussed *infra*—is that each claim term is construed according to its ordinary and accustomed meaning as understood by one of ordinary skill in the art at the time of the invention in the context of the patent. *Phillips*, 415 F.3d at 1312–13; *Alloc, Inc. v. Int'l Trade Comm'n*, 342 F.3d 1361, 1368 (Fed. Cir. 2003); *see also Azure Networks, LLC v. CSR PLC*, 771 F.3d 1336, 1347

(Fed. Cir. 2014) ("There is a heavy presumption that claim terms carry their accustomed meaning in the relevant community at the relevant time.").

"The claim construction inquiry . . . begins and ends in all cases with the actual words of the claim." *Renishaw PLC v. Marposs Societa' per Azioni*, 158 F.3d 1243, 1248 (Fed. Cir. 1998). "[I]n all aspects of claim construction, 'the name of the game is the claim.' " *Apple Inc. v. Motorola, Inc.*, 757 F.3d 1286, 1298 (Fed. Cir. 2014) (quoting *In re Hiniker Co.*, 150 F.3d 1362, 1369 (Fed. Cir. 1998)). First, a term's context in the asserted claim can be instructive. *Phillips*, 415 F.3d at 1314. Other asserted or unasserted claims can also aid in determining the claim's meaning, because claim terms are typically used consistently throughout the patent. *Id.* Differences among the claim terms can also assist in understanding a term's meaning. *Id.* For example, when a dependent claim adds a limitation to an independent claim, it is presumed that the independent claim does not include the limitation. *Id.* at 1314–15.

"[C]laims 'must be read in view of the specification, of which they are a part.' " *Id.* (quoting *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 979 (Fed. Cir. 1995)). "[T]he specification 'is always highly relevant to the claim construction analysis. Usually, it is dispositive; it is the single best guide to the meaning of a disputed term.' " *Id.* (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)); *Teleflex, Inc. v. Ficosa N. Am. Corp.*, 299 F.3d 1313, 1325 (Fed. Cir. 2002). In the specification, a patentee may define his own terms, give a claim term a different meaning than it would otherwise possess, or disclaim or disavow some claim scope. *Phillips*, 415 F.3d at 1316. Although the Court generally presumes terms possess their ordinary meaning, this presumption can be overcome by statements of clear disclaimer. *See SciMed Life Sys., Inc. v. Advanced Cardiovascular Sys., Inc.*, 242 F.3d 1337, 1343–44 (Fed. Cir. 2001). This presumption does not arise when the patentee acts as his own

lexicographer. *See Irdeto Access, Inc. v. EchoStar Satellite Corp.*, 383 F.3d 1295, 1301 (Fed. Cir. 2004).

"Although the specification may aid the court in interpreting the meaning of disputed claim language, particular embodiments and examples appearing in the specification will not generally be read into the claims." *Comark Commc'ns, Inc. v. Harris Corp.*, 156 F.3d 1182, 1187 (Fed. Cir. 1998) (quoting *Constant v. Advanced Micro-Devices, Inc.*, 848 F.2d 1560, 1571 (Fed. Cir. 1988)); *see also Phillips*, 415 F.3d at 1323. "[I]t is improper to read limitations from a preferred embodiment described in the specification—even if it is the only embodiment—into the claims absent a clear indication in the intrinsic record that the patentee intended the claims to be so limited." *Liebel-Flarsheim Co. v. Medrad, Inc.*, 358 F.3d 898, 913 (Fed. Cir. 2004).

The prosecution history is another tool to supply the proper context for claim construction because, like the specification, the prosecution history provides evidence of how the U.S. Patent and Trademark Office ("PTO") and the inventor understood the patent. *Phillips*, 415 F.3d at 1317. However, "because the prosecution history represents an ongoing negotiation between the PTO and the applicant, rather than the final product of that negotiation, it often lacks the clarity of the specification and thus is less useful for claim construction purposes." *Id.* at 1318; *see also Athletic Alternatives, Inc. v. Prince Mfg.*, 73 F.3d 1573, 1580 (Fed. Cir. 1996) (ambiguous prosecution history may be "unhelpful as an interpretive resource").

Although extrinsic evidence is useful, it is "less significant than the intrinsic record in determining the legally operative meaning of claim language." *Phillips*, 415 F.3d at 1317 (quoting *C.R. Bard, Inc.*, 388 F.3d at 862) (internal quotation marks omitted). Technical dictionaries and treatises may help a court understand the underlying technology and the manner in which one skilled in the art might use claim terms, but technical dictionaries and treatises may provide

definitions that are too broad or may not be indicative of how the term is used in the patent. *Id.* at 1318. Similarly, expert testimony may aid a court in understanding the underlying technology and determining the particular meaning of a term in the pertinent field, but an expert's conclusory, unsupported assertions as to a term's definition are not useful. *Id.* Generally, extrinsic evidence is "less reliable than the patent and its prosecution history in determining how to read claim terms." *Id.*

A. Functional Claiming and 35 U.S.C. § 112, ¶ 6(pre-AIA)/ § 112(f) (AIA)

A patent claim may be expressed using functional language. *See* 35 U.S.C. § 112 ¶ 6; *Williamson v. Citrix Online, LLC*, 792 F.3d 1339, 1347–49 & n.3 (Fed. Cir. 2015) (en banc in relevant portion). Section 112, Paragraph 6, provides that a structure may be claimed as a "means . . . for performing a specified function" and that an act may be claimed as a "step for performing a specified function." *Masco Corp. v. United States*, 303 F.3d 1316, 1326 (Fed. Cir. 2002).

But § 112 ¶ 6 does not apply to all functional claim language. There is a rebuttable presumption that § 112 ¶ 6 applies when the claim language includes "means" or "step for" terms and that it does not apply in the absence of those terms. *Masco Corp.*, 303 F.3d at 1326; *Williamson*, 792 F.3d at 1348. The presumption stands or falls according to whether one of ordinary skill in the art would understand the claim with the functional language, in the context of the entire specification, to denote sufficiently definite structure or acts for performing the function. *See Media Rights Techs., Inc. v. Capital One Fin. Corp.*, 800 F.3d 1366, 1372 (Fed. Cir. 2015) (Section 112, ¶ 6 does not apply when "the claim language, read in light of the specification, recites sufficiently definite structure" (internal quotation marks omitted) (citing *Williamson*, 792 F.3d at 1349; *Robert Bosch, LLC v. Snap-On Inc.*, 769 F.3d 1094, 1099 (Fed. Cir. 2014))); *Personalized Media Communications, L.L.C. v. Int'l Trade Commission*, 161 F.3d 696, 704 (Fed. Cir. 1998)

(" '[W]here a claim recites a function, but then goes on to elaborate sufficient structure, material, or acts within the claim itself to perform entirely the recited function, the claim is not in means-plus-function format' even if the claim uses the term 'means' ").

When it applies, § 112 ¶ 6 limits the scope of the functional term "to only the structure, materials, or acts described in the specification as corresponding to the claimed function and equivalents thereof." *Williamson*, 792 F.3d at 1347. Construing a means-plus-function limitation involves multiple steps. "The first step . . . is a determination of the function of the means-plus-function limitation." *Medtronic, Inc. v. Advanced Cardiovascular Sys., Inc.*, 248 F.3d 1303, 1311 (Fed. Cir. 2001). "[T]he next step is to determine the corresponding structure disclosed in the specification and equivalents thereof." *Id.* A "structure disclosed in the specification is 'corresponding' structure only if the specification or prosecution history clearly links or associates that structure to the function recited in the claim." *Id.* The focus of the "corresponding structure" inquiry is not merely whether a structure is capable of performing the recited function, but rather whether the corresponding structure is "clearly linked or associated with the [recited] function." *Id.* The corresponding structure "must include all structure that actually performs the recited function." *Default Proof Credit Card Sys. v. Home Depot U.S.A., Inc.*, 412 F.3d 1291, 1298 (Fed. Cir. 2005). However, § 112 does not permit "incorporation of structure from the written description beyond that necessary to perform the claimed function." *Micro Chem., Inc. v. Great Plains Chem. Co.*, 194 F.3d 1250, 1258 (Fed. Cir. 1999).

AGREED TERMS

Before the *Markman* hearing, the parties agreed to construction for the following terms:

TERM	AGREED CONSTRUCTION
"function devices" ('794 patent, claims 1, 3, 6)	Function: equipped with independent functions

	Structure: modem devices, audio communication devices and videophone devices; or equivalents thereof
"component devices" ('794 patent, claims 9, 14)	Function: performing different functions Structure: modem devices, audio communication devices and videophone devices; or equivalents thereof
"a time zone which is set up in advance" ('306 patent, claim 14)	"a duration of time or a range of hours set up in advance"
"an authentication process for allowance to use said display apparatus" ('438 patent, claim 1)	"a process that authorizes the user to use the display apparatus"
"an authentication process for allowance to use said information-processing terminal" ('438 patent, claim 4)	"a process that authorizes the user to use the information-processing terminal"
"A cellular telephone adapted to be used in a CDMA system" ('193 patent, claims 1, 7)	The preamble is limiting.
"variable amplitude amplifier" ('193 patent, claims 1, 6, 7)	"an amplifier whose output amplitude may be varied and that provides a variable gain in response to a control signal"
"function defining a relation between bias data and gain data stored in said memory" ('193 patent, claim 7)	"a relationship between bias data and gain data stored in memory such that each gain data value has a corresponding bias data value"
"voice signal code" and "voice code signal" ('193 patent, claims 1, 7)	The two terms have the same meaning.
"an image-instability detector" ('493 patent, claims 4, 6)	"a detector, such as a gyroscopic sensor or the like, capable of detecting an image instability of the electric camera"
"an image-instability of the electric camera" ('493 patent, claims 4, 6)	"instability caused by vertical and/or horizontal movement of the electric camera"
"a device for getting a direction information denoting an orientation of said portable terminal"	Function: getting direction information denoting an orientation of said portable terminal

('317 patent, claims 1, 10; '498 patent, claims 1, 10; '999 patent, claim 1)	Structure: a compass, gyroscope, and/or sensor such as a clinometer in conjunction with a CPU, or equivalents thereof

The Court adopts the constructions agreed to by the parties as listed above.

DISPUTED TERMS

A. The '371, '498 and '999 Patents

The '317 patent, the '498 patent and the '999 patent share a specification. The '317 patent is a continuation of the '999 patent, which is a continuation of the '498 patent. The patents have the same title: "Portable Terminal with the Function of Walking Navigation." The '317 patent's abstract is reproduced below:

> A portable terminal has a function of walking navigation. The direction of a destination is displayed by an indicating arrow that always points in the direction of the destination. In the navigation processing, the user enters data to select a menu and/or set retrieving conditions on the setup screen. At first, the user gets the location information of the portable terminal, represented by a latitude/longitude or coordinates and an altitude, for example. Then, the user gets the direction information of the portable terminal, which is the direction of the tip of the portable terminal as determined by a compass, a gyro, or a clinometer. The location information and the direction information are set as terminal information for the retrieving conditions. The system controls retrieving of the database and retrieves the information corresponding to the selected menu, such as route guidance.

More particularly, the patents disclose a portable terminal which includes devices for obtaining a location and direction of the user's present place so that the user does not have to input such information. '317 patent at 2:51–3:26. A block diagram of a portable terminal is illustrated in Figure 10 in the '317 patent. In the figure, the portable terminal has various devices (input device, display device, etc.) coupled to a CPU that provides for the walking navigation functions described in the patent.

Claim 1 of the '317 patent is an asserted claim and is reproduced below:

1. A portable terminal, comprising:

a device for getting location information denoting a present place of said portable terminal;

a device for getting a direction information denoting an orientation of said portable terminal;

an input device for inputting a destination; and

a display,

wherein said display displays positions of said destination and said present place, and a relation of said direction and a direction from said present place to said destination, and

said display changes according to a change of said direction of said portable terminal orientation for walking navigation.

The Court construed various terms in the '317 in the prior litigation, but none of them are currently disputed.

The parties dispute four terms in the '317, '498 and '999 patents. All are agreed to be means-plus-function limitations. Three of the disputed terms have the same dispute as to the corresponding structure and are thus grouped together for similar analysis.

1. "a device for getting location information denoting a present place"

Maxell's Proposed Construction	**Apple's Proposed Construction**
Agreed function: getting location information denoting a present place of said portable terminal Structure: a wireless or cellular antenna, a GPS, a PHS, or the like; such a data receiver as an infrared ray sensor, or the like; and a CPU for analyzing received data; or equivalents thereof.	Agreed function: getting location information denoting a present place of said portable terminal Structure: a wireless or cellular antenna, or a GPS, or a Personal Handyphone System (PHS); and an infrared ray sensor; and a control unit for analyzing received data, with the control unit calculating location information as disclosed in '498 at 5:48-56 and Fig. 2; or equivalents thereof

The term "a device for getting location information denoting a present place" appears in claims 1 and 10 of the '317 patent, claims 1 and 10 of the '498 patent and claim 1 of the '999 patent.

(1) The Parties' Positions

The parties agree that the term is a means-plus-function term and agree on the recited function. The parties dispute whether the corresponding structure must include an "infrared ray sensor" or whether it may include other "data receivers."

The parties first dispute whether statements made in a prior IPR proceeding mandate the inclusion of an "infrared ray sensor" as opposed to a general "data receiver." *See, e.g.*, Docket No. 161 at 26. Apple asserts that Maxell disclaimed claim scope to defeat an *Inter Partes* review ("IPR") petition filed by ASUStek Computer Inc. ("ASUS"). *Id.* Specifically, Maxell distinguished each prior art reference in the petition as lacking an infrared ray sensor. *Id.* To Apple, "by distinguishing the claimed invention over prior art, [Maxell has] indicat[ed] what the claims do not cover." *Id.* at 26 (quoting *Bd. of Regents of the Univ. of Texas Sys. v. BENQ Am. Corp.*, 533 F.3d 1362, 1373 (Fed. Cir. 2008)). Apple argues this is a "clear disclaimer of claim scope." *Id.*

Maxell asserts that the Court is not bound by the PTAB's claim interpretation because, at the time of the IPR in question, the PTAB had a different claim construction standard.[1] Docket No. 136 at 28. Maxell further contends that it did not clearly disclaim claim scope. Docket No. 165 at 10. Instead, Maxell asserts that it used ASUS's proposed construction to argue that ASUS failed to meet the PTAB's requirements, but did not adopt its construction, reserving its right to contest that construction later. *Id.*

Apple then asserts that, even if the IPR proceedings are not binding, the corresponding structure is limited to an "infrared ray sensor." Docket No. 161 at 28. Apple notes that the specification depicts a "device for getting location information" in Figure 10 and describes the

[1] The PTAB has since abandoned the broadest reasonable interpretation standard and adopted the *Phillips* standard for claim construction. *See* 37 C.F.R. 41.100(b).

structure of this device as containing three components: (1) a wireless antenna, GPS or PHS; (2) an infrared ray sensor; and (3) a control unit. *Id.* Apple asserts that "because an 'infrared ray sensor' is part of the only disclosed embodiment for performing the recited function," the claim construction must include an "infrared ray sensor." *Id.* at 28 (citing *Mettler-Toledo, Inc. v. B-Tek Scales, LLC*, 671 F.3d 1291, 1296 (Fed. Cir. 2012)). Apple asserts that the phrase "such a receiver as an infrared ray sensor" does not disclose any structure beyond an infrared ray sensor because "data receiver" itself is not sufficiently definite structure. *Id.*; Docket No. 187 at 17:10–11.

Maxell asserts that Apple's construction is overly narrow because it "rewrites the non-limiting phrase of 'such a data receiver as an infrared ray sensor or the like' to 'and an infrared ray sensor.' " Docket No. 136 at 27.[2] Maxell also contends that in the context of the patent—portable telephones—and the rest of the corresponding structure, "data receiver" recites sufficient structure. Docket No. 187 at 26:21–27:4.

(2) Analysis

The parties agree that the term is a means plus function term and that the recited function is "getting location information denoting a present place of said portable terminal." "[T]he next step is to determine the corresponding structure disclosed in the specification and equivalents thereof." *Id.* Under § 112 ¶ 6, means-plus-function terms are limited "to only the structure, materials, or acts described in the specification as corresponding to the claimed function and equivalents thereof." *Williamson*, 792 F.3d at 1347. Consistent with the claims, the specification discloses that the portable terminal has a "device for getting location information 77," depicted in

[2] Maxell also asserted in briefing that the patents disclose "data receiver" as an alternative to a GPS or PHS. Docket No. 136 at 27. However, during the *Markman* hearing, Maxell agreed that "data receiver" was a separate requirement from the GPS or PHS. Docket No. 187 at 28:4–6.

Figure 10 of the '498 patent. Both parties agree that device 77 is corresponding structure for the recited function. The specification describes device 77 as follows:

> The device for getting location information 77 is provided with such a wireless antenna, a GPS or PHS, or the like; such a data receiver as an infrared ray sensor, or the like; and a control unit for analyzing received data, thereby calculating location information.

'498 patent at 9:40–44. The parties dispute whether the "infrared ray sensor" is an exemplary "data receiver," which is itself disclosed structure, or whether the corresponding structure requires an "infrared ray sensor." For the reasons detailed below, the Court finds that the corresponding structure is not limited to an infrared ray sensor.

Maxell's statements during the IPR proceedings are not a clear disavowal of claim scope. In its IPR petition, ASUS proposed a construction for the corresponding structure of the currently disputed limitation: "a wireless or cellular antenna, OR a GPS, OR a Personal Handyphone System, AND an infrared ray sensor; AND a control unit for analyzing received data, with the control unit calculating information as disclosed in 5:48–56, and Fig. 2." Docket No. 165-4 at 18–19. ASUS then applied this limitation to the prior art. *Id.*

Maxell responded:

> While Patent Owner ***does not contend that such a construction is proper***, for purposes of the IPR, it is Petitioner's burden to propose a construction and then explain how the construed claim is unpatentable. *See* 37 C.F.R. § 42.104(b)(4). The Petition fails to do so. Thus, the Petition does not comply with the requirements set forth in 37 C.F.R. § 42.104, and for this reason alone, the Petition should not be instituted.

Id. at 14 n.4 (emphasis added). Maxell then argued that ASUS had failed to meet its burden of demonstrating that institution of the IPR was warranted because it had not shown that the cited prior art included an infrared ray sensor, part of ASUS's own proposed construction. *Id.* at 14–15. Maxell never agreed that the corresponding structure is limited to an "infrared ray sensor" and

instead expressly reserved its right to contest the construction. *Id.* at 10–11, n. 3. Maxell had no reason to contest the propriety of ASUS's construction because Maxell successfully used ASUS's own proposed construction to defeat the IPR petition. These statements are far from clear and unmistakable surrender of claim scope.

Turning to the traditional claim construction analysis, then, Apple's proposed structure improperly limits the corresponding structure. Section 112 ¶ 6 requires that a means-plus-function term be given the full scope of the structure described in the specification. *IP Innovation LLC v. Red Hart, Inc.*, No. 2:07-cv-447, 2009 WL 2460982, at *6 (E.D. Tex. Aug. 10, 2009); *see also Home Diagnostics, Inc v. LifeScan, Inc.*, 381 F.3d 1352, 1357 (Fed. Cir. 2004). The description for the "device for getting location information 77" recites "such a data receiver as an infrared ray sensor." '498 patent at 9:40–44. "Data receiver" is clearly associated with the agreed function. *See Williamson*, 792 F.3d at 1352 (Corresponding structure is adequate if "a person of ordinary skill in the art would be able to recognize the structure in the specification and associate it with the corresponding function of the claim.").

Just as a non means-plus-function term may cover a broad class of structures, the corresponding structure in a means-plus-function term can include a broad class of structures if the class of structures is identifiable by a person of ordinary skill in the art. *See Linear Tech. Corp. v. Impala Linear Corp.*, 379 F.3d 1311, 1322 (Fed. Cir. 2004) (holding that corresponding structure is not limited to a single structure); *Network Appliance Inc. v. Sun Microsystems, Inc.*, No. C-07-06053 EDL, 2008 WL 4193049, at *20 n.7 (N.D. Cal. 2008) (confirming that *Linear Tech's* holding applies to corresponding structure of MPF terms).

Courts routinely conclude that "receiver" connotes sufficiently definite structure. *See, e.g., EnOcean GmbH v. Face Intern. Corp.*, 742 F.3d 955, 959 (Fed. Cir. 2014) ("The term receiver

presumptively connotes sufficiently definite structure to those of skill in the art."); *Ambato Media, LLC v. Clarion Co., Ltd.*, No. 2:09-cv-242-TJW, 2011 WL 2912764, at *8–9 (E.D. Tex. July 18, 2011) (declining to limit corresponding structure for means-plus-function term to a subset of exemplary receivers "such as television receivers, VCRs, cable interface boxes and the like" because broader "receiver" was structure clearly linked to the function); *see also Mobile Telecommunications Tech. LLC v. LG Elec. Mobilecomm USA, Inc.*, No. 2:13-cv-947-JRG-RSP, 2015 WL 2250418, at *18 (E.D. Tex. May 13, 2015) (construing a "receiver" as corresponding structure for a means-plus-function term). Apple's expert does not opine that "data receiver" is not structural. Instead, Apple's expert stated that not all data receivers were capable of determining location information in the same way as infrared ray sensors and that "infrared ray sensor" was the only example of a data receiver disclosed. *See* Docket No. 161-5 at ¶ 34. This does not render data receiver not structural.

Because "data receiver" is structure that is clearly linked to the recited function, data receiver is disclosed structure. *See Ambato Media*, 2011 WL 2912764, at *8–9 (construing means-plus-function term to have corresponding structure of "receiver" because receiver was structure linked to the recited function for the disputed term). Limiting the corresponding structure to require more specifically an "infrared ray sensor" would be improper. *Id.*

It would also be improper for the construction to include "infrared ray sensor" as an exemplary data receiver. The phrase "such a data receiver as an infrared ray sensor" is properly read as disclosing a "data receiver" and providing "infrared ray sensor" as an example. Such exemplary language could be interpreted as limiting. *See Hitachi Consumer Elecs. Co. Ltd. v. Top Victory Elecs. (Taiwan) Co. Ltd.*, No. 2:10-cv-260-JRG, 2012 WL 5494087, at *13 (E.D. Tex. Nov. 13, 2012) (omitting exemplary language from the construction because examples were

"unnecessary and might be read as limiting"). That would be improper for the reasons discussed above.

Accordingly, the Court construes "**a device for getting location information denoting a present place**" to mean:

Function: getting a location information denoting a present place of said portable terminal

Structure: a wireless or cellular antenna, a GPS, a PHS, or the like; a data receiver; and a CPU for analyzing received data; or equivalents thereof.

2. "device for getting a location information . . ." / "device for retrieving"

Term	Maxell's Proposed Construction	Apple's Proposed Construction
"a device for getting a location information of another portable terminal from said another portable terminal via connected network" ('317 patent, claim 10)	Agreed function: getting a location information of another portable terminal from said another portable terminal via connected network Structure: CPU and device for data communication 76 of a portable terminal; or equivalents thereof	Agreed function: getting a location information of another portable terminal from said another portable terminal via connected network Structure: CPU 71 and device for data communication 76 of a portable telephone and a Personal Handyphone System (PHS) terminal (Figure 10, '317 Patent at 9:40–50); or equivalents thereof
"a device for getting a location information of another portable terminal"; ('999 patent, claim 1)	Agreed function: getting a location information of another portable terminal Structure: [same as above]	Agreed function: getting a location information of another portable terminal Structure: [same as above]
"a device for retrieving a route from said present place to said destination" ('317 patent, claim 15)	Agreed function: retrieving a route from said present place to said destination Structure: [same as above]	Agreed function: retrieving a route from said present place to said destination Structure: [same as above]

The disputed term "a device for getting a location information of another portable terminal from said another portable terminal via connected network" appears in claim 10 of the '317 patent.

The disputed term "a device for getting a location information of another portable terminal" appears in claim 1 of the '999 patent. The disputed term "a device for retrieving a route from said present place to said destination" appears in claim 15 of the '317 patent.

(1) Parties Positions

The parties agree that the terms are means-plus-function terms. The parties also agree on the recited functions and that the corresponding structure for each of the above disputed terms is the same.

Maxell asserts that the patents disclose as corresponding structure "portable terminals," including a "portable telephone and Personal Handyphone System (PHS) . . . and a personal data assistance (PDA) terminal provided with portable telephone or PHS data communication functions." Docket No. 136 at 29 (citing '498 patent at 1:5–10). As such, Maxell argues the portable terminal is not limited to a device for data communication of both a portable telephone and a PHS. *Id.* at 29. To Maxell, the patents provide "exemplary structures" and additional disclosures refer to the use of a portable telephone or a PHS. *Id.* Maxell concludes that using "device for data communication 76 of a portable terminal" ensures that the disclosed embodiment of the PDA is not excluded. *Id.*

Apple notes that in the prior litigation the Court construed a means-plus-function term in claim 6 of the '317 patent—"a . . . device connected to said server outputting said location information and said direction information and receiving retrieved information based on said outputted information at said server"—as having the corresponding structure a "device for data communication, which is 'described in the specification as a device for data communication 76 of an ordinary portable telephone and a PHS [Personal Handyphone System] terminal.' " *Id.* at 29–30 (citing *Huawei*, 297 F. Supp. 3d at 722). Apple asserts that the corresponding structure for both

this term and the term construed in the prior litigation are the same, and therefore the Court's prior construction must control. Docket No. 161 at 30.

Maxell responds that the Court's prior construction of a different term is not controlling. Docket No. 165 at 10.

(2) Analysis

As an initial matter, the prior term is not the same or similar to the currently dispute term, so collateral estoppel does not apply. Nevertheless, the Court agrees with Apple's proposed construction. Claim 10 of the '317 patent discloses in part:

- A device for getting location information denoting a present place of said portable terminal;
- A device for getting direction information denoting an orientation of said portable terminal;
- A device for getting a location information of another portable terminal from said another terminal via connected network

Consistent with claim 10, the specification discloses in Figure 10 a portable terminal with (1) "a device for getting location information 77"; (2) a "device for getting direction information 78"; and (3) "a device for data communication 76." '317 patent at Fig. 10. The specification further describes Figure 10 as including a "CPU 71, which is a control unit" and "a device for data communication 76 of an ordinary portable telephone and a PHS [Personal Handyphone System] terminal." '317 patent at 9:47–49. This is the only structure disclosed and clearly linked to the function in claim 10. The parties agree that the corresponding structure for the disputed terms includes a CPU and device for data communication 76.

Maxell's argument regarding the specification is also unpersuasive. The specification's references to "portable telephone and/or a PHS terminal" do not overcome the clear disclosure of device for data communication 76's structure: "an ordinary portable telephone and a PHS." '317

patent at 9:47–49 (emphasis added). Those other references in the specification are not "clearly linked" to the recited function or the specific device for data communication 76. *See Mettler-Toledo*, 671 F.3d at 1296 (rejecting a broader corresponding structure of A/D converter because, although referenced in the specification, such broader structures were not clearly linked to the function). In fact, the specification's reference to "portable telephone and/or a PHS terminal" often describes the inventions display component, not the function of getting location information. *See, e.g.*, '317 patent at 2:55–5'6 (reciting the "use of a narrow screen of a portable telephone and/or PHS terminal").

Accordingly, the Court adopts Apple's proposed construction and construes the disputed terms to have the agreed recited functions and the following corresponding structure: **CPU 71 and device for data communication 76 of a portable telephone and a Personal Handyphone System (PHS) terminal (Figure 10, '317 Patent at 9:40–50); or equivalents thereof.**

B. The '794 Patent

The '794 patent is entitled "Information Processing Device and Method for Controlling Power Consumption Thereof." The patent relates to an information processing device in which a plurality of independent function devices are driven by a common power supply, where the device prioritizes power to independent function devices with higher usage priorities. '794 patent at 1:6–8, 49–52. "Another object of the present invention is to provide a method for controlling power consumption of an information processing device." *Id.* at 1:52–54. The'794 patent's abstract recites:

> A power supply section includes a capacity detector capable of detecting the remaining capacity in a battery and a controller issuing power consumption reduction instructions to independently operable function devices based on usage priorities thereof. This allows power consumption operations to be performed such as stopping function devices with low priorities first based on the remaining battery capacity. As a result, power to function devices with higher priorities can be

> maintained. Based on the remaining battery capacity, the controller controls the operations of the function devices and uses a display to show information allowing the operator to identify operable and inoperable function devices as the battery capacity drops.

More particularly, the '794 patent describes a device that sets priority levels for individual function devices in the information processing device and prioritizes battery time or power consumption for function devices with higher priorities. *See, e.g.*, 2:21–27, 3:57, 4:12, Figs. 8 and 9. The device turns off power to individual function devices based on the priority levels set for the function devices and the remaining battery capacity. In this manner, a lower prioritized function device can be turned off when a first battery capacity is reached, while a higher prioritized function device remains powered. This enables longer operation of function devices with higher priority. *Id.* at 5:17–27.

The '794 patent discloses a "capacity detector" that detects a remaining capacity of a battery. *See, e.g.*, *id.* at 1:34–40; 4:18–34; Figs. 1 and 4. Figure 1 shows capacity detector 107 and Figure 4 shows various operations the capacity detector performs according to one embodiment. The '794 patent was asserted in prior litigation, and the prior parties agreed that the "capacity detector" term had its plain and ordinary meaning. *See, e.g.*, *Maxell*, 297 F. Supp. 3d. at 684.

3. "capacity detector" ('497 patent claims 1 and 9)

Maxell's Proposed Construction	**Apple's Proposed Construction**
Plain and Ordinary Meaning	Function: detecting a remaining capacity of a battery Structure: Capacity Detector 107 (as configured in Figs. 1, 6, 10, or 11) performing the steps shown in Fig. 4.; or equivalents thereof

The disputed term appears in claims 1 and 9 of the '497 patent.

(1) The Parties' Positions

Maxell contends that "capacity detector" is readily understood by one of skill in the art and should have its plain and ordinary meaning. *See, e.g.*, Docket No. 136 at 3–5. Maxell points out that the term had its plain and ordinary meaning in the prior litigation, and the parties, experts and jury in that case had no trouble understanding the term without construction. *Id.* at 3. Maxell also argues that capacity detector has sufficient structure to one of skill in the art—both as to the term "detector" itself and the word "capacity detector." Maxell further contends that both parties' experts "agree that the term connotes sufficient structure to a person of ordinary skill in the art," and they identified software and hardware solutions for implementing the capacity detector. *Id.* at 5.

Apple contends that "capacity detector" is a means-plus-function term because it "merely describes the function of detecting battery capacity without reciting any structure." Docket No. 161 at 7–8. Apple argues that, although "detector" has identified structure in unrelated contexts, Maxell presented no evidence that "capacity detector" has meaning in the relevant field—power management. *Id.* at 6–7 (citing *Kensey Nash Corp. v. Perclose, Inc.*, No. 98-1629, 2001 U.S. Dist. LEXIS 12754, at *18–19 (E.D. Pa. Aug. 21, 2001) (finding "location detector" to be a means-plus-function term because it "recites no specific structure or material for performance of location detection")). Apple also asserts that Maxell "mischaracterizes" Apple's expert reports because neither expert testified that "capacity detector" connotes structure. *Id.* at 7.

As to the corresponding structure, Apple asserts that the only structure disclosed in the specification is the Capacity Detector 107, shown as a box in Figures 1, 6, 10 and 11. Apple asserts that the corresponding structure must also include the algorithm associated with Capacity Detector

107, in the specification shown in the flowchart of Figure 4. *Id.* at 8 (citing '794 patent at 2:55–57 ("FIG. 4 is a flowchart showing the operations performed by a capacity detector . . . .").

Maxell disputes Apple's application of § 112 ¶ 6. First, Maxell asserts that "detector" alone connotes sufficient structure to avoid the ambit of § 112 ¶ 6. Docket No. 136 at 4 (citing *Apple*, 757 F.3d at 1299 (noting that courts find "detector" to be a structural term)). Maxell also emphasizes that the claim language and specification connotes sufficient structure to the term. *Id.*

Maxell further disputes Apple's proposed corresponding structure as "an attempt to shoehorn additional limitations into the claims." *Id.* at 5. Specifically, Maxell contends that Apple's proposed structure includes steps (402–405) which are not stated functions of the capacity detector, such as "providing a notification when the battery reaches a particular capacity." *Id.*

(2) Analysis

Section 112 ¶ 6 presumptively does not apply to a claim term that does not use "means." *Williamson*, 792 F.3d at 1349. The presumption is rebuttable if a party can "demonstrate[] that the claim term fails to 'recite sufficiently definite structure' or else recites 'function without reciting sufficient structure for performing that function.' " *Id.* (quoting *Watts v. XL Sys., Inc.*, 232 F.3d 877, 880 (Fed. Cir. 2000)).

Here, "capacity detector" does not recite the word "means," and § 112 ¶ 6 presumptively does not apply. Apple has not demonstrated that "capacity detector" "fails to recite sufficiently definite structure" or else "recites function without reciting sufficient structure for performing that function" so as to overcome this presumption. *See Williamson*, 792 F.3d at 1349.

The term "capacity detector" has sufficiently specific structure. In claim 1, the "capacity detector" is described as a component in a "power supply circuit." '794 patent at 8:33–36 ("said power supply circuit including a battery, a capacity detector for detecting a remaining capacity of

said battery"). The claim language connotes sufficient structure by describing how the "capacity detector" operates within the claim invention. *See Free Stream Media Corp. v. Alphonso Inc.*, No. 2:15-cv-1725-RWS, 2017 WL 1165578, at *25 (E.D. Tex. Mar. 29, 2017).

The specification further establishes the structural character of "capacity detector." *See Finjan, Inc. v. Proofpoint, Inc.*, No. 13-cv-05808-HSG, 2015 WL 7770208, at *11 (N.D. Cal. Dec. 3, 2015) (finding "content processor" had sufficient structure because the specification described how the processor interacted with the invention's other components and illustrated the processor's location and relationship to other components). The specification describes "capacity detector 107" as a "capacity detector circuit." '794 patent at 4:48. Figure 11 further illustrates capacity detector 107's location in "power supply circuitry" and its relationship to other components in the invention. '794 patent at Fig. 11. These structural descriptions, which show how the elements are connected together and show "how the function is achieved the context of the invention," removes "capacity detector" from means-plus-function usage. *See Inventio AG v. ThyssenKrupp Elevator Americas Corp.*, 649 F.3d 1350, 1358 (Fed. Cir. 2011); *Williamson*, 792 F.3d at 1349; *Apple Inc.*, 757 F.3d at 1298–1300; *Personalized Media*, 161 F.3d at 704–05.

The expert testimony Apple relies on does not negate the intrinsic evidence showing that "capacity detector" is a known class of structure. "Extrinsic evidence may not be relied upon during claim construction when intrinsic evidence unambiguously defines the disputed claim language." *Personalized Media*, 161 F.3d at 706. Indeed, Apple's expert was able to identify structures for the "capacity detector" term. *See* Docket No. 161-2 ¶ 63. Further, consistent with the structural descriptions in the specification, Maxell's expert explained that a person of ordinary skill would have known of "several commercially available integrated circuits designed for measuring analog signals, including, for example, integrated circuits manufactured by Texas

Instruments and National Semiconductor, and others such as Linear Technology's LTC1325 Battery Management IC." *See* Docket No. 136-1 ¶ 32. Based upon these factors, Apple has not rebutted the presumption that "capacity detector."

Accordingly, the Court construes the term "**capacity detector for detecting a remaining capacity of said battery**" to have its **plain and ordinary meaning**.

C. The '306 Patent

The '306 patent is entitled "Portable Mobile Unit." The patent generally relates to a portable mobile unit for alerting a user of an incoming signal by ringing and, in particular, to a portable mobile unit suitable for alerting a user of an incoming phone call using a ringing sound. '306 patent at 1:6–10. The'306 patent's abstract is reproduced below:

> A portable mobile unit for alerting on incoming of a signal by a ringing sound, comprises: a ringing sound generator for generating the ringing sound in a plurality of patterns; and a controller for controlling operations of the portable mobile unit, wherein the controller select one pattern from the a plurality of patterns based on conditions which are set up in advance, when the signal comes in, so as to control the ringing sound generator to generate the ringing sound for alerting a user of the incoming call, thereby providing the portable mobile unit being superior in the usability, with which various conditions can be grasped by means of change in the ringing sound when the telephone call comes in, while achieving the discrimination of the ringing sound for alerting of the incoming call.

Figure 15 of the '306 patent depicts a "ringing sound generator 1519" within the structure of the "portable mobile unit. '306 Patent at Fig.15. Figure 1 shows the "ringing sound generator 1519" and its operation with a communication controller 1516, in more detail. *Id.* at Fig.1.

4. "ringing sound generator"

Maxell's Proposed Construction	**Apple's Proposed Construction**
Plain and Ordinary Meaning	Function: to generate a ringing sound Structure: Element 1519 in Figure 15 comprising 1, 3a- 3c, and 4a-4c in Figure 1; or equivalents thereof

(1) Parties' positions

Maxell contends that "a person of ordinary skill in the art would have understood the meaning of this term when used in the context of a 'portable mobile,' as claimed." Docket No. 136 at 7 (citing Docket No. 136-4 ¶ 31). Specifically, Maxell contends that, in context, " 'ringing sound generator' refers to a class of structure, namely the circuitry and software in portable devices that produces audio alerts." *Id.* Maxell cites to the claims and the specification, which both describe exemplary structures for the ringing sound generator, and an expert report as showing that a person of ordinary skill in the art would have understood the meaning of the term. *Id.* at 8. Maxell's expert opined that "ringing sound" refers to the notification of an incoming call and "ringing sound generator," in context, recites structure. Docket No. 136-4 ¶ 35.

Apple asserts that the phrase "ringing sound generator" is a means-plus-function term because it "does not connote sufficiently definite structure to a POSA" and because it is not the "name of a known structure in the field of portable mobile devices." Docket No. 161 at 9. Apple asserts that courts have found similar phrases, such as "alert sound generator" and "symbol generator," to be means-plus-function terms. *Id.* at 9 (citing *Mobilemedia Ideas, LLC v. Apple Inc.*, 178 F. Supp. 3d 209, 218–19 (D. Del. 2016) and *Advanced Ground Info. Sys. v. Life360, Inc.*, 830 F.3d 1341, 1346–49 (Fed. Cir. 2016)). Apple's expert opined that "one of ordinary skill in the art would understand that 'ringing sound generator' could be anything that generates a ringing sound. For example, a person ringing a cowbell could be a 'ringing sound generator.' " Docket No. 161-3 ¶ 33. The expert further stated that, even considering the fields of electrical engineering, computer engineering or computer science, he could identify "many different classes of structures that could generate a ringing sound." *Id.* ¶ 34.

Apple then proposes construing the term as a means-plus-function term with the function to generate a ringing sound" and Ringing Sound Generator 1519 in Figure 15 as the corresponding structure. Docket No. 161 at 9. Apple adds that the corresponding structure includes the details shown in Figure 1, *i.e.*, elements 1 ("reproduction timing memory"), 3a–3c (multiple "sound source[s]") and 4a–4c ("multiple "sound data reproduction portion[s]"). *Id.* (citing '306 patent at 4:34–65, Fig.1). Apple also asserts that the specification's disclosure of MP3 as potential "data" does not disclose "structure" for the ringing sound generator. *Id.* at 9–10.

Maxell responds that Apple's expert testimony regarding the potential class of structures such as a cowbell "ignores the context of the patent (mobile phones)." Docket No. 136 at 7. Maxell also argues that Apple's proposed structure is improper because it limits the term to one embodiment to the exclusion of others. Specifically, Maxell contends that the proposal excludes the specification's teaching that "the sound data of the MP3 method can be used." '306 patent at 5:1–8.

(2) Analysis

Section 112 ¶ 6 presumptively does not apply to "ringing sound generator" because it does not use the word "means." Apple has not demonstrated that the term "fails to recite sufficiently definite structure" or else "recites function without reciting sufficient structure for performing that function" to overcome this presumption. *See Williamson*, 792 F.3d at 1349.

The claims show that "ringing sound generator" is structural. The claims provide some detail as to how the ringing sound generator interacts with other components of the claim invention and describes the input data for the "ringing sound generator." *See Linear Tech* 379 F.3d at 1319–21 (finding "circuit [for performing a function]" to be sufficient definite structure where claims recite the circuit's "operation in sufficient detail to suggest structure to persons of ordinary skill in

the art"); *Free Stream Media*, 2017 WL 1165578, at *25 ("declining to construe "client device" as a means-plus-function term because "the claims themselves connote sufficiently definite structure by describing how the 'client device' operates within the claims invention to achieve its objections"). For example, claim 1 discloses a "ringing sound generator having a plurality of sound sources therewith" and a controller that "controls the ringing sound generator so as to generate the ringing sound using at least two of said sound sources when the signal comes in."

The specification confirms that "ringing sound generator" connotes structure. *See Inventio AG*, 649 F.3d at 1358 (finding term structural based on description in specification); *Finjan, Inc.*, 2015 WL 7770208, at *11. Figure 15 depicts the ringing sound generator as a component in the "circuit constructions of the cellular phone" where it is connected to a communication controller and a speaker. '306 patent at 15:50–51. The specification describes the operation of the "ringing sound generator 1519":

> A reference numeral 1519 indicates a ringing sound generator for generating the ringing sound when it receives the radio-wave signal, and a 1520 speaker for outputting the alerting signal that is reproduced in the ringing sound generator 1519 audibly. Further . . . "reproduce" means to output a sound data that is stored or a sound data that is received with the incoming call, or to put an audible frequency signal that is converted from an inputted sound data.

Id. at 4:24–33. In Figure 1, the patent shows additional "details of the communication controller 1516 and the ringing sound generator 1519," further describing how the controller and ringing sound generator operate to "reproduce" sound data. *Id.* at 4:34–65. These structural descriptions confirm that "ringing sound generator" is not a means-plus-function term. *See Free Stream Media*, 2017 WL 1165578, at *25 (E.D. Tex. Mar. 29, 2017); *Finjan, Inc*, 2015 WL 7770208, at *11.

Apple's expert testimony does not negate the intrinsic evidence showing that the full phrase "ringing sound generator" is structural. *See Personalized Media*, 742 F.3d at 706. Though "generator" may connote a broad class of structures, the context of the term in mobile phone

technology and the "ringing sound" modifier limits the potential class of structures. *See Williamson*, 792 F.3d at 1351; *Free Stream Media*, 2017 WL 1165578, at *24–25 (noting that a modifier "further narrows the scope of these structure covered by the claim") (citations omitted). Further, though the "ringing sound generator" covers a broad class of structures and identifies the structure by its function, this does not necessarily render it insufficiently structural. *See Skky, Inc. v. MindGeek, s.a.r.l.*, 859 F.3d 1014, 1019 (Fed. Cir. 2017) (finding a term may be sufficiently structural "even if the term covers a broad class of structures and even if the term identifies the structure by their function' "); *Personalized Media*, 161 F.3d at 705 ("Even though the term 'detector' does not specifically evoke a particular structure, it does convey to one knowledgeable in the art a variety of structures known as 'detectors.' ").

The structural descriptions in the specification distinguish this case from *Mobilemedia Ideas*, which Apple cites for the proposition that a ringing sound generator has no structural meaning. There, the court found "alert sound generator for generating an alert sound when the call is received from the remote caller" to be means-plus-function in part because the specification did not describe the term. *Mobilemedia Ideas*, 178 F. Supp. 3d at 218–19. Importantly, the court subsequently concluded that "alert sound generator" provided sufficient corresponding structure for the means-plus-function limitation because, in the context of a cellular phone, the alert sound generator was "understood by persons of ordinary skill in the art to refer to an electronic circuit, including a speaker or vibrator, that was capable of generating sounds, as well as stopping the generation of such sounds." *Id.* The Court thus concluded that "those of skill in the art would recognize the structure in the specification and associate it with the corresponding functions in the claim." *Id.* *Advanced Ground Info* is similarly unavailing because the patentees in that case

acknowledged that the term "symbol generator" was coined for purposes of the patent. 830 F.3d at 1348.

For these reasons, the Court construes "**ringing sound generator**" to have its **plain and ordinary meaning**.

D. The '438 Patent

The '438 patent, entitled "Terminal for Information Processing," "relates to an information-processing terminal having a communication function and relates to a system for displaying information on a notice board at a request made by the information-processing terminal." '438 Patent at 1:6–10. "More particularly the present invention relates to an electronic notice-board system having an information processing terminal in addition to a display apparatus." *Id.* at 1:10–12. An object of the patent is to provide an electronic notice-board system that simplifies a command to start use of a nearby notice board and allows only users close to the notice board to contribute an article to the notice board and/or inspect the notice board. *Id.* at 1:46–50. Maxell asserts claims 1 and 4 of the '438 patent which are:

> **1**. An information-processing terminal comprising:
>
> an input unit for receiving an input entered by a user;
>
> a first short-distance communication unit for carrying out a short-distance communication with a display apparatus; and
>
> a second communication unit for carrying out a communication with said display apparatus through a network; wherein
>
> said first short-distance communication unit using said input, carries out an authentication process for allowance to use said display apparatus;
>
> said second communication unit carries out data exchange with said display apparatus if said authentication process is affirmed; and
>
> said second communication unit does not carry out data exchange with said display apparatus if said authentication process is not affirmed. . . .

> **4.** A display apparatus for presenting information to users surrounding said display apparatus, comprising:
>
> a first short-distance communication unit for carrying out a short-distance communication with an information processing terminal; and
>
> a second communication unit for carrying out a communication with said information-processing terminal through a network; wherein
>
> said first short-distance communication unit carries out an authentication process for allowance to use said information-processing terminal;
>
> said second communication unit carries out data exchange with said information-processing terminal if said authentication process is affirmed; and
>
> said communication unit does not carry out data exchange with said information-processing terminal if said authentication process is not affirmed.

The '438 patent describes a preferred embodiment "implementing an electronic notice-board system provided by the present invention." *Id.* at 2:60–62. The embodiment discloses a mobile terminal, illustrated in Figure 2, and a display terminal, whose internal configuration is shown in Figure 3.

5. "an input unit for receiving an input entered by a user"

Maxell's Proposed Construction	**Apple's Proposed Construction**
Plain and Ordinary Meaning	Function: to receive input entered by a user Structure: a keyboard; or equivalents thereof

The disputed term "an input unit for receiving an input entered by a user" appears in claim 1 of the '438 patent.

(1) Parties' arguments

Maxell asserts that "an input unit for receiving an input entered by a user" is readily understood by a person of ordinary skill in the art and that the specification uses the term "input unit" consistent with its plain and ordinary meaning. Docket No. 136 at 9–10. Maxell further

argues that extrinsic evidence—including the dictionary definition of input unit—reflects that the term refers to a definite class of structures that are used to receive an input entered by a user. *Id.* at 10 (citing IBM's 1994 Dictionary of Computing at 343 (defining "input unit" as a "device in a data processing system by means of which data can be entered into the system")).

Apple contends that "unit for" is a nonce phrase, and "input" imparts no further structure. Docket No. 161 at 10–11. Apple asserts that "input unit" is defined "only by its function . . . without imposing any structural limits." *Id.* at 11. Accordingly, Apple asserts that the term must be construed according to § 112 ¶ 6 and proposes a recited function of "to receive input entered by a user" and, as structure, "a keyboard; or equivalents thereof." *Id.* at 10.

(2) Analysis

The parties dispute whether this term is a means-plus-function term according to § 112 ¶ 6. Because the claims do not recite the word "means," there is a rebuttable presumption that § 112 ¶ 6 does not apply. While "unit" is a nonce term that can be "tantamount using the word means," *Williamson*, 792 F.3d at 1350, the full term in question is "input unit." The "input" modifier imparts structural significance to the term, and, as such, "input unit" is structural. *See id.* (holding that modifiers can provide structure to otherwise nonce nonstructural terms); *Alcatel USA Resources Inc. v. Microsoft Corp.*, No. 6:06-cv-500, 2008 WL 2625852, at *17 (E.D. Tex. Jun 27, 2008) (finding term "input unit" sufficiently structural). Apple has not overcome the presumption that "input unit" connotes structure.

One of ordinary skill would understand that an input unit connotes structure. *See Alcatel USA Resources*, 2008 WL 2625852, at *17 (finding "input unit" not a means-plus-function term and applying plain and ordinary meaning); *see TiVo Inc. v. EchoStar Commc'ns Corp.*, No. 2:04-

CV-1, 2005 U.S. Dist. LEXIS 46879, at *25 (E.D. Tex. Aug. 18, 2005) (applying the plain and ordinary meaning to "input section").

The specification provides some structural description for the term. The specification discloses an embodiment comprising a "mobile terminal" and a "display terminal." The mobile terminal serves as the "information processing terminal" and, as depicted in Figure 2, contains an "input/output unit" connected to other components. Specifically, the input/output unit is connected to a processor, a storage unit, a transmission/reception unit, a camera unit and a short distance communication unit which are all "connected to each other by an internal bus so that they are capable of exchanging information with each other." '438 patent at 3:39–42, Fig. 2. The specification further provides an exemplary structure for the input/output unit, including but "not limited to the liquid crystal display device and the ten-key board." '438 patent at 50–67; *Cf. Linear Tech.*, 379 F.3d at 1320 (finding that the term "circuit" when coupled with a description of the circuit's operation is sufficiently structural). The specification also describes the operation of the input/output unit, allowing a user to enter a comment to be displayed, and examples of inputs received by the user. *Id.* at 8:5; 8:57–60.

Extrinsic evidence further indicates that "input unit" connotes structure. *See, e.g.*, IEEE STANDARD DICTIONARY OF ELECTRICAL AND ELECTRONICS TERMS, "input device," 524 (6th ed. 1997) (defining "input device" as a "device used to enter data into a computer system" and listing "input unit" as a synonym for input device."); *see also MIT*, 462 F.3d at 1355 (relying on technical dictionaries to determine whether the term "circuitry" connotes structure). The fact that a term is described according to its function does not necessarily mean that the term fails to designate structure. *See Skky,* 859 F.3d at 1019 (Fed. Cir. 2017) (citing *TecSec, Inc. v. Int'l Bus. Machs. Corp.*, 731 F.3d 1336, 1347 (Fed. Cir. 2013)).

Apple's expert recognized that "input unit" refers to various known structures such as a "mouse, keyboard, touch screen, touch-pen, [and] voice activated inputs." Docket No. 136-2 ¶ 79. Nevertheless, the expert stated that "input unit" is not a term in the field "because many different classes of structure can act as an 'input unit.' " *Id.* However, as discussed previously, the fact that "a disputed term is not limited to a single structure does not disqualify it as corresponding structure, as long as the class of structures is identifiable by a person of ordinary skill in the art." *Linear Tech*, 379 F.3d at 1322. Even if the term covers a broad class of structures, it is sufficient if the claim term is used by persons of ordinary skill in the art to designate structure. *Id.*; *Skky,* 859 F.3d at 1019 (Fed. Cir. 2017); *see also Personalized Media*, 161 F.3d at 704–05 (finding the term "detector" to not be a means-plus-function limitation because it conveyed to one of skill in the art a variety of structures known as "detectors"). The fact that an "input unit" may refer to a "wide variety of structures" does not render the term nonstructural, nor does the fact that term is defined by its structure. *Personalized Media*, 161 F.3d at 704–05.

Accordingly, the Court construes "**an input unit for receiving an input entered by a user**" according to its **plain and ordinary meaning**.

6. "means for selecting an object displayed on said display apparatus"

Maxell's Proposed Construction	**Apple's Proposed Construction**
Agreed function: "selecting an object displayed on said display apparatus" Structure: Input/output unit 103 and associated software that allows for the claimed selection function.	Agreed function: "selecting an object displayed on said display apparatus" Structure: input/output unit 103, including a liquid crystal display device and a keyboard, and associated software; or equivalents thereof

(1) Parties' Positions

The parties agree that the term is a means-plus-function term and that the recited function is "selecting an object displayed on said apparatus." The parties also agree that the corresponding

structure relates to input/output unit 103 but dispute whether the associated structure requires further specificity.

Maxell argues that the disclosed structure is "input/output unit 103 and associated software that allow for the claimed function." Docket No. 136 at 13. Maxell asserts that the input/output unit connotes sufficient structure. *Id.* at 14.

Apple cites its arguments for the previous term asserting that "for the same reasons that 'input unit' is a means-plus-function limitation . . . 'input/output unit' does not recite sufficiently definite structure." Docket No. 161 at 12. Apple contends that "Maxell's construction simply replaces a black box that performs a recited function with another black box." *Id.* at 12 (citing *Blackboard, Inc. v. Desire2Learn, Inc.*, 574 F.3d 1371, 1383–84 (Fed. Cir. 2009)). Apple then asserts that "a liquid crystal display device and ten-key board" are the only disclosed structures.

(2) Analysis

Input/output unit 103 is clearly linked to the function of selecting an object displayed on said display apparatus. *See* '438 patent at 8:57. For the reasons discussed for the previous term, the Court finds that input/output unit connotes sufficient structure to one of ordinary skill in the art. Accordingly, the Court construes "**means for selecting an object displayed on said display apparatus**" as a means-plus-function term:

Function: "**selecting an object displayed on said display apparatus**" and

Structure "**Input/output unit 103 and associated software that allows for the claimed selection function.**"

7. "display apparatus"

Maxell's Proposed Construction	Apple's Proposed Construction
"a display device comprising a first short-distance communication apparatus for carrying out a short distance communication with an information processing terminal and a second communication apparatus for carrying out a communication with the information-processing terminal through a network"	"an electronic notice board"

(1) The Parties' Positions

Maxell contends that the inventors of the '438 patent acted as lexicographers and defined "display apparatus" in the summary of the invention, describing the "display apparatus" according to the recited limitations in claim 4. *See, e.g.*, Docket. No. 136 at 11–12. Maxell argues that Apple's proposed construction improperly limits the term to a preferred embodiment. *Id.* Maxell further contends that Apple's construction violates the doctrine of claim differentiation because dependent claims 6 and 7 explicitly limit "display apparatus" to an "electronic notice board." Docket No. 165 at 6.

Apple agrees that the term has special meaning within the context of the '438 patent but argues for a narrower construction. *See* Docket. No. 161 at 12–13. Apple argues that the patent's repeated description of the invention as an "electronic notice-board system" limits the invention's scope and trumps claim differentiation. *Id.* at 12–14. In accordance with such limitation, Apple asserts that the patent uses the terms "electronic notice board" and "notice board" to describe the claimed "display apparatus" *Id.* at 13 (citing Docket No. 161-1 ¶ 73). Apple further asserts that the patent describes a "display apparatus" as a "display terminal," which is in turn defined as an "electronic notice board." *Id.* at 13–14 (citing '438 patent at 4:27–28; 4:46–47; 9:33–36). Accordingly, Apple asserts that "display apparatus" should be construed as an "electronic notice board."

Apple further asserts that Maxell's construction improperly attempts to import the specification's paraphrasing of claim 4 to define "display apparatus" which would render claim 4 superfluous. *Id.* at 14.

(2) Analysis

The parties' dispute amounts to a conflict, familiar in claim construction analysis, between the teachings in the specification and claim differentiation. *See, e.g.*, *Marine Polymer Tech. Inc. v. HemCon, Inc.*, 672 F.3d 1350 (Fed. Cir. 2012) (where an evenly divided en banc panel split over whether a construction dictated by the specification or a construction dictated by claim differentiation was more proper).

The claims support Maxell's proposal. Claims 1 and 4 define the invention from opposite directions: claim 1 is directed to and claims an "information-processing terminal" that communicates with a "display apparatus," while claim 4 is directed to and claims a "display apparatus" that communicates with an "information processing terminal." Claim 4 claims a "display apparatus . . . comprising a first short-distance communication apparatus for carrying out a short distance communication with an information processing terminal and a second communication apparatus for carrying out a communication with the information-processing terminal through a network." The "display apparatus" term also appears in claims 1–3 and 5–7. For example, claim 1 specifies that an "information processing terminal" has a "first short-distance communication unit" and a "second communication unit" for communicating with a "display apparatus." Unlike claim 4, claim 1 provides no further detail on the "display apparatus."

The parties agree that the "display apparatus" in claims 1 and 4 is the same. It follows that claim 4's limitations are incorporated into "display apparatus" in all the claims. Such a construction does not violate the principles of claim differentiation because claim differentiation

principles operate differently in the context of two independent claims. *Curtiss-Wright Flow Control Corp. v. Velan, Inc.*, 438 F.3d 1374, 1381 (Fed. Cir. 2006) (explaining that claim differentiation arguments have less force in the context of two independent claims because "two claims can use different terminology to define the exact same subject matter").

Apple asserts that "display apparatus" should be limited to an "electronic notice board." However, dependent claims 6 and 7 claim an electronic notice board system "including a display apparatus . . . wherein said display apparatus is an electronic notice board." The doctrine of claim differentiation therefore creates a rebuttable presumption that "display apparatus" is not limited to an "electronic notice board." *Liebel-Flarsheim*, 358 F.3d at 910. This presumption is strongest where, as here, "the limitation sought to be 'read into' an independent claim is the only meaningful difference between the two claims." *InterDigital Commns. LLC v. Inter. Trade Com'n*, 690 F.3d 1318, 1324 (Fed. Cir. 2012); *Wenger Mfg., Inc. v. Coating Mach. Sys., Inc.*, 239 F.3d 1225, 1233 (Fed. Cir. 2001); *SunRace Roots Enter. Co. v. SRAM Corp.,* 336 F.3d 1298, 1303 (Fed.Cir.2003).

Apple argues that the written description overcomes the presumption against claim differentiation because it teaches that "display apparatus" is limited to an "electronic notice board." Apple argues that the patent repeatedly and consistently characterizes the invention as an electronic notice board system and characterizes the "display apparatus" as an "electronic notice board." *Id.* (citing *Verizon Servs. Corp. v. Vonage holdings Corp.*, 503 F.3d 1295, 1308 (Fed. Cir. 2007) (when a patent describes the features of the "present invention" as a whole, this description limits the scope of the invention)). Apple also argues that "the specification uses the terms 'electronic notice board' and 'notice board' 47 times to describe the claimed 'display apparatus.' " *Id.* at 13 (citing *GPNE Corp. v. Apple, Inc.* 830 F.3d 1365 (Fed. Cir. 2016) ("A patent's repeated and consistent characterization of a claim term in a particular way may require the claim term to be

construed in accordance with that characterization.")). Apple asserts that these statements in the specification overcome the presumption from claim differentiation. *Id.*

Apple does not, however, overcome the strong presumption of claim differentiation here. While the specification does discuss the "present invention" as relating to an "electronic notice board system," the specification also describes the invention as containing a general "display apparatus," not an "electronic notice board." '438 patent at 1:10–12 ("[T]he present invention relates to an electronic notice-board system having an information-processing terminal in addition to a display apparatus"); *see id.* at 2:5–17 (describing the "display apparatus of the present invention" in broad terms as used in claim 4).

The patent includes a single preferred embodiment "implementing an electronic-notice board system provided by the present invention." *Id.* at 2:61–63. The description of this embodiment does not use "electronic notice board" in place of "display apparatus." Instead, the specification describes a "display terminal" with generic components that serves as the "display apparatus" in the embodiment.

The patentees' broad descriptions of "display terminal" shows that they did not intend to limit "display apparatus" to an "electronic notice board." The patent discloses a broad "display apparatus" capable of serving as an electronic notice board in an electronic notice board system. For example, rather than simply disclosing an "electronic notice board," the embodiment describes a generic "display unit" which "serv[es] as a notice board" in the embodiment. '438 patent at 4:46–47. Moreover, the embodiment describes installing an "electronic notice-board program for implementing an electronic notice board function" on the display terminal, which again suggests that the display terminal/display apparatus is broader than an electronic notice board. *Id.* at 4:66–5:33.

That the inventors anticipated the invention being used in an electronic notice board system does not limit the scope of the patent to that narrow context where, as here, the specification uses broader terms to describe the invention. *See Brookhill-Wilk 1, LLC v. Intuitive Surgical, Inc.*, 334 F.3d 1294, 1301 (Fed. Cir. 2003) ("[T]he fact that the inventor anticipated that the invention may be used in a particular manner does not limit the scope to that narrow context."); *Vehicular Techs. Corp. v. Titan Wheel Int'l.* 141 F.3d 1084 (Fed. Cir. 1998). Advantages described in the body of the specification are not *per se* limitations to the claimed invention. *Vehicular Techs.*, 141 F.3d at 1096. The principal invention—the display terminal and display apparatus capable of performing two-way communication—appears to be useful in contexts outside of the electronic notice board system. Thus, the patentee's focus on the effect of the claimed invention in electronic notice board systems does not clearly "disavow the use of the invention outside the context of the electronic notice board system." *See Teleflex*, 299 F.3d at 1328. Ultimately, the specification's discussion of the invention in relation to an electronic notice board system does not "compel" a contrary construction despite the claim differentiation presumption. *See Marine Polymer* (Dyk, J., dissenting in part) (explaining that courts should adopt a construction violating the principles of claim differentiation only if it is the only construction consistent with the claim language and the written description).

With that said, Maxell's reasoning is also unpersuasive. Maxell asserts that the repetition of claim 4's language in the Summary of Invention is an express definition. The Court disagrees. Repeating claim language in the Summary of the Invention is a common practice by patent practitioners and does not ordinarily constitute an express definition. Moreover, the Court declines to include the phrase "display device" in the construction as Maxell proposes. "Display device" as used in the specification, refers to structure *within* the display terminal/display apparatus, not

structure for the display apparatus itself. *See* '438 patent at 4:50–52 (explaining that the "display unit" in the "display terminal" can be "any display device as long as the display device is capable of displaying information"). It would be improper to use "display device" in the construction of "display apparatus."

Accordingly, the Court construes "**display apparatus**" to mean **"a display comprising a first short-distance communication apparatus for carrying out a short distance communication with an information processing terminal and a second communication apparatus for carrying out a communication with the information-processing terminal through a network."**

7. "adding a comment to contributed data"

Maxell's Proposed Construction	**Apple's Proposed Construction**
Plain and Ordinary Meaning	"written content responsive to the contributed data"

The disputed term "adding a comment to contributed data" appears in claim 2 of the '438 patent.

(1) The Parties' Positions

Maxell asserts that the term is readily understood by those of skill in the art and requires no construction. *See* Docket No. 136 at 12–13. Maxell argues that the term is not limited to "written content" and that Apple inserts words that do not appear in the specification. *Id.* at 13.

Apple asserts that a construction is required because the word "comment" has different meanings in different contexts. Docket No. 161 at 15 (citing Docket No. 161-11 at 98:3–23). Apple then asserts that the specification requires that a comment added to contributed data be a "written content responsive to that data." *Id.* (citing '438 patent at 8:64–9:6 ("Subsequently, the user . . . ***writes a comment*** into the display field 1302. The content ID 502 is an ID identifying a

content for which the ***comment is written***. . . . Finally, the user selects a transmission button 1303 to start a process to select the content and input the ***written comment***.") (emphasis added)). To Apple, its construction is supported by the patent's goal—writing and posting text on an electronic notice board in response to "contributed data" already on the board. *Id.* (citing Docket No.161-2 ¶ 92).

(2) Analysis

Nothing in the intrinsic evidence supports limiting the meaning of "adding a comment to contributed data." Claim 2, for example, requires that the information-processing terminal of claim 1 have (i) a function of contributing data to said display apparatus and (ii) a function of adding a comment to contributed data. This language does not require the comment to be "written." To the extent that Apple's proposed requirement that the comment be "responsive" is different than the plain meaning of "adding . . . to contributed data," such limitation finds no support in the claim language.

Likewise, the specification does not support limiting the meaning of "adding a comment to contributed data." Apple has not pointed to language of lexicography, disavowal or disclaimer mandating that the content must be written or responsive. *See GE Lighting Solutions, LLC v. AgiLight, Inc.*, 750 F.3d 1304, 1309 (Fed. Cir. 2014); *Cordis Corp. v. Boston Sci. Corp.*, 561 F.3d 1319, 1329 (Fed. Cir. 2009). The descriptions in the Background of the Invention and Summary of the Invention do not indicate any intent to limit the term to written and responsive content.

Instead, Apple cites non-limiting descriptions of the preferred embodiment to support its proposed construction. However, "even where a patent describes only a single embodiment, claims will not be read restrictively unless the patentee has demonstrated a clear intention to limit the claim scope using words of expressions of manifest exclusion or restriction." *Arlington Indus.,*

Inc. v. Bridgeport Fittings, Inc., 632 F.3d 1246, 1254 (Fed. Cir. 2011); *see Innova/Pure Water*, 381 F.3d at 1117. Even within the description of the preferred embodiment, the patent does not describe "written" and "responsive" content as relevant or necessary to the patent's goal.

Apple has not demonstrated a clear intent to limit the claim term from its plain and ordinary meaning. The embodiment's description of a comment as written does not suggest a clear intent to limit the scope. The Court hereby construes the term "**adding a comment to contributed data**" to have its **plain and ordinary meaning**.

E. The '493 Patent

The '493 patent is entitled "Electric Camera." The patent generally relates to an electric camera that solves a problem of conventional electric cameras incapable of taking both moving and static images of satisfactory quality. *Id.* at 2:62–3:7. The'493 patent's abstract is reproduced below:

> An electric camera includes an image sensing device with a light receiving surface having N vertically arranged pixels and an arbitrary number of pixels arranged horizontally, N being equal to or more than three times the number of effective scanning lines M of a display screen of a television system, a driver to drive the image sensing device to vertically mix or cull signal charges accumulated in individual pixels of K pixels to produce, during a vertical effective scanning period of the television system, a number of lines of output signals which corresponds to 1/K the number of vertically arranged pixels N of the image sensing device, K being an integer equal to or less than an integral part of a quotient of N divided by M, and a signal processing unit having a function of generating image signals by using the output signals of the image sensing device.

More particularly, the '493 patent describes an electric camera including an image sensing device having a number (*e.g.*, 1200 pixels) of vertically arranged pixels and a number (*e.g.*, 1600 pixels) of horizontally arranged pixels. *Id.* 4:34–48. When taking still images, all of the effective pixels on the image sensing device are used to produce signals with as high a resolution as possible. *Id.* at 7:31–39. When taking moving video, a number (*e.g.*, 1200/240 = 5) of the vertically arranged pixels are mixed or culled so that the number of lines of output signals conforms to the number of

effective scanning lines (*e.g.*, 240 lines if in an NTSC system) of a television monitor. *See, e.g.*, 4:64–5:6; 9:30–43.

Claim 1 of the '493 patent is reproduced below:

1. An electric camera comprising:

an image sensing device with a light receiving sensor having an array of pixels arranged vertically and horizontally in a grid pattern, in an N number of vertically arranged pixel lines, wherein N is equal to or greater than three times a number of effective scanning lines M of a display screen;

a signal processing unit, that generates image signals by using the output signals of the image sensing device; and

a display unit with the display screen, to display an image corresponding to the image signals;

wherein during monitoring in a static image mode, the signal processing unit generates the image signals by mixing or culling signal charges accumulated in the N number of vertically arranged pixel lines to provide pixel lines only at pixel intervals of K1 pixels;

wherein during recording in a moving video mode, the signal processing unit generates image signals by mixing or culling signal charges accumulated in the N number of vertically arranged pixel lines to provide pixel lines only at pixel intervals of K2 pixels, a value of K1 being different from a value of K2; and

wherein during recording in the static image mode, the signal processing unit generates the image signals by using all signal charges accumulated in the N number of vertically arranged pixel lines, to provide N pixel lines.

8. "effective scanning lines . . . of a display screen"

Maxell's Proposed Construction	**Apple's Proposed Construction**
"lines on a display screen corresponding to an actually displayed image"	"the lines displayed in a single field of an interlaced scanning display"

The disputed term "effective scanning lines . . . of a display screen" appears in claim 1 of the '493 patent.

(1) The Parties' Positions

The parties' dispute centers on whether the patent is limited to "interlaced scanning" displays. Interlaced scanning involves displaying half of the pixel lines in one frame and the other half in the next frame. Docket No. 136 at 18. Another scanning technique, developed after interlaced scanning, is progressive scanning, which involves displaying each of the pixel lines in sequence for each frame. *Id.* at 19. According to Maxell, by the time of the invention of the '493 patent, those of skill in the art were familiar with progressive scanning techniques. *Id.* at 19.

Maxell claims that the term should be construed to mean "the number of lines on a display screen corresponding to an actually displayed image." Docket No. 136 at 18. Maxell contends that the term "effective" is used consistently to refer to "that which is actually being used." *Id.* at 20. As such, Maxell argues that "effective scanning lines" mean the "lines actually being utilized to display an image." *Id.* at 20. At bottom, Maxell asserts that descriptions of interlaced scanning and the use of terms such as "field" and "vertical blanking period" relate only to a nonlimiting embodiment. *Id.* at 22.

According to Apple, a person of ordinary skill would have understood that television displays at the time of the alleged invention utilized interlaced scanning. *Id.* at 19. Apple's expert acknowledges that "interlaced" and "progressive" scanning were both known at the time of the patent but states that interlaced scanning displays were more "common." Docket No. 161-4 ¶ 34.

Apple asserts that the invention aims to produce "signals conforming to a television system such as NTSC and PAL," and all disclosed embodiments refer to interlaced television standards. *Id.* at 21 (citing '493 patent at 1:30–34; 10:18–21). Accordingly, Apple argues that the construction of "effective scanning lines" should reflect this goal. Docket No. 161 at 18.

Apple argues that its proposed construction is consistent with the specification's definition of "effective scanning line" as part of a display field, a term relevant only in interlaced scanning systems.

> The NTSC system, for example, performs interlaced scanning on ***two fields, each of which has an effective scanning line*** number of about 240 lines (the number of scanning lines actually displayed on the monitor, which is equal to the number of scanning lines in the vertical blanking period subtracted from the total number of scanning lines in each field).

'438 patent at 1:39–43.

Maxell argues that Apple's proposed construction impermissibly excludes progressive scanning displays. *Id.* at 19. According to Maxell, the claim language does not support such a limitation. Maxell further points to the specification, which states that the "invention can also be applied to other television systems," to allege that the invention covers progressive scanning systems. Docket No. 136 at 21 (citing '493 patent at 10:18–21).

(2) Analysis

The claims do not support limiting the term to interlaced scanning. The term appears in claim 1 of the '493 patent, which is reproduced below in relevant part:

> An electric camera comprising:
>
> > an image sensing device with a light receiving sensor having an array of pixels arranged vertically and horizontally in a grid pattern, in an N number of vertically arranged pixel lines, wherein N is equal to or greater than three times a number of **effective scanning lines M of a display screen**; …

'493 patent at 15:57–63 (emphasis added). The claim specifies that pixels are arranged vertically and horizontally in a grid pattern, where N is the number of vertically arranged pixel lines and M is the number of effective scanning lines. The claim does not reference "interlaced" scanning, nor does it mention a "single field," "vertical blanking period" or any other term unique to interlaced scanning.

Nor does the specification support limiting the term to interlaced scanning. The specification describes the patent in general terms as relating to "photography of video cameras, camcorders, digital still cameras and others using solid state image sensing device, and more particularly to an electric camera using a solid state image sensing device with a large number of pixels." *Id.* at 2:57–61. This does not support any limitation.

Contrary to Apple's position, the patent's stated goal is quite broad: to solve issues in the prior art by providing an "image sensing device with a sufficient number of pixels for still images and enables taking of highly details still images of a moving video taking with reduced image quality degradation without increasing circuitry such as field memory." '438 patent at 3:8–13. The patent discusses limitations in prior art systems adapted to interlaced scanning systems. *See* '493 patent at 1:51–53 (describing prior art image sensing devices designed to take moving images according to the NTSC system). However, describing the patent as providing an advantage over these systems, without more, is not a *per se* limitation to the claimed invention. *See Teleflex*, 299 F.3d at 1328. The patent's use of NTSC standards in the embodiments similarly fails to limit the term. *See Comark Commc'ns, Inc.*, 156 F.3d at 1187 ("Although the specification may aid the court in interpreting the meaning of disputed claim language, particular embodiments and examples appearing in the specification will not generally be read into the claims."); *Arlington Indus.*, 632 F.3d at 1254; *Innova/Pure Water*, 381 F.3d at 1117; *see also Liebel-Flarsheim Co.*, 358 F.3d at 906. Both parties rely on the following portion of the specification to define "effective scanning lines."

> The NTSC system, for example, performs interlaced scanning on two fields, each of which has an effective scanning line number of about 240 lines (the number of scanning lines actually displayed on the monitor which is equal to the number of scanning lines in the vertical blanking period subtracted from the total number of scanning lines in each field).

'493 patent at 1:30–50 (emphasis added). This discussion of the NTSC standard is a non-limiting example in the specification used to explain the limitations of prior art systems. *See Comark Commc'ns, Inc*, 156 F.3d at 1187. This phrase is best read as both broadly defining "effective scanning lines"—the number of scanning lines actually displayed on the monitor—and applying that meaning to the exemplary NTSC system. Consistent with this provision, the term "effective scanning lines" refers to the "number of scanning lines actually displayed on the monitor."

Accordingly, the Court construes "**effective scanning lines**" as "**the number of scanning lines displayed on the display screen.**"[3]

9. "culling" and "mixing"

Term	Maxell's Proposed Construction	Apple's Proposed Construction
"mixing … signal charges"/ "mixed"	"combining signal charges from multiple pixels" / "combined"	"collecting charges from multiple pixels for combined transfer" / "collected"
"culling signal charges" / "culled"	Plain and ordinary meaning	"selecting pixels for output by skipping pixels at predetermined intervals" / "selected"

The disputed terms "culling signal charges" / "culled" and "mixing . . . signal charges" / "mixed" appear in claims 1, 4, 5 and 10 of the '493 patent. These terms are combined for analysis based on the similarity of the terms as used in the patent and the parties' positions as to these terms.

(1) The Parties' Positions

Maxell proposes construing "mixing" to mean "combining signal charges from multiple pixels" and "mixed" as "combined." Maxell asserts that its proposed constructions use language from Apple's constructions and supported by the specification. Docket No. 136 at 25. Maxell

[3] The court utilizes the term "display" instead of "monitor" to remain consistent with the language in the claims referring to displays.

argues that Apple's construction is unclear and improperly limits the claims to an undefined "combined transfer."

Apple asserts that further clarification is necessary. Apple argues that the patent "consistently describes 'mixing' as collecting charges from multiple pixels for combined transfer" and that " 'mixing' occurs as part of the charge transfer process." *Id.* at 22. Apple further explains that the specification's disclosure that pixels are "mixed together to reduce the number of output lines from the image sensing device" teaches that the combination "of pixel charges occurs as part of charge transfer to reduce the number of output lines from the image sensor." *Id.* Apple further asserts that post-transfer processing is "disparaged" by the '493 patent. *Id.* (citing '493 patent at 2:10–17). Specifically, the patent criticizes prior art systems that combined signal charges after they were read out from the image sensing device as requiring "a large processing circuit, such as field memory." *Id.* at 23 (citing '493 patent at 2:18–25). Because the patent purports to eliminate the need for field memory, Apple asserts that the mixing must be " part of the transfer process."

As to "culling," Maxell contends that it requires no construction because one of ordinary skill in the art would have no difficulty understanding its meaning. Docket No. 136 at 23 (citing 136-8 ¶¶ 49–50). Maxell asserts that Apple's construction is unduly limiting and at least "partially redundant" with the other limitations because "skipping" and "predetermined intervals" are not used to describe "culling" and because the patent's description of "culling" would be familiar to and easily understood by persons of ordinary skill. Docket No. 136 at 23.

Apple and its expert assert that "culling" has special meaning within the context of the '493 patent. Docket No. 161-12 at 66:18–68:18. Apple argues that the specification's only explanation of "culling"—which equates culling with skipping pixel lines—supports its construction. *Id.* at 24; Docket No. 161 at 23 (citing '493 patent at 10:9–12 ("The number of

lines of output signals can also be reduced by a so-called culling operation, by which only one line of signal charges of pixels is read out for every predetermined number of lines.")). Apple argues that Maxell's construction stretches "culling" to cover any operation that results in fewer than all pixels in the array.

(2) Analysis

The claim language does not expressly define the "mixing" or "culling" terms. Rather, the surrounding claim language specifies the result of the mixing/culling operations. *See* '493 patent at 16:1–6. The claims explain that mixing/culling results in pixel lines only at pixel intervals of K1 pixels (for claim 1) or pixel lines separated from one another by intervals of a first/given distance (claims 5 and 10). Claim 1 further explains that the "signal processing unit" performs the mixing/culling operation using the "output signals of the image sensing device." *Id.* at 15:64–16:5.

The specification has numerous references to the "mixing" and "culling" terms. Consistent with the claims, the specification makes clear that "mixing" or "culling" reduces the number of pixel lines of output signals. *See* '493 patent at 1:6–12 ("vertically adjoining pixels are mixed together to reduce the number of output lines"); 5:3–5 ("vertically mixing five pixels (1200 pixel rows/240 scanning lines) can match the number of lines of output signals from the image sensing device to the number of effective scanning lines"); 1:43–50 (describing that for an image sensing device having about 480 pixel rows, two vertically adjoining pixels in each field are mixed together inside or outside the image sensing device to generate 240 scanning lines). The joint usage of "mixing" and "culling" in the patent suggests that the operations use on the same input and result in a similar output (*i.e.*, a reduced number of pixel lines), and are performed by the same device. The main difference appears to be the manner by which the pixel rows are reduced.

The parties agree that "mixing" involves combining signal charges. Apple's expert describes the "mixing" process as "combining signal charges from multiple pixels." *See* Docket No. 161-4 at ¶ 49 (further describing lines of pixels as "vertically mixed together by combining charges accumulated in four pixels"). Maxell's construction incorporates this understanding; indeed, Maxell proposes aconstruction using Apple's expert's own language: "combining signal charges from multiple pixels." Maxell's construction also comports with the teaching of the claim and specification that the "mixing" function combines pixels to reduce signal lines.

Apple argues that a more limited construction is required based on the patent's disparagement of the prior art. But the phrases "collecting" and "combined transfer" are not found anywhere in the claims or specification.

Apple explains that its proposed construction limits the mixing process to "part of transferring the charges from the sensor" rather than including the post-transfer processing approach disparaged by the patent (Maxell's position)." Docket No. 161 at 22. According to Apple, the only way to distinguish the invention from the prior art "is to perform mixing as part of the signal transfer, to combine these charges ***as it is being transferred from image sensor to another device.***" Docket No. 153 at 35 (emphasis added). Apple's expert testimony likewise suggests that Apple's construction aims to restrict the mixing function specifically to the image sensing device. Docket No. 161-4 ¶ 52 (stating that Maxell's construction is too broad because it "permits the combination of pixels to occur anywhere in the system, for example, in the camera system after all effective pixels were read out from the image sensing device"). Apple's counsel likewise asserted in the *Markman* hearing that the only way for the invention to make sense "is to perform mixing as part of the signal transfer, to combine the charges as it is being transferred from image sensor to another device." Docket No. 187 at 153:1–7.

Apple's proposed construction does not clearly limit the mixing operation as Apple suggests. Apple's construction makes no mention of the image sensing device. Notably, Apple's counsel later stated during rebuttal that that its "construction is that mixing can occur inside the image sensor ***or outside the image sensor***" but that the "mixing operation has to be performed as part of a signal transfer from one place to another." *Id.* at 154:19–20 (emphasis added).

If Apple's construction requires the mixing process to occur in the image sensing device or as signals are transferred from the image sensing device, then the construction would contradict the language of claim 1, which states:

> a signal processing unit, that generates signals by using ***the output signals of the image sensing device***; . . . wherein . . . the signal processing unit generates the image signals by mixing or culling signal charges accumulated in the N number of vertically arranged pixel lines to provide pixel lines only at pixel intervals of K1 pixels.

Under Claim 1, then, mixing occurs *after* the image sensing device outputs the charges to the signal processing unit.

The specification's criticism of a prior art system utilizing post-transfer processing does not overcome the plain language of claim 1. The specification does not describe the invention as requiring mixing to occur before transfer from the image sensing device or as part of the transfer process. The specification des not "repeatedly extoll the virtues" of combined transfer or repeatedly criticize post transfer processing. *See UltimatePointer, L.L.C. v. Nintendo Co., Ltd.*, 816 F.3d 816 (Fed. Cir. 2016) (finding the "repeated description of the invention as a direct pointing system, the repeated extolling of the virtues of direct pointing, and the repeated criticism of indirect pointing clearly indicated that "handled device" should be limited to "direct-pointing device"). And in fact, the specification also criticizes a prior art system that performs mixing

inside the image sensing device. *See* '493 patent at 2:44–53. Ultimately, neither the claims nor the specification requires mixing to occur as signals are transferred from the image sensing device.

Apple's alternative argument that the mixing function may occur anywhere, so long as it is performed "as part of a transfer process," is likewise unsupported by the claims. Again, neither the claims nor the specification contains this language. Claim 1 explains that the mixing is performed by the "signal processing unit" and does not discuss any related transfer operation. Apple's argument appears to be derived from the patent's discussion of an embodiment. '493 patent at 5:56–66 (explaining, in the context of the embodiment, that signals are mixed in the "horizontal transfer unit 33" of an image sensing device). As discussed previously, terms will not be narrowed according to embodiments in the specification absent a clear intent to so limit the terms. Further, this embodiment is targeted to a system where the image sensing device performs the mixing function. However, the patent clearly did not intend to limit the invention to this embodiment because Claim 1 performs the mixing operation on signals output from the image sensing device. Further, the specification does not indicate that this process is necessary to address limitations in prior art. Ultimately, Apple has not shown that its construction is required pursuant to prior art disparagement or that its construction is otherwise supported or mandated.

As to the "culling" and "culled" term, Apple and Maxell's experts disagree as to whether term is understood by persons of ordinary skill in the art. As discussed above, the claims themselves do not define "culling." However, the specification defines "culling:"

> The number of output signals can also be reduced by a so-called culling operation, by which only one line of signal charges of pixels is read out for every predetermined number of lines.

'493 patent at 10:9–12.

Though provided in the context of an embodiment, this statement is not simply a description of an embodiment or a single example of the culling operation. Instead, it explains the

"culling operation" referred to in the invention. Though there is always tension in determining "whether a statement was designed to define the claim term or to describe a preferred embodiment," *E-Pass Technologies, Inc. v. 3Com Corp.*, 343 F.3d 1364, 1369 (Fed. Cir. 2003), an express definition should not be ignored just because it appears in the context of a preferred embodiment, as the term does here. *Edwards Lifesciences LLC v. Cook Inc.*, 582 F.3d 1322 (Fed. Cir. 2009). Accordingly, culling should be construed consistent with this description.

Apple asserts that its construction imports the same meaning. The Court disagrees. First, the phrase "selecting" is not explained or consistent with any language in the specification. Further, the specification requires one line of signal charges of pixels to be read out for every predetermined number of lines—*e.g.* reading out any one line for every five pixels. Apple's construction appears more limiting, requiring skipping pixels at predetermined intervals—*e.g.* always selecting the first line and skipping the next four. Though the result is the same—one pixel line for every 5 pixels—the operation is not the same. Ultimately, such rephrasing, even if true to the outcome described in the patent, is unnecessary because the definition in the patent is clear on its own.

Accordingly, the Court construes "**mixing . . . signal charges**" and "**mixed**" as "**combining signal charges from multiple pixels"** and **"combined."** Further, the Court construes "**culling signal charges**" and "**culled**" as "**reading out only one line of signal charges of pixels for every predetermined number of lines**" and "**only one line of signal charges of pixels is read out for every predetermined number of lines**."

F. The '991 Patent

The '991 patent is entitled "Communication Apparatus and Method for Receiving an Inbound Videophone Call Notice While Displaying Digital Information on the Display." The

Background of the patent explains that a telephone communication system and a TV broadcast system are independent systems and different apparatuses, and various problems exist with a conventional telephone and TV system. *See* '991 patent at 1:39–2:31. To provide a solution to conventional systems, the '991 patent discloses "a new and improved TV receiver with TV function (referred to as videophone function-added TV 35 receiver hereafter) set having videophone call handling functionality, which performs both the reception of a digital broadcast program signal and the transmission and reception of a videophone signal between itself and another videophone function-added TV receiver at the other end of a 40 communication line." *Id.* at 2:32–40.

Maxell asserts claim 1 of the, reproduced below:

> A communication apparatus for transmitting and receiving digital information to and from another communication apparatus, comprising:
>
> a network interface configured to receive first digital information which is received from a contents server which is coupled to the communication apparatus via the network interface and second digital information from the another communication apparatus;
>
> a camera configured to generate video information which is included in third digital information;
>
> a display configured to display at least the first and the second digital information; and
>
> a processor;
>
> wherein when the processor receives an inbound videophone call notice while displaying the first digital information on the display, the processor pauses the displaying of the first digital information and renders the camera operative;
>
> wherein the processor outputs the third digital information to the another communication apparatus and displays the second digital information of the videophone call on the display; and
>
> wherein when the processor receives an input for stopping the videophone call, the processor stops output of the third digital information and stops the camera.

10. "communication apparatus"

Maxell's Proposed Construction	Apple's Proposed Construction
Plain and Ordinary Meaning	"videophone function-added TV receiver"

The disputed term "communication apparatus" appears in claims 1–4, 8–10 and 12 of the '991 patent.

(1) The Parties' Positions

Maxell asserts that a person of ordinary skill in the art would understand "communication apparatus" according to its plain and ordinary meaning. Docket No. 136 at 15 (citing *Biscotti Inc. v. Microsoft Corp.*, No. 2:13-cv-01015, 2016 U.S. Dist. LEXIS 155336, at *16 (E.D. Tex. Nov. 9, 2016) (construing "communication device" according to its plain and ordinary meaning)).

Apple asserts that "communication apparatus" should be construed according to the patent's "repeated and consistent characterization of the alleged invention" as a "videophone function-added TV receiver." Docket No. 161 at 15–16 (citing *GPNE*, 830 F.3d at 1370). Apple notes that the phrase "communication apparatus" is not used anywhere in the specification, whereas "videophone function-added TV receiver" is used 284 times. *Id.* According to Apple, such a construction is consistent with the patent's goal of improving television receivers. *Id.* at 16. Apple also asserts that its proposed construction is consistent with the prosecution history because, throughout the substantive examination, the application was titled "Television Receiver with a TV Phone Function." *Id.* at 17.

Maxell responds that Apple's construction is improper for two reasons. First, Maxell asserts that the proposed construction excludes preferred embodiments which describe a "video telephone system using but not including the videophone function-added TV receiver sets."

Docket No. 136 at 16 (citing '991 patent at 3:29–33; 4:8–10; 5:16–28; 6:8–10). Maxell also argues that Apple's expert "confuses repetition with redefinition." *Id.* at 16.

Apple argues that its construction does not exclude alternative embodiments because such embodiments include a plurality of videophone function-added TV receiver sets. *Id.* at 16 n.8 (citing '991 patent at 2:56–60).

(2) Analysis

The parties dispute centers on whether the specification's repeated characterization of the invention limits the construction of "communication apparatus." The claim terms themselves do not require limitation. However, the specification is always highly relevant to claim construction analysis. "Usually it is dispositive; it is the single best guide to the meaning of a disputed term." *Honeywell Intern. Inv. v. ITT Industries, Inc.*, 452 F.3d 1312, 1318 (Fed. Cir. 2006).

Describing features of the "present invention" as a whole can be "clear and unmistakable statements constituting disavowal or disclaimer." *Luminara Worldwide, LLC v. Liown Elecs. Co.*, 814 F.3d 1343, 1353 (Fed. Cir. 2016); *Honeywell Int'l Inv.*, 452 F.3d at 1318; *Verizon Serv. Corp*, 503 F.3d at 1308. Similarly, when a patent "repeatedly and consistently characterizes a claim term in a particular way, it is proper to construe the claim term in accordance with that characterization." *See, e.g., GPNE.*, 830 F.3d at 1370; *VirnetX, Inc. v. Cisco Sys., Inc.*, 767 F.3d 1308, 1318 (Fed. Cir. 2014).

Here, the patent characterizes the invention as relating to videophone function-added TV receivers. In the "Summary of the Present Invention," the specification describes in detail eight features of the "technology" of the invention, each time referring to a "videophone function added TV receiver." *See* '991 patent at 2:33–3:26. ("This technology provides a new and improved TV receiver with TV function (referred to as a videophone function-added tv receiver hereafter");

2:56-57; 3:29–30; 4:8–10; 4:53–54; 5:26–27; 5:58-59; 6:78. Each embodiment similarly describes using a "videophone function-added TV receiver." The specification never uses the phrase "communication apparatus," but uses the phrase "videophone function-added TV receiver" over 200 times. These statements impose a limit on the term "communication apparatus." Maxell has not demonstrated that Apple's proposed construction excludes any embodiments. In fact, every embodiment is focused on features of the "video telephone-function added TV receiver," even those embodiments disclosing a "video telephone system." "When, as here, the written description clearly identifies what the invention is, an expression by a patentee during prosecution that he intends his claims to cover more than what his specification discloses is entitled little weight." *Honeywell*, 452 F.3d at 1319; *see also Biogen, Inc. v. Berlex Labs*, 318 F.3d 1132, 1140 (Fed. Cir. 2003).

Accordingly, the Court construes "**communication apparatus**" as "**videophone function-added TV receiver.**"

CONCLUSION

The Court adopts the constructions above for the disputed and agreed terms of the '317, '999, '498, '493, '794, '193, '306, '991 and '438 patents. Furthermore, the parties should ensure that all testimony that relates to the terms addressed in this Order is constrained by the Court's reasoning. However, in the presence of the jury the parties should not expressly or implicitly refer to each other's claim construction positions and should not expressly refer to any portion of this Order that is not an actual construction adopted by the Court. The references to the claim construction process should be limited to informing the jury of the constructions adopted by the Court.

So ORDERED and SIGNED this 18th day of March, 2020.

ROBERT W. SCHROEDER III
UNITED STATES DISTRICT JUDGE

EXHIBIT 1027

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.
Petitioner,

v.

MAXELL, LTD.,
Patent Owner

Case: IPR2020-00597

U.S. Patent No. 8,339,493

PATENT OWNER PRELIMINARY RESPONSE TO PETITION FOR *INTER PARTES REVIEW* OF U.S. PATENT NO. 8,339,493

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PATENT OWNER'S EXHIBIT LIST

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I. INTRODUCTION

Patent Owner Maxell, Ltd. ("Patent Owner") respectfully requests that the Board deny institution because Petitioner Apple Inc. (hereinafter, "Apple" or "Petitioner") has failed to demonstrate a reasonable likelihood of success on the grounds submitted in its Petition for challenging the patentability of claims 1, 3-6, and 10-11 ("challenged claims") of U.S. Patent No. 8,339,493 ("the '493 patent").

First, the Board should exercise its discretion pursuant to 35 U.S.C. § 314(a) and deny this petition. Application of the *General Plastic* and *Fintiv* factors weighs heavily in favor of denying institution. One of the purposes of IPRs is to be an "effective and efficient alternative" to litigation. *Gen. Plastic Indus. Co., Ltd. v. Canon Kabushiki Kaisha*, IPR2016-01357, Paper 19 at 16-17 (PTAB Sept. 6, 2017) (precedential). Here, instituting an IPR would not be an effective or efficient alternative to litigation, particularly given the advanced stage of the co-pending District Court case *Maxell, Ltd. v. Apple Inc.*, No. 5:19-cv-00036-RWS (E.D. Tex.), the finite resources of the Board, and Apple's delay in filing its Petition.

Second, Apple fails to show with particularity that the Casio User Guide ("*Casio*") was publicly accessible prior to the critical date of January 11, 2000; this is fatal to all Grounds.

Third, even if *Casio* is prior art, Apple's obviousness analysis fails to show

that *Casio* in view of *Juen* discloses "an image sensing device with a light receiving" sensor as well as the claimed "signal processing unit." These deficiencies are fatal to all Grounds.

For at least reasons, more fully explained below, Apple has failed to show a reasonable likelihood of success on any ground presented.

II. THE BOARD SHOULD EXERCISE ITS DISCRETION AND DENY INSTITUTION FOR ALL GROUNDS PURSUANT TO 35 U.S.C. § 314

Apple filed its petition one day before expiration of the one year deadline to do so. The '493 Patent is asserted in a co-pending District Court case, *Maxell, Ltd. v. Apple Inc.*, No. 5:19-cv-00036-RWS (E.D. Tex.) ("District Court Action"). The District Court Action will be complete **eleven months** before any final decision would issue in this proceeding. Nor did Apple inform the Board—when attempting to justify its delay in filing its Petition—that Maxell identified Apple's infringement of the claims at issue in the '493 Patent over a year prior to Apple filing its Petition, and that the trial date of October 2020 for the District Court Action was scheduled in May 2019. Ex. 2001.[1] The jury trial is scheduled in the District Court Action only one month after the Board's anticipated Institution

[1] As explained further herein, over the next year Maxell consistently and periodically identified asserted claims of the '493 Patent to Apple. *See, e.g.,* Ex. 1010 at ¶ 51.

Decision, and will adjudicate the validity of the '493 Patent *eleven months before* any Final Written Decision issues in this proceeding.

Not only will the District Court Action conclude long before this proceeding, but it will also resolve substantially the same invalidity arguments that Apple raises in the instant Petition. The prior art references relied on in this proceeding are the same, or substantially the same, as those at issue in the District Court Action at the time Apple filed its Petition. Apple fought to add and succeeded in adding its primary reference here, *Casio*, to the District Court Action, only to later drop the reference from the District Court Action in a cynical attempt to avoid discretionary denial here. But Apple only replaced *Casio* in the underlying litigation with a similar camera manufactured by Sony, supported by the Sony User Guide. The Board should not countenance such tactics, as they run directly contrary to the reasons why the Board declared the *NHK* and *Fintiv* cases precedential, and directly contrary to the purpose of IPR proceedings to be an "effective and efficient alternative" to litigation, and would needlessly consume the finite resources of the Board. *Gen. Plastic*, IPR2016-01357, Paper 19 at 16-17..

Additionally, the challenged claims are substantially the same in scope as those asserted in the District Court Action at the time Apple filed its Petition. The Court has already issued a *Markman* Order and the Court and the parties have

spent considerable resources on the District Court Action. Any questions of whether the grounds of invalidity raised in Apple's Petition invalidate the asserted claims of the '493 Patent will be decided in the District Court action at least eleven months prior to when the Board would issue a Final Written Decision in this proceeding.

Simply put, instituting an IPR in this circumstance would needlessly duplicate the District Court Action, and unnecessarily waste the Board's resources. *See NHK Spring Co., Ltd. v. Intri-Plex Techs., Inc.*, IPR2018-00752, Paper 8 at 20 (PTAB Sept. 12, 2018) (precedential) (denying institution under similar facts). For at least these reasons and those further set forth below, the Board should exercise its discretion not to institute this proceeding pursuant to 35 U.S.C. § 314.

A. Application of the *General Plastic* Factors Weighs in Favor of Denying Institution

There is no requirement that the Board institute IPR. *Harmonic Inc. v. Avid Tech.*, 815 F.3d 1356, 1367 (Fed. Cir. 2016). Instead, the decision to institute is delegated to the Board and is purely discretionary. As 35 U.S.C § 314(b) explains, "[t]he Director shall determine whether to institute an inter partes review." *See also Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131, 2140 (2016); 37 C.F.R. § 42.108(a). The Director's discretion is informed by many things, including the

consideration of "the integrity of the patent system, [and] the efficient administration of the Office." 35 U.S.C. § 316(b).

The USPTO recognized that these factors, and the Board's discretionary denial, apply where "other proceedings relating to the same patent, either at the Office, in district courts, or the ITC" are at advanced stages and will resolve the same or similar issues presented in the Petition before the Board can. *See* Trial Practice Update, 83 Fed. Reg. 39,989 at 10 (August 2018). That is because one of the purposes of IPRs is to be an "effective and efficient alternative" to litigation. *Gen. Plastic*, IPR2016-01357, Paper 19 at 16-17. Here, instituting an IPR would not be an effective or efficient alternative to litigation because the co-pending District Court Action, among other things, (1) involves the same, or substantially the same prior art that Apple relies on here, and (2) will be complete well before a final decision in this proceeding.

The majority of the *General Plastic* factors weigh heavily in favor of the Board using its discretion to deny institution. Indeed, even if other factors weighed in favor of institution, Board precedent demands denial of institution due to Apple's delay in filing its Petition and the advanced stage of the District Court Action. *Apple v. Fintiv*, IPR2020-00019, Paper 11 at 5-6 (PTAB March 20, 2020) (precedential); *NHK Spring*, IPR2018-00752, Paper 8 at 20 ("Institution of an *inter*

partes review under these circumstances would not be consistent with an objective of the AIA . . . to provide an effective and efficient alternative to district court litigation. . . . Accordingly, we find that the advanced state of the district court proceeding is an additional factor that weighs in favor of denying the Petition under § 314(a).") (internal quotes omitted); *see also Apple v. Fintiv*, IPR2020—00019, Paper 15 (PTAB May 13, 2020) (same); *Samsung v. Uniloc*, IPR2020-00117, Paper 11 (PTAB May 28, 2020) (same); *Intel v. VLSI Technology*, IPR2020-00158, Paper 16 (PTAB May 20, 2020) (same); *Cisco v. Ramot at Tel Aviv University*, IPR2020-00123, Paper 14 (PTAB May 15, 2020) (same).

1. *General Plastic* Factors 6 and 7 Weigh in Favor of Denial

Apple boldly claims that the "Board's finite resources will not be adversely affected by this IPR." Petition at 9. But Apple only considers the Board's resources in relation to the prior denial of institution of a petition filed by ZTE against the '493 Patent and ignores the duplicative efforts the Board would engage in as a result of the co-pending District Court Action. Considering the status of the District Court Action, and Apple's delay in filing this Petition, granting institution here would work against the purposes of IPRs to be an "effective and efficient alternative" to litigation, and would needlessly consume the finite resources of the Board. *Gen. Plastic*, IPR2016-01357, Paper 19 at 16-17.

a. The District Court Action Will Resolve the Same or Substantially the Same Arguments as Those Presented Here

The scope of Apple's challenge to the '493 Patent's validity in this proceeding is substantially the same as Apple's challenge in the District Court Action. For example, there is overlap in the claims challenged in both proceedings. Here, Apple asserts that Claims 1, 3-6, and 10-11 of the '493 Patent are unpatentable. Petition at 1. These claims cover all the asserted claims against Apple in the District Court Action at the time Apple filed its Petition, including the independent claims and the same or similar dependent claims. *See* Ex. 2002 at 2.

The prior art that Apple relies on in its Petition is the same, or substantially the same, as the prior art at issue in the District Court Action. For example, in the Petition Apple utilizes *Casio*, *Juen*, *Misawa*, and *Takase* as references covering the three grounds presented. In the District Court Action, Apple also relies on *Casio*, *Juen*, *Misawa*, and *Takase* to support its invalidity contentions. Ex. 2002 at 35-42; Ex. 2003 at 37.

With respect to *Casio*, Apple attempts to mislead the Board by claiming that the Petition presents grounds not raised in Apple's invalidity contentions. Petition at 10. In fact, Apple moved to supplement its invalidity contentions to add *Casio*, claiming that *Casio* was important prior art. Ex. 2004. The parties fully briefed the

issue, and the Court ultimately ruled in favor of Apple allowing Apple to add *Casio* to its invalidity case in the District Court Action. Ex. 2005; Ex. 2006. Then, after the parties and the Court having spent considerable time briefing and deciding the issue, Apple withdrew this alleged "important" prior art after filing its Petition to manufacture a "non-overlapping prior art" argument in anticipated response to Maxell's §314 arguments. Ex. 2007.

In any event, even Apple's Final Election of Prior Art served on April 7, 2020 shows that Apple continues to rely on at least *Juen* and *Misawa* to set forth its invalidity case at trial in the District Court litigation in October 2020—*eleven months before a final written decision is expected in this IPR. See id.* at 3.

Thus, substantially the same issues will be decided by a jury, using the same or similar prior art, same invalidity theories, and substantially the same citations of the prior art, all eleven months prior to the issuance of a Final Written Decision.

Here, no meaningful distinction exists between Apple's references and grounds used in the Petition versus those in the District Court Action. In the District Court Action, Apple relied upon the same prior art as this Petition until at least April 7, 2020, at which point it selectively dropped certain prior art references in an attempt to compensate for its delay in filing its Petition and avoid discretionary denial. But from Fall of 2019 through April 7, 2020, Apple relied on

identical prior art.

For example, Apple dropped the "important prior art" *Casio* and simply replaced it with the Sony MVC-FD83 and MVC-FD88 digital cameras ("Sony") and their associated manuals. For purposes of analyzing the overlap between the references and grounds in this proceeding, there is no difference between *Casio* and Sony. Indeed, the Court found that Apple failed to demonstrate that *Casio* discloses features not previously disclosed in its other prior art, and that "the Casio Camera seems cumulative to the already disclosed references" including Sony. Ex. 2006 at 6. Apple's expert in the District Court Action appears to agree:

> For example, many companies independently developed products having both still and video image capture features, as well as electronic image stabilization features, before the filing of the '493 patent….
>
> Below are images I took of the Casio QV-8000SX, Apple QuickTake 200, Sony MVC-FD83, and Sony MVC-FD88 cameras that I used and tested.



Ex. 2008, ¶¶123, 175.

In fact, an examination of Apple's invalidity contention charts with respect to Sony and Casio in the District Court Action illustrate the substantial similarity between the references and Apple's use of the references both here and in the District Court Action. For example, in both matters, Apple argues that the devices inherently must have a signal processing unit based on their ability to encode in known still image and video formats, like JPEG. *See* Ex. 2008 at 61 ("The existence of a signal processing unit is evident from the camera's capability to produce still images compressed in the JPEG format and video images compressed in the MPEG format."); Petition at 28 ("Casio discusses processes well understood

by a POSITA to be performed by a signal processing unit, such as converting or encoding images to a JPEG or AVI file format (Casio, 61, 118), converting images to a lower resolution for display on the monitor (Casio, 16), and digital zoom (Casio, 58-59).").

Additionally, a side-by-side comparison of Apple's use of *Casio* both here and in the District Court Action, and Sony in the District Court Action illustrates the substantial similarity in allegations between *Casio* and Sony when attempting to map the claims of the '493 Patent:

Sony MVCFD83	Casio QV8000SX
A PHOSITA would have found it obvious to modify MVCFD83's multimode camera to operate using an image sensing device with a light receiving sensor having an array of pixels arranged vertically and horizontally in a grid pattern, in an N number of vertically arranged pixel lines, as also taught by Sato.	A PHOSITA would have found it obvious to modify QV8000SX's multimode camera to operate using an image sensing device with a light receiving sensor having an array of pixels arranged vertically and horizontally in a grid pattern, in an N number of vertically arranged pixel lines, as also taught by Sato.

Compare Ex. 2009 at 15 (Sony chart) *with* Ex. 2010 at 13 (Casio chart). Many other examples exist. *Id.* Thus, there is no substantial difference between *Casio* used here and Sony used in the District Court Action.

Apple's expert here relies on some of the additional prior art that remains in the District Court Action, namely *Anderson*. Ex. 1003. Apple's expert discusses *Anderson* 29 times throughout his report. *Id.* ¶¶ 39; 61-62; 104; 113; 117; 121; 134-135; 151; 153. Indeed, Apple appears to supplement its contentions with respect to *Juen* with *Anderson* in the same way it does in the District Court Action.

The claims at issue in this proceeding are also the same or similar to those remaining in the District Court Action, and raise the same validity issues. The Court ordered Maxell to elect a narrower set of claims. This narrowing should not have an impact on the Board's decision with respect to §314. *See NetApp Inc. v. Realtime Data LLC*, IPR2017-01195, Paper 9 at 7-8 (PTAB Oct. 12, 2017). Second, even though independent Claims 1 and 10 are no longer asserted in the District Court Action, Apple itself acknowledges the substantial overlap at least between Claims 1, 5, and 10; it substantially relies on its Claim 1 analysis for both Claims 5 and Claim 10. Petition at 57-68.

The Board should not countenance Apple's delayed filing of its IPRs, and its attempt to then take advantage of the Court's narrowing order *after filing its petition* in an attempt to avoid discretionary denial. This "gotcha" tactic runs contrary to why the Board found *NHK* and *Fintiv* important to declare precedential.

Moreover, Apple's position in the District Court Action is that there is

complete overlap of issues. "Apple reserves the right to amend its election of prior art as appropriate. . . ." Ex. 2007 at 2. Apple's invalidity contentions in the District Court Action also purport to "incorporate[] by reference all prior art cited during prosecution of the Asserted Patents, and all *inter partes* review (IPR) petitions filed against the Asserted Patents and the prior art cited in these IPR petitions" Ex. 2002 at 2. In other words, Apple has expressly and specifically sought to incorporate all of the Petition's contentions into the District Court Action.

Thus, substantially the same issues will be decided by a jury, using the same prior art, eleven months prior to the issuance of a Final Written Decision. At bottom, the issues presented in the Petition that differ from what will be argued in the District Court Action do not meaningfully distinguish the arguments in this proceeding from those in the District Court Action. *Edwards Lifesciences Corp. v. Evalve*, IPR2019-01546, Paper 7, 12-13 (PTAB Feb. 26, 2020) (denying institution despite lack of a 1:1 overlap of claims and prior art, finding such distinction not meaningful).

b. The District Court Action Will Be Complete Well Before a Final Written Decision in This Proceeding

Not only are the substantive arguments overlapping, but the District Court Action will be complete well before a Final Written Decision is issued in this proceeding. The Court has invested significant time and resources into the District

Court Action. For example, the Court conducted a four-hour *Markman* hearing and issued a 57-page *Markman* order with a detailed discussion of a number of disputed claim terms and phrases for the ten patents at issue in the District Court Action. Ex. 2011; Ex. 2014. The Court also has invested many hours in holding arguments and issuing numerous rulings on various motions, including Apple's motion to dismiss, motion to transfer, and motion to stay along with several discovery related motions and the parties' other various motions. *See* Exs. 2011-2014.

The parties have also invested significant time and resources into the District Court Action. For example, fact discovery closed on March 31, 2020, except for remaining depositions postponed due to COVID-19 that are now complete. Ex. 2015. During fact discovery, the parties collectively produced nearly 2 million pages of documents, conducted 35 depositions, filed 20 motions, and served 50 interrogatories and 120 requests for admission. Ex. 2016, ¶¶3-4. The parties also served over 30 third-party subpoenas. *Id.* ¶5. Expert discovery closed June 25, 2020. Maxell's experts spent over 600 hours reviewing source code produced by Apple. *Id.* ¶6. Maxell's expert report regarding infringement and Apple's expert reports regarding invalidity of the '493 Patent were served on May 7, 2020 after substantial expense and effort by counsel and experts on both sides. Ex. 2017. The

parties have already conducted depositions of the experts.

The District Court Action is set for trial beginning October 26, 2020. Ex. 2001 at 1. Apple has known about the trial date in the District Court Action since May 31, 2019, over nine months prior to filing the instant petition. *Id.* In the jurisdiction where the District Court Action is pending, a Standing Order issued "to keep cases moving" despite COVID-19, and an in-person hearing will occur on a remaining discovery motion in the near future. *See* Ex. 2018; Ex. 2019. Thus trial will likely proceed as scheduled. *See Fintiv*, IPR 2020-00019, Paper 15 at 13 ("We generally take courts' trial schedules at face value absent some strong evidence to the contrary."). Here, there is no evidence to the contrary.

In contrast, if this proceeding is instituted, an oral hearing would not be expected until June 2021, and a Final Written Decision would not be expected until September 25, 2021, eleven months after the trial in the District Court Action. *See* 35 U.S.C. §316(a)(11).

As the Board has recognized, this fact pattern weighs in favor of denying the Petition. For example, in a precedential decision, the Board denied institution when the Petitioner had asserted the same prior art and arguments in a co-pending district court proceeding set to go to trial six months before the IPR hearing. *See NHK Spring*, IPR2018-00752, Paper 8 at 20. Specifically, the Board found that

institution in that situation "would not be consistent with 'an objective of the AIA…to provide an effective and efficient alternative to district court litigation.'" *Id.* (quoting *Gen. Plastic*, IPR2016-01357, Paper 19 at 16-17).

Similarly, the Board in *Apple v. Fintiv* denied Apple's petition pursuant to §314(a) where trial preceded FWD by only two months, fact discovery was in its preliminary stages, the same art was asserted in the Petition and in the invalidity contentions, the parties to the Petition and the underlying litigation were the same, and the merits of the Petition did not outweigh the other considerations.

In *Samsung v. Uniloc*, the Board denied the petition pursuant to §314(a) where trial preceded FWD by nine months, no claim construction hearing had taken place, the parties to the Petition and the underlying litigation were the same, the same art was asserted in the Petition and in the invalidity contentions. IPR2020-00117, Paper 11 at 7-10 (PTAB May 28, 2020).

In *Intel v. VLSI Technology*, the Board denied the petition pursuant to §314(a) where trial preceded FWD by seven months, notwithstanding some uncertainty surrounding COVID-19, a claim construction order had been issued and fact discovery was near its end, the parties to the Petition and the underlying litigation were the same, the same art was asserted in the Petition and in the invalidity contentions. IPR2020-00158, Paper 16 at 7-14 (PTAB May 20, 2020).

In *Cisco v. Ramot at Tel Aviv U*, the Board denied the petition pursuant to §314(a) where trial preceded FWD by six months, no claim construction order had issued but expert discovery was near its end, the parties to the Petition and the underlying litigation were the same, the same art was asserted in the Petition and in the invalidity contentions. IPR2020-00123, Paper 14 at 6-11 (PTAB May 15, 2020) (same).

In *VIZIO v. Polaris PowerLED Technologies*, the Board denied the petition pursuant to §314(a) where trial preceded FWD by seven months, a claim construction order had issued, fact discovery was closed and expert discovery was near its end, the parties to the Petition and the underlying litigation were the same, the same art was asserted in the Petition and in the invalidity contentions, and some claims were different in the Petition as remained in the underlying litigation. IPR2020-00043, Paper 30 at 7-12 (PTAB May 4, 2020). *See also Google LLC v. Uniloc 2017 LLC*, IPR2020-00115, Paper 8, at 3 (PTAB March 27, 2020) (denying institution where the underlying trial would begin less than five months from the Institution decision); *Hormel Foods Corp. v. HIP, Inc.*, IPR2019-00469, Paper 9 at 50 (PTAB July 15, 2019) (recognizing "in cases such as *NHK Spring* that the fact that [a] court will resolve the same issues raised by [a] Petition, at an earlier date than the Board, gives rise to inefficiencies and duplication of effort between the

tribunals."); *E-One, Inc. v. Oshkosh Corp.*, IPR2019-00161, Paper 16 at 9 (PTAB May 16, 2019) (denying institution pursuant to §314(a) due to parallel district court trial scheduled eleven months away).

Indeed, inefficiency is amplified here where the district court trial is set to occur eleven months before a Final Written Decision.

c. Apple's Inexcusable Delay in Filing the Petition

Apple argues that it has not delayed in filing this Petition (Petition at 10), but the facts are otherwise. Although Apple filed its Petition within the statutory deadline at the eleventh hour, it has known about the District Court Action trial date for nearly a year.

Apple argues that § 315(b) "originally contained only a 6-month filing window, which was amended to 1-year prior to passage of the America Invents Act to 'afford defendants a reasonable opportunity to identify and understand the patent claims that are relevant to the litigation' before having to file an IPR petition." Petition at 12. But Apple has had over a year to understand the patent claims of the '493 Patent. Additionally, having analyzed and charted all of the references that support the grounds asserted in its Petition by at least August/November 2019, Apple could have been ready to file an IPR at that time, but it chose to delay filing until many months later. This delay undermines any argument that Apple was not

afforded "a reasonable opportunity to identify and understand the patent claims that are relevant to the litigation before having to file an IPR petition." 157 Cong. Rec. S5429 (daily ed. Sept. 8, 2011) (statement of Sen. Kyl).

Even the District Court has taken notice of Apple's delay in filing its IPR petitions. In denying Apple's motion to stay the District Court Action in view of its IPR petitions, the Court noted:

> **Apple has not sufficiently explained its delay in filing the [IPR] petitions.** Apple filed its first wave of petitions nine months after Maxell filed suit and six months after Maxell served its initial infringement contentions.

Ex. 2020 at 4-5 (emphasis added). The Court concluded that "The case is not in its infancy and is far enough along that a stay would interfere with ongoing proceedings." *Id.* at 4. Though the Court denied the motion without prejudice, it presaged that **"[t]he late stage of the proceedings will certainly weigh against granting a stay"** because the last institution decision [this proceeding] will only be complete on September 25, 2020, one month prior to trial.

Here, the advanced stage of the District Court Action relative to a hearing or Final Written Decision in this matter is the same as in *NHK*, *Mylan, Hormel Foods*, *E-One*, *Samsung*, *Intel*, and *Cisco*. Quite simply, the arguments at issue in this proceeding will be resolved in the District Court Action well before the Board

would reach a Final Written Decision on the same issues. Accordingly, it would be inefficient and contrary to the Board's express goals and finite resources to institute IPR here due to the advanced stage of the District Court Action.

Accordingly, *General Plastic* factors 6 and 7 weigh in favor of denial of institution.

2. *General Plastic* Factors 4 and 5 Weigh in Favor of Denial

Apple asserts that it commenced prior art searching no earlier than May 2019 and continued to perform prior art searching as late as October 2019. Petition at 9. Apple then claims that it only located the *Casio* reference in late October 2019. In the underlying litigation, Apple moved the Court to supplement its invalidity contentions, contending as it does here, that it only located *Casio* in October 2019. In support of that motion, Apple attached a declaration from a technical analyst at Erise IP, counsel to Apple in this proceeding. Ex. 2004. In that declaration, the technical analyst states "I determined on or about October 25[, 2019] that the user's manual for the Casio Camera appear to include technical information relevant to the claims of the '493 Patent…." Notwithstanding its claim in the Petition that obtaining evidence that *Casio* is a printed publication "required several months," even if true, the span of over four months between the location of *Casio* and the filing of its Petition is unreasonable. Apple chose to litigate the issue

of supplementing its invalidity contentions with *Casio* rather than focus on diligent preparation of the instant Petition.

Additionally, *seven* months prior to the filing of the instant Petition, Apple served its invalidity contentions in the District Court Action. Ex. 2002. Apple's '493 Patent invalidity contentions disclose that as early as August 14, 2019, Apple was aware of *Juen*, *Misawa*, and *Takase*. *Id.* at 35-37. The contentions also disclose that at least as early as August 14, 2019, Apple had hundreds pages of charts attempting to map these references to the challenged claims of the '493 Patent. Based on these facts, it is clear Apple located at least *Juen*, *Misawa*, and *Takase* well before August 2019 and well before it filed this Petition seven months later in March 2020.

Yet, Apple admits that it did not even begin preparing its Petition until *after* completing its invalidity contentions. *See Apple Inc. v. Maxell Ltd.*, IPR2020-00204, Paper 1 at 46 ("immediately upon completing the invalidity contentions [on August 14, 2019], Apple began preparing the IPRs for the ten asserted patents"). Apple purposefully chose to delay filing its Petition, and elected to litigate in the District Court rather than focus on preparation of its Petition.

General Plastic factor 4 weighs in favor of denial of institution.

As to Factor 5, "whether the petitioner provides adequate explanation for the time elapsed between the filings of multiple petitions directed to the same claims of the patent," Apple provides *no* explanation, much less an adequate one. Rather than explaining the gap between the time elapsed between when the '493 IPR was filed and the filing of its Petition, Apple examines the time between the filing of the lawsuit against ZTE and the lawsuit against Apple. Apple then claims, without any evidentiary support, that "Apple has been diligently engaged in prior art searching and preparation of this IPR." As the facts above with respect to Factors 4, 6, and 7 set forth, Apple has not been diligent in preparing this IPR nor has it provided an adequate explanation for its lack of diligence. This is especially so where Apple waited until *after* August 14, 2019 to begin preparing this Petition and took yet another seven months to file the Petition. *Apple Inc. v. Maxell Ltd.*, IPR2020-00204, Paper 1 at 46.

General Plastic factor 5 weighs in favor of denial of institution.

3. *General Plastic* Factor 3 Weighs in Favor of Denial

Apple admits that at the time it filed the Petition Maxell's preliminary responses to the '236 IPR and '904 IPR had been filed, as well as the Board's institution decision in the '236 IPR. Petition at 8. *See also* Ex. 2021, Ex. 2022, and Ex. 2023. Apple downplays these facts claiming that "because this IPR applies

different art for the challenged independent claims than used in the '236 and '904 IPRs, the preliminary responses are irrelevant to this IPR...." Petition at 8. Notwithstanding some differences in the prior art, Apple nevertheless gained an unfair tactical advantage by having Maxell's preliminary responses to the '236 IPR and '904 IPR, as well as the Board's institution decision in the '236 IPR, while preparing its Petition. Under 35 U.S.C. §325(d), the Board has discretion not to institute a petition when "the same or substantially the same prior art or arguments" were previously presented to the Office. *See* 35 U.S.C. §325(d); *see also Becton, Dickinson & Co. v. B. Braun Melsungen AG*, IPR2017-01586, Paper 8 (PTAB Dec. 15, 2017). Indeed, the Board has used its discretion to deny grounds relying on art that is the same or similar to that considered by the Office during examination. *See Agrinomix, LLC v. Mitchell Ellis Prods., Inc.,* IPR2017-00525, Paper 6 (PTAB Jun. 14, 2017) (denying institution for grounds based on prior art that was considered during prosecution even though the prior art reference was not relied upon to reject all the challenged claims).

First, *Misawa* was used in the '904 IPR, and thus Apple had the advantage of Maxell's arguments against *Misawa* while preparing this petition. For example, in that preliminary response, Maxell criticized *Misawa* and the motivation to combine it with another reference. Ex. 2023 at 26-29. By reviewing Maxell's

substantive discussion of *Misawa*, Apple was able to craft its Petition with the benefit of Maxell's arguments regarding *Misawa*'s shortcomings. *Compare* Ex. 2023 at 26-29 *with* Petition at 78-79.

Apple provides no evidentiary support that it did not review Maxell's preliminary response in the '236 IPR or the Board's institution decision prior to or during preparation of its Petition. Indeed, Maxell invited Apple to review the '236 IPR on October 9, 2018, months after Maxell had already filed its preliminary response. *See* Ex. 2024; *see also* Ex. 2021. In fact, the references presented in the '236 IPR are cumulative to those Apple presents here, and were rejected on the merits by the Board in the '236 IPR.

For example, the Board found several problems with one of the references relied on by the '236 IPR petitioner, Parulski '406 (Ex. 2025). The Board found Parulski '406 failed to teach the claimed requirement for a "display unit" and the requirement for "monitoring" in static image recording mode. Ex. 2022 at 16-18. Parulski '406 was also considered by the original examiner during prosecution of the '493 Patent. '493 Patent at (56). Thus, the Office has twice considered—and twice rejected—the argument that Parulski '406's teachings somehow show that the '493 Patent's claims are obvious.

The Office's treatment of Parulski '406 for the "monitoring" and "display" limitations illustrates that *Juen*, *Misawa*, and *Takase* are merely cumulative of the teachings already considered. Additionally, similar to Apple's contentions regarding the features of *Casio* and *Juen*, Parulski '406 also has image sensors and built-in displays, and also teaches a form of downscaling. Additionally, statements by the petitioner's expert in the '236 IPR further highlights the cumulative nature of *Casio* and *Juen*:

> Parulski '406 is directed to an electronic camera that produces high quality still images using complex digital image processing technique and acceptable quality of preview images using simple image processing technique.
>
> The electronic camera includes two modes that can be tailored for a low quality motion mode and a high quality still mode. *Id.* at 6:22-45. The motion mode corresponds to a "line skipping" mode which the timing and control section of the device controls the fast dump structure to eliminate two or more consecutive lines of the image charge from the image sensor. *Id.* The still mode corresponds to a high quality still image mode wherein all rows of image pixel charge are readout during a single scan. *Id.*
>
> Additionally, the electronic camera includes an electronic color display wherein a number of user control buttons, such as zoom

> buttons, preview button and a capture button, are available. *Id.* at 3:20-24.

Ex. 2026 (¶¶67-69).

Apple's expert here characterizes *Juen* and *Casio* similarly. *E.g.*, Ex. 1003 at ¶¶72-80

Accordingly, Apple has simply stuffed the same stale arguments into a new package. The Office has already twice analyzed these points in considering Parulski '406 and rejected a prior petitioner's analysis of the same. *Casio* and *Juen* do not add anything new to the analysis, and Apple has not even attempted to distinguish them from the previously considered art.

General Plastic factor 3 weighs in favor of denial of institution.

4. *General Plastic* Factors 1 and 2 Have Little Probative Value in this Case

Factors 1 and 2 have little probative value in this case. Apple has not previously filed a petition against the '493 Patent. With respect to factor 2, Apple claims that the references were located by Apple's counsel since the March 15, 2019 filing of the District Court Action. Apple, however, does not make clear whether it knew (or should have known) about the prior art asserted in the second petition at the time of the filing of the '236 IPR, particularly in light of the notice given it by Maxell back in May and October 2018, respectively. *See* Exs. 2027 and

2024. Apple appears to limit its claim to its counsel, rather than Apple itself. In any event, even were these factors to favor institution, the other five factors weigh in favor of denying institution.

* * *

Application of the *General Plastic* factors weighs heavily in favor of denial of institution. One of the purposes of IPRs is to be an "effective and efficient alternative" to litigation. *Gen. Plastic*, IPR2016-01357, Paper 19 at 16-17. Here, instituting an IPR would not be an effective or efficient alternative to litigation, particularly given the advanced stage of the District Court Action, the finite resources of the Board, and Apple's delay in filing its Petition.

B. Application of the *Fintiv* Factors Weighs in Favor of Denying Institution

Recently, in *Apple Inc. v. Fintiv, Inc.*, the Board set forth factors relevant to the Board's decision on whether to apply its discretion under 35 U.S.C. § 314(a) to deny institution. IPR2020-00019, Paper 11 at 5-6 (PTAB March 20, 2020) (precedential). These factors are:

(1) whether the court granted a stay or evidence exists that one may be granted if a proceeding is instituted;

(2) proximity of the court's trial date to the Board's projected statutory deadline for the final written decision;

(3) investment in the parallel proceeding by the court and the parties;

(4) overlap between issues raised in the petition and in the parallel proceeding;

(5) whether the petitioner and the defendant in the parallel proceeding are the same party; and

(6) other circumstances that impact the Board's exercise of discretion, including the merits.

Id. In view of the foregoing analysis under *General Plastic*, every single one of these factors favor, if not demand, the Board's denial of the Petition pursuant to 35 U.S.C. § 314(a).

III. THE PETITION DOES NOT SHOW A REASONABLE LIKELIHOOD OF PREVAILING WITH RESPECT TO ANY CHALLENGED CLAIM

While application of the *General Plastic* and the *Fintiv* factors weighs heavily in favor of denial of institution, institution should also be denied because, for the reasons more fully set forth below, the petition fails to show a reasonable likelihood of prevailing with respect to any challenged claim.

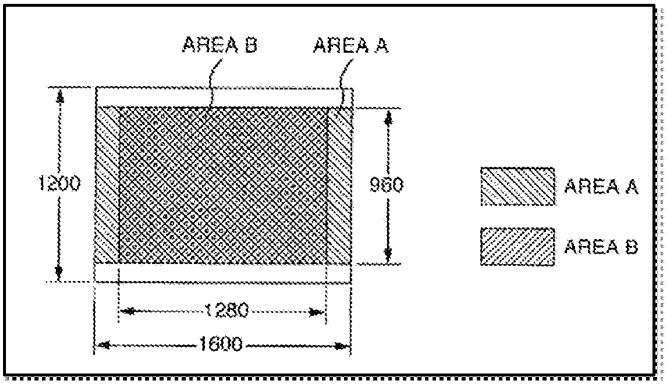
A. Background

1. Background Of The Relevant Technology

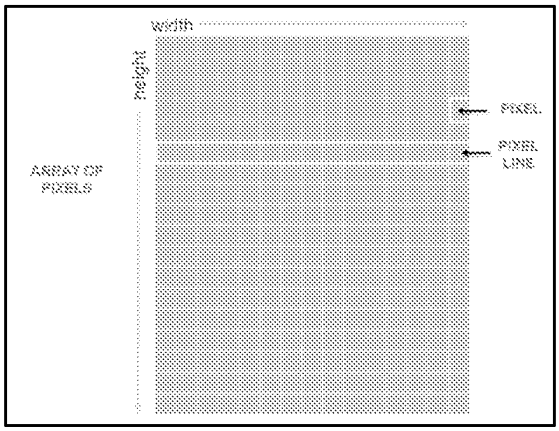
The '493 Patent is titled "Electric Camera" and issued to inventors Takahiro Nakano, Ryuji Nishimura, and Toshiro Kinugasa on December 25, 2012. This

patent is a continuation of a patent application that issued as U.S. Patent No. 8,059,177, which is itself a divisional of a patent application that issued as U.S. Patent No. 6,765,616. The '493 Patent claims priority to a Japanese patent application filed on January 11, 2000. The priority date of this patent is no later than this date.

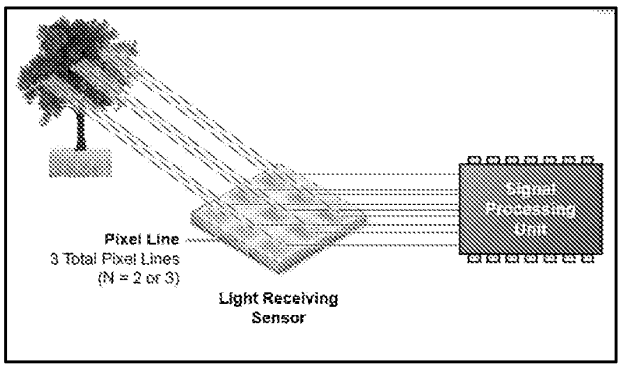
The '493 Patent relates to electric cameras and other devices used to capture images. '493 Patent at 1:18-22. Electric (or, digital) cameras operate using devices called "light receiving sensors" or simply "image sensors." '493 Patent at 1:20-31. An exemplary image sensor disclosed in the '493 Patent contains an effective array of picture elements (or, pixels) arranged in a two-dimensional grid. '493 Patent at 4:30-40. Examples of effective pixel arrays of 1200 by 1600 pixels and 1280 by 960 pixels are shown in Figure 5 of the patent:



Another example of a pixel array is shown in the following demonstrative:



Each pixel in the sensor array will generate a digital signal in response to light incident on a photodiode within the pixel. '493 Patent at 4:40-65. These signals are collected by specialized circuitry and output as a digital image. '493 Patent at 4:40-65. One visual representation of this process is shown in the following demonstrative:



Here, a relatively simple 3 x 3 image sensor is shown, which generates signals as a result of light incident on photodiodes in each pixel. In this example, a

light receiving sensor consists of 3 vertically arranged pixel lines (so the claimed "N number" of pixel lines could be 2 or 3 in this simple example). As shown, an image of a tree on the left reflects light onto the pixel circuits on the pixel array of the light receiving sensor. The light receiving sensor converts the light incident on these pixel circuits into electric signals, which are then passed along to the signal processing unit.

The claims of the '493 Patent recite an improved electric camera (and methods for operating an electric camera) that include an image sensing device, a signal processing unit, and a display unit, each of which is configured to perform certain operations. While generic components like CCD image sensors and display screens may have been known at the time, the specific configurations of these components and their capabilities as outlined in the challenged claims of the '493 Patent were not.

Prior to the inventions disclosed in the '493 Patent on January 11, 2000, conventional electric cameras could not effectively capture both static (still) images and moving videos. For example, when taking still pictures with a camera designed for taking moving videos, the number of pixels was insufficient for a high-quality image. Conversely, when taking moving images with a camera designed for taking still images, the dynamic image quality and frame rate of the

moving video would deteriorate, and the required circuitry would increase. The patent explains this problem as follows:

> The conventional electric cameras, as described above, have drawbacks that when taking a still picture by using a video camera, the number of pixels is not sufficient and that when taking a moving image with a still camera, the associated circuit inevitably increases and the dynamic image quality deteriorates.

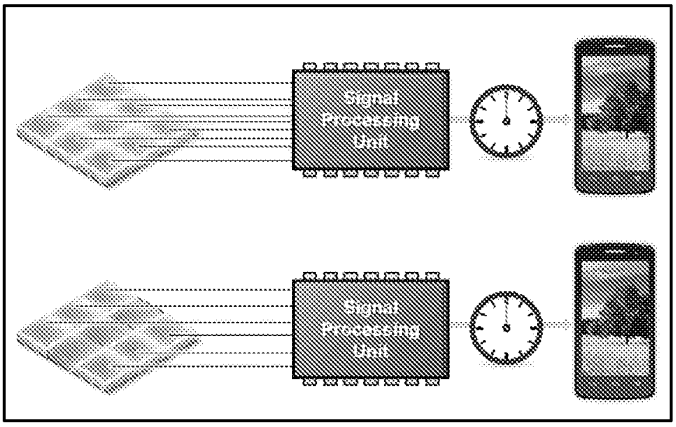
'493 Patent at 2:62-66.

As the patent itself observes, "[t]aking both moving and static images of satisfactory quality with a single camera is difficult to achieve." '493 Patent at 2:67-3:2. So it was that conventional devices before the invention of the '493 Patent could not take high-resolution still images and high-quality moving videos using the same device.

But the inventors of the '493 Patent solved these problems. For example, the claims of the '493 Patent recite an electric camera and other devices that allow signal charges from differing numbers of pixels in an image sensor's pixel array to be used based on whether the device is operating in static image recording mode, monitoring mode, or moving video recording mode.

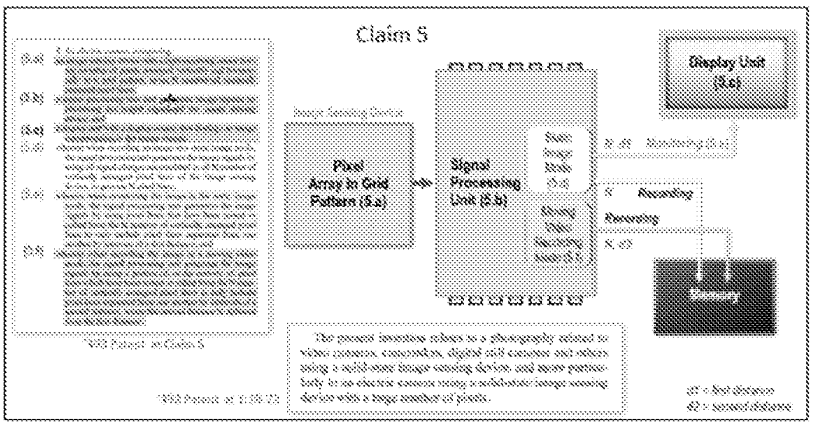
For example, as shown in the following demonstrative, reading out and processing all of the pixels from a light receiving sensor will take a long time.

However, reading out only a portion of those pixels can significantly reduce the processing time for the signal processing unit. This will allow the signal processing unit to process the image signals many more times per second than would be possible with the full array. This allows for an increased frame rate. Thus, the specific mixing or culling of pixels lines described in the '493 Patent's claims is one feature that sets it apart from conventional devices.



A visual representation of one of the '493 Patent's solutions is shown in the following demonstrative. Using claim 5 of the patent as an example, it shows some of the claimed components and the novel functionality discussed in the patent. In particular, it shows a high-level representation of how signals may pass from the light receiving sensor in the image sensing device through the signal processing unit for either recording as static images or moving videos, or for display on a

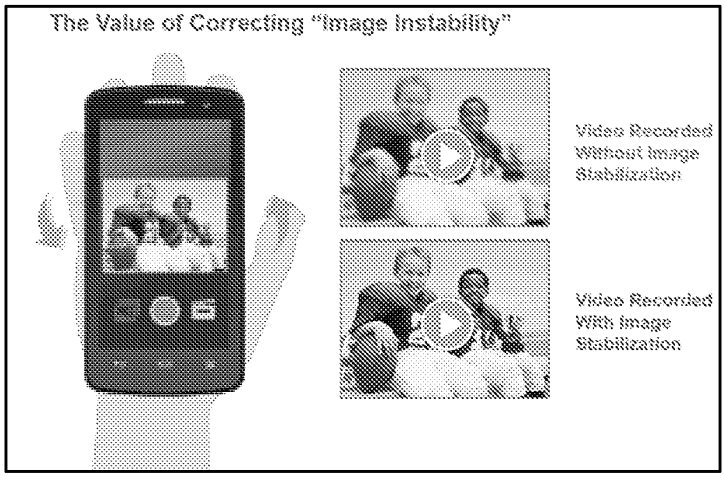
display screen during monitoring in static image mode. The claim's limitations are color coded to correspond to the various features in the demonstrative.

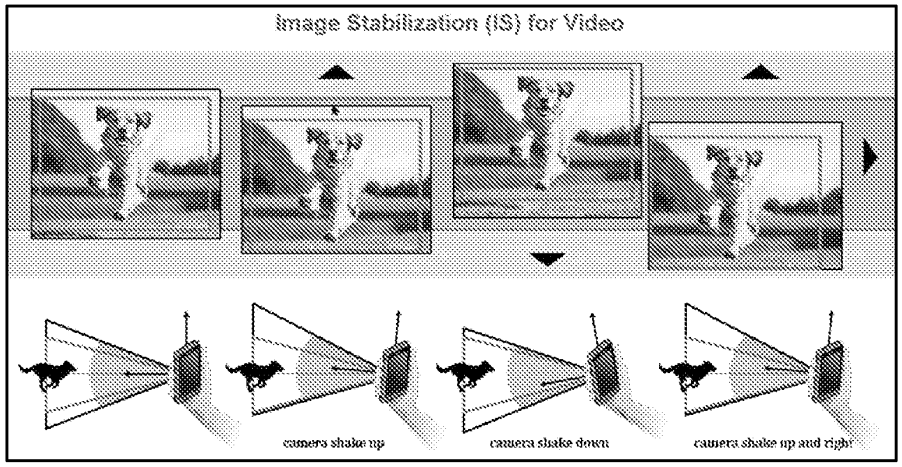


Further, through the use of a novel "signal processing unit" that performs many functions that were previously performed by other components, the invention facilitates a new and more effective "architecture" for digital cameras.

An additional unique feature of the patent's claims is the incorporation of image stabilization for video recording mode to correct image instability, as shown below. For example, consider the example of a user recording a video of a dog running toward the camera. If the user's hand is causing the camera to shake during recording, image stabilization will readjust the pixels on the light receiving sensor used to capture the image so that the dog remains in frame and the "shake"

of the camera is corrected by reducing or completely eliminating the vertical and horizontal camera movement.





The inventors arrived at these solutions no later than January 11, 2000. This was well before the massive popularity of smart phones and over seven years before the release of the first iPhone in June 2007.

2. Level of Skill of a POSITA

For the purposes of this Preliminary Response only, Patent Owner does not dispute the level of skill of a POSITA identified in the Petition.

B. Claim Construction

It is Petitioner's burden to propose a construction and then explain how the construed claim is unpatentable under that proposed construction. *See* 37 C.F.R. § 42.104(b)(4). The District Court has construed certain terms of the '493 Patent:

Term	Claim	Court's Construction
"image-instability detector"	4, 6, 11	"a detector, such as a gyroscopic sensor or the like, capable of detecting an image instability of the electric camera"
"an image-instability of the electric camera"	4, 6, 11	"instability caused by vertical and/or horizontal movement of the electric camera"
"effective scanning lines…of a display screen	1	"the number of scanning lines displayed on the display screen."
"mixing … signal charges"/ "mixed"	1, 3-5, 10	"combining signal charges from multiple

		pixels" and "combined."
"culling signal charges" / "culled"	1, 4, 5, 10	"reading out only one line of signal charges of pixels for every predetermined number of lines" and "only one line of signal charges of pixels is read out for every predetermined number of lines."

Ex. 2014. Given the multiple reasons why the Petition should not be instituted, including 35 U.S.C. § 314, and to minimize the disputes that the Board needs to address at this preliminary stage, for the purposes of this Preliminary Response only, Patent Owner simply applies Petitioner's own constructions to show how the Petitioner has not met its burden under 37 CFR § 42.104(b)(4).

Patent Owner, however, reserves all rights to dispute Petitioner's proposed construction with the support of expert testimony to the extent the Board decides to institute review of this Petition. Any statements made herein with respect to the lack of a claim element in a prior art reference are under Petitioner's proposed constructions and should not be construed as an admission on behalf of Patent

Owner that such construction is proper under the *Phillips* standard.

C. Petitioner Failed to Establish that *Casio* Is Prior Art

Apple must prove that *Casio* constitutes a "printed publication . . . by a preponderance of the evidence." *Nobel Biocare Servs. AG v. Instradent USA, Inc.*, 903 F.3d 1365, 1375 (Fed. Cir. 2018), as amended (Sept. 20, 2018). Apple fails to carry its burden because it fails to "*identify, with particularity*, evidence sufficient to establish a reasonable likelihood" that *Casio* was publicly accessible before the critical date of the '493 patent. *Guardian All. Techs., Inc., v. Tyler Miller*, IPR2020-00031, 2020 WL 1499414, at *3 (P.T.A.B. Mar. 26, 2020) (brackets omitted) (emphasis added) (quoting *Hulu, LLC v. Sound View Innovations, LLC*, IPR2018-01039, Paper 29 at 6 (PTAB Dec. 20, 2019) (precedential).

Apple cites *Hulu* yet does not address nor adhere to its requirements. *Hulu* requires that Apple must (1) "identify with particularity the grounds for institution," and (2) provide "evidence supporting such grounds," including "prior art relied upon and evidence." *Id.* at 13. But that's not all. The precedential opinion goes one step further and requires that this "standard is *far more than [what] is required in typical notice pleading, which only requires that a party make plausible claims*." *Id.* Apple fails to carry its burden.

1. The Etchells Declaration is Insufficient to Show Public Accessibility of the Casio User Guide

The Etchells declaration (Ex. 1007) fails to show that *Casio* was indexed and "sufficiently accessible to the public" so that it can be considered a printed publication. *In re Klopfenstein*, 380 F.3d 1345, 1348 (Fed. Cir. 2004). Apple offers no evidence showing communication between Etchells and Casio. Thus, Ex 1007 fails the identification and particularity requirements set forth in *Hulu*.

First, it is Apple's burden to identify evidence that supports its claim that the public had access to *Casio* before the critical date—January 11, 2000. It has not. The Etchells declaration hinges on an alleged interaction between Etchells and Casio, but Apple *provides no evidence that this ever happened.* Apple fails to *identify* the evidence upon which Etchells bases his *entire* declaration. *Hulu*, IPR2018-01039, Paper 29 at 13. Apple provides no evidence of any communication *from* Casio to Etchells. Conversely, Apple provides no evidence confirming that Etchells contacted Casio. This in insufficient. Indeed, "[i]t is of the *utmost importance* that petitioners in the IPR proceedings *adhere* to the *requirement* that the initial petition *identify* with *particularity* the *evidence* that *supports* the grounds for the challenge to each claim." *Apple Inc. v. Andrea Elecs. Corp.*, 949 F.3d 697, 705 (Fed. Cir. 2020) (internal quotes omitted) (emphasis added).

Ex. 1007 identifies no interaction between Etchells and Casio. Etchells claims that he "reached out to Casio requesting" the camera and that Casio "provided" him with one. Ex. 1007 at 3. Apple proffers no evidence to prove this. Etchells attempts to show that he received the camera "as early as November 1, 1999" based on an email from November 1, 1999. *Id.* But this email is not between Etchells and Casio. Indeed, emails on a private server are not public nor publicly accessible. *SRI Int'l, Inc. v. Internet Sec. Sys., Inc.*, 511 F.3d 1186, 1196 (Fed. Cir. 2008) (an asserted reference is not a printed publication where "a customary search would not have rendered the work reasonably accessible even to a person informed of its existence"). Based on Apple's evidence, there is no way to substantiate if, how, or when the *Casio* User Guides first became publicly accessible. All that is left is speculation.

Etchells states that his "standard practice" was to "request" the "open market, consumer version of the product for review," and that, it is his "*recollection* the Casio QV8000SX camera was available for purchase by the time [he] received the camera . . . and by the time Imaging Re-source posted the product review [on] January 26, 2000." Ex. 1007 at 4-5 (emphasis added). Etchells further claims that "Casio did not require any confidentiality from [him] or Imaging Resource as part of preparing and publishing the product review of the Casio

QV8000SX camera." *Id.* at 5. These are hollow claims absent confirmation. Put another way, from Apple's evidentiary showing, it is just as likely that Etchells never received a Casio QV8000SX until after the critical date. Along the same line, it is also just as plausible that Etchells received a non-public version of the camera. Indeed, none of Apple's evidence alleging access to the camera even pertains to the *Casio* User Guide. Apple's burden is to show evidence that the *Casio User Guides* were publicly accessible prior to the critical date. It has not.

Etchells states that "*In order to begin [his] product review, [he] reached out to Casio requesting* the QV8000SX digital camera, and [that] Casio *provided* [him] with" one. *Id.* at 3 (emphasis added). Etchells further claims that he was "not required to sign a non-disclosure agreement." *Id.* at 5. Despite this, it was his "recollection [that] the Casio QV8000SX camera was available for purchase by the time [he] received the camera from Casio (by at least November 1, 1999)." *Id.* Etchells never states that he purchased a camera. If Etchells could not go to the store to buy a camera by November 1, 1999, then his statement that "the Casio QV8000SX camera was available for purchase . . . *by the time Imaging Resource posted the product review [on] January 26, 2000*" is *more plausible*. *Id.* That said, Apple's evidence actually supports the conclusion that the Camera was not available until *after the critical date*.

In Etchells' review of the Casio QV-8000SX, he states that "the QV-8000 completely captures the low-light picture-taking crown, at least as of this writing in *January, 2000*." *Id.* at 16 (emphasis added). Etchells also states that "we found the QV-8000 surprisingly quick compared to the current crop of cameras (January 2000)." *Id.* at 17. These are not two isolated statements. Etchells repeatedly frames his review not in 1999, but in 2000, at least four other times. *See id.* at 22-25. Thus, Apple only proves that Etchells posted his review in the same year as the critical date, and only after the critical date. This fails to satisfy the burden of proof—"[m]erely establishing that the [asserted reference] existed in the same year as the critical date is insufficient." *ATEN Int'l Co. v. Uniclass Tech. Co.*, 932 F.3d 1364, 1368 (Fed. Cir. 2019). Apple's evidence, when viewed in its entirety, simply does not make sense—*inconsistent evidence is not even "plausible*." *Hulu*, IPR2018-01039, Paper 29 at 13.

Second, Apple must not only "identify" evidence that substantiates its position, but it must also do so with "particularity." *Id.* Thus, Apple must show with *particularity* that the User Guides were "disseminated" or "made available" before the critical date. *SRI*, 511 F.3d at 1194; *Hulu*, IPR2018-01039, Paper 29 at 13.

For example, Appendix C of Ex. 1007 purportedly shows the User Guide

Etchells received more than two decades ago from Casio. But nothing Apple proffers supports the availability of the User Guide in 1999. There are no date stamps, no confirmation numbers, no receipts, no tickets of purchase, and no confirmation from Casio that Etchells purchased or received the User Guide before the critical date. There are also no dates on either the camera or the purported original packaging. As the evidence stands, it is equally likely that Etchells acquired the Camera and User Guide after rather than before the critical date. *TypeRight Keyboard Corp. v. Microsoft Corp.*, 374 F.3d 1151, 1158 (Fed. Cir. 2004) (holding that doubts caused by "undated" documents warranted reversal of judgment); *Nobel*, 903 F.3d at 1375.

Third, the determination of whether an asserted reference is a printed publication is not conducted in a vacuum. Rather, it requires a comprehensive "inquiry into the facts and circumstances surrounding the reference's disclosure to members of the public." *In re Klopfenstein*, 380 F.3d at 1350. Indeed, there are factors used to determine whether a reference is publicly accessible. *Id.* These factors include length of display, target audience and their expertise, expectations (or lack) of copying, and ease of copying. *Id.* Apple does not adequately address a single one.

Apple does not provide evidence showing how long (if at all) the User Guide

was ever disclosed or displayed to the public. On the contrary, Apple notes that the "product review was posted by Imaging Resource on January 26, 2000." *See* Apple Petition at 15. This is more than two weeks after the critical date. Apple does not provide evidence proving who the target audience is, nor what their level of expertise is. From Apple's evidence, the target audience could be anyone, with any education, with any level of interest in anything.

Apple notes that Etchells was not subject to a confidentiality agreement and that there were no use restrictions. However, if the cameras were available for purchase—as Apple contends—why would a consumer be required to sign a non-disclosure form? More plausibly, if they were not publicly available, Apple provides no evidence that Casio told Etchells that he was not bound to confidentiality with respect to the camera and the User Guide until, for example, after publication of his review on January 26, 2000. Nor does Apple provide evidence of the interaction that allegedly occurred between Casio and Etchells. And Apple does not even mention ease of copying. Apple's showing, at best, inadequately addresses one factor. This is insufficient.

2. The Etchells Declaration Lacks Corroboration and Credibility

Etchells' claims concern events allegedly happening over 20 years ago; this "long lapse of time suggests possible faulty recollection." *TypeRight*, 374 F.3d at

1158. Apple is paying Etchells "$250.00" per hour and Etchells' declaration lacks sufficient corroboration. Ex. 1007 at 2. This case requires corroboration. *Nobel*, 903 F.3d at 1377–78.

Even if Etchells is not an interested party, Apple still needs to corroborate his declaration because "[u]ninterested witnesses are also subject to the corroboration requirement." *Finnigan Corp. v. Int'l Trade Comm'n*, 180 F.3d 1354, 1367 (Fed. Cir. 1999); *Nobel*, 903 F.3d at 1377–78 (corroboration required). Indeed, as discussed below, none of the other declarations support Etchells' testimony for they, too, lack credibility, are internally inconsistent, and, when viewed in their entirety, come to an illogical conclusion.

3. The Casio Press Release Does Not Demonstrate Public Accessibility of the User Guide Prior to the Critical Date

Apple claims that on "July 21, 1999, Casio issued a press release for the QV-8000SX digital camera . . . ." Petition at 14. Absent a showing that the *User Guides* were present, this is irrelevant. *TypeRight*, 374 F.3d at 1158 (holding that doubts about the credibility of the evidence about a trade show required reversal). Apple provides no credible evidence that the User Guides *existed* at the time of the press release—let alone were publicly accessible.

VanderSchans claims to have "personal knowledge" of the trade show—but she did not start working at Casio until more than a year *after* the trade show and

did not testify that she attended. Ex. 1028 at 1. VanderSchans' declaration is insufficient. *TypeRight*, 374 F.3d at 1158 (rejecting a claim for a printed publication based on "tentative" testimony about a witness who *attended* a trade show "over 18 years ago"); *A.R.M., Inc. v. Cottingham Agencies Ltd.*, IPR2014-00671, Paper 10 at 5-8 (P.T.A.B. Oct. 3, 2014) (Paper 10) (a brochure did not qualify as a printed publication because there was no evidence of the date of publication, that it was disseminated, or that it was otherwise made available). No evidence shows that VanderSchans attended the trade show; no evidence shows that the User Guides were at the trade show (or existed on July 21, 1999). Apple has failed to carry its burden. *Norian Corp. v. Stryker Corp.*, 363 F.3d 1321, 1330 (Fed. Cir. 2004) (abstract from conference not shown to be a printed publication where defendant presented insufficient evidence of dissemination or accessibility).

Further, Apple has not brought forth any evidence showing that the product did not change since the press release. What is more, Ex. 1028 does not reference the User Guide nor the User Guide's detailed *125 pages*—Ex. 1028 is a simply a four-page boast. Apple provides no legal authority for why Ex. 1028 supports a finding of public accessibility. Regardless, "[o]ne can publicize that a new product exists while still keeping an enabling disclosure of the structure and function of the product secret." *Bennett Regulator Guards, Inc. v. Canadian Meter Co.*, 184 Fed.

App'x 977, 982 (Fed. Cir. 2006).

Finally, Apple's evidence on the trade show is contradictory. Ex. 1028 provides that on "*July* 21, 1999—Casio . . . *today* introduced the QV-8000SX . . . The camera . . . was introduced . . . in New York City *today*." (at 2) (emphasis added). But then in Ex. 1026, Lang states that "the Casio QV8000-SX digital camera was *first* sold in the United States in *April* 1999." (at 1) (emphasis added). It is inconsistent to claim that cameras were somehow sold *four-months* before they were introduced. Absent secret sales (which Apple provides no evidence of), this is contradictory. And Lang provides no disclosure of the underlying sales records upon which he allegedly relies on to make his declaration. Yet if one or both declarations are true, neither answer the following questions: why Etchells would be subject to a confidentiality agreement, and why Apple cannot present clear evidence of exactly when the User Guide was first on the market and publicly accessible.

In fact, Apple could have presumably provided answers to these questions. Apple subpoenaed Casio in the underlying litigation in December 2019, asking for the dates by which the User Guide was available, and when particular sales of the QV8000-SX occurred. Ex. 2028. Casio responded to those questions on January 8, 2020 indicating it would produce documents "to the extent they exist." Ex. 2029.

The fact that Apple has not supported the petition with these documents is telling.

4. Apple Fails to Show Relevant Sales Prior to the Critical Date

Apple relies on the declaration of Lang for the proposition that the Casio QV-8000SX digital camera was sold in 1999—nothing corroborates this assertion and Exs. 1007 and 1028 contradict Lang's declaration. Lang states that he "reviewed certain sales record [sic]." Ex. 1026 at 1. This level of ambiguity does not show public accessibility by a preponderance of the evidence. *Nobel*, 903 F.3d at 1375.

The ambiguity is compounded because Apple has not offered this "record" for review. Instead, the Board is left with only the uncorroborated testimony of Lang and the anonymous "certain sales record" that purportedly shows that a sale occurred in 1999. What is more, Apple fails to consider how Casio treated its financial records, which fiscal year dates were applicable, and whether Casio's fiscal year extended into 2000. In fact, Casio's fiscal year is from April to March, thus making Casio's 1999 fiscal year spanning April 1999 through March 2000. *See* Ex. 2030. Lang's claim that there were alleged sales in 1999, based on Casio's fiscal year accounting, means that the supposed twenty-five or so sales of the QV-8000SX digital camera may have occurred only after the critical date of January 11, 2000—towards the last quarter of Casio's Fiscal Year 1999. The Board should

reject Apple's deficient evidence of sales. *Juicy Whip, Inc. v. Orange Bang, Inc.*, 292 F.3d 728, 743 (Fed. Cir. 2002) ("Reliable evidence of corroboration preferably comes in the form of physical records . . . .").

Apple repeatedly emphasizes that the User Guides were included with the camera and that "[t]here were no restrictions placed on the purchaser's use of the User Guide . . . ." Apple Petition at 14. Absent evidence *of a sale*, these arguments are irrelevant. Thus, for at least the reasons above, the Board should find that Apple has failed to carry its burden and find that the Casio User Guide is not a printed publication that was publicly accessible prior to January 11, 2000, and that for this reason Apple has failed to show a reasonable likelihood of success for any ground presented in the Petition.

D. Ground 1: Petitioner Failed To Establish That Claims 1, 3, 5, and 10 Are Obvious Over *Casio* In View Of *Juen*

Apple has not carried its burden showing that *Casio* was publicly available prior to the critical date. As such, Ground 1 fails for this reason alone. However, even if the Board considers *Casio*, for at least reasons, more fully explained below, Apple has failed to show that Claims 1, 3, 5, and 10 are obvious over *Casio* in view of *Juen*.

1. A POSITA Would Not Have Combined *Casio* and *Juen* Without the Benefit of Hindsight.

Apple contends a POSITA would have found it obvious and been motivated

to combine *Casio* and *Juen*. Petition at 25-26; 55-56. More specifically, Apple argues that "it would be obvious and desirable to modify the *Casio* camera so the CCD captured the pixels in the standard grid-like array, given the commonly-accepted format for photographs and moving video was rectangular." *Id.* However, a POSITA would not attempt to incorporate *Juen*'s functions with *Casio*'s hardware. First, Apple's argument is not consistent with Ground 1. Apple asserts in Ground 1 the Casio *User Guide* along with *Juen* renders claims unpatentable. Yet, when making its motivation to combine argument, Apple argues "it would be obvious and desirable to modify the *Casio* camera so the CCD captured the pixels in the standard grid-like array, given the commonly-accepted format for photographs and moving video was rectangular." *Id.* (emphasis added). For at least this reason, Apple has failed to satisfy its burden to show a POSITA would be motivated to combine *Juen* (Ex. 1005) with the *Casio* (Ex. 1004) reference.

Next, a POSITA would not be motivated to incorporate the complicated and specialized features of *Juen* into *Casio*. That a POSITA would not have been motivated to do so at the time can be shown from a reference heavily relied on by Apple's expert here and Apple in the District Court Action: *Anderson* (Ex. 1021). For example, Anderson criticizes "specialized circuitry to handle each of the advanced features" because "it dramatically increases the overall cost, size, battery

consumption, and weight of the digital cameras." Anderson at 1:50-58. Anderson teaches that this architecture "was deceptively difficult to conceive." Anderson at 9:19-36. A person of ordinary skill reading Anderson would heed these teachings and would not have altered the precise hardware architecture *Casio* discloses by attempting to incorporate features from *Juen*. Yet Apple, without explanation, would ignore these warnings and attempt to merge *Juen*'s features with *Casio*'s teaching. This would have destroyed whatever "performance benefits" may have been achieved by using *Juen*'s system. A person of ordinary skill would have recognized these drawbacks and not have made the modifications that Apple suggests.

For instance, *Juen* teaches that its "moving image recording" circuit is in an entirely separate pipeline or data flow path from the still image recording means, *see Juen* at FIG. 1, but *Anderson* warns not "to use different circuits and data paths," Anderson at 1:56-58. Apple would disrupt *Casio*'s design with additional circuitry, which a POSITA is instructed not to do by the very same art (*Anderson*) that Apple and its expert repeatedly rely upon.

Any suggested modification of the architecture of *Casio* to incorporate any part of *Juen* would not have been a simple exercise in replacing one component with another. Again, *Anderson* highlights these difficulties:

> Although the final hardware architecture of the present invention appears straightforward in retrospect, **it was deceptively difficult to conceive**. This is because one has to first decide on which blocks are to be implemented and define each block's respective functions. Duplication must be minimized. Next, the data paths must be laid out so as to interconnect the various blocks in such a manner that certain combinations produce all of the desired results correctly. Flexibility, adaptability, and high functionality are key. Moreover, the data must be routed through the various data paths as fast as possible so that there is no bottleneck in any one path that might reduce the overall bandwidth. Other considerations include which ones of the blocks should be activated and under what circumstances should they be activated. All these factors were taken into account in order to produce the integrated solution of the present invention which effectively and efficiently utilizes the available hardware resources.

Anderson at 9:19-36 (emphasis added).

Thus, as Apple's own evidence teaches, the combination of disparate image processing systems raises a host of issues—all of which Apple and its expert leave unaddressed. For example, *Anderson* teaches that, when attempting to import functionality from one electric camera into another, a POSITA would need to account for (1) which functional blocks to implement and how to define those blocks' functions to minimize duplication, (2) the layout and interconnections of data pathways between those functional blocks so that the combinations "produce

all of the desired results correctly," (3) the routing of data through the data paths "as fast as possible" to avoid bottlenecking, and (4) which functional blocks to activate and when. Anderson at 9:19-36.

Apple fails to account for any of these difficulties in its assertion that *Casio* and *Juen* can be combined. Thus, Apple has failed to meet its burden to show how these aspects of the prior art would be combined, what the resulting device would look like, and that combined device how it would operate. *See Guangdong Alison Hi-Tech Co., Ltd. v. Aspen Aerogels, Inc.*, Case IPR2017-00152, Paper 8 at 16 (P.T.A.B. Mar. 23, 2017) ("To establish that a particular combination of references would have been obvious, Petitioner must explain both *how* and *why* one of ordinary skill in the art would have combined the references to produce the claimed invention." (emphasis in original)).

2. Petitioner fails to establish that *Casio* in view of *Juen* Discloses Elements 1(a)/5(a)/10(a).

Claim elements 1(a)/5(a)/10(a) recite "an image sensing device with a light receiving" sensor [elements 1(a) and 5(a)] or surface [element 10(a)]. Thus, the claim recites at least two structures for this limitation: (1) an image sensing device and (2) a light receiving sensor/surface that is part of that image sensing device.

To allegedly satisfy the elements of an *image sensing device* with a *light receiving sensor*, Apple contends that *Casio* teaches an "Image Element" that is a

"1/2.7 inch CCD." Petition at 22. Apple then relies on its expert for its claim that CCDs operatively receive incident light at photodiodes, "indicating the CCD is a light receiving sensor." *Id.* citing Ex. 1003. Apple then claims, relying on its expert, that because the *Casio* CCD receives light via the camera lens, a POSITA would have understood the CCD is an "image sensing device with a light receiving sensor."

Apple and its expert have pointed to just one component (a CCD image sensor) as satisfying this requirement for two components. But that is not what Claims 1, 5, and 10 require. Those claims plainly recites an "an image sensing device" as a structure and a "light receiving sensor/surface" as part of that structure. The Petition makes no attempt to resolve this inconsistency. Nor does Apple or its expert clarify whether the CCD image sensor is the claimed "image sensing device" or the "light receiving sensor." Because it cannot be both, Apple has failed to show that *Casio* satisfies this limitation. *SandBox Logistics LLC v. Proppant Express Investments LLC*, No. 2019-1684, 2020 WL 2517113, at *5 (Fed. Cir. May 18, 2020) ("Where a claim lists elements separately, the clear implication of the claim language is that those elements are distinct components of the patented invention.").

Apple perhaps anticipated this, and thus contends that "Should Maxell

contend *Casio* does not teach an image sensing device," *Juen* teaches such a device. Petition at 22. Apple contends that *Juen* teaches "Light passing through the photographic lens 12 is refracted within the camera part 11a, and received by a photoreceptor surface of an imaging element 13, which is composed of a CCD image sensor." Petition at 22 citing *Juen,* 5:63–6:2. Because *Juen's* CCD image sensor receives light on a photoreceptor surface, *Juen* teaches "an image sensing device with a light receiving sensor." *Id.* citing Ex. 1003. Apple's contentions with respect to *Juen* also fail for the same reasons as it has failed to show *Casio* discloses elements 1(a)/5(a)/10(a). Apple again has pointed to one component (a CCD image sensor) as satisfying this requirement for two components.

Although Apple arguably claims *Juen*'s "imaging element 13" is the claimed "image sensing device" and that *Juen*'s "CCD image sensor" is the claimed light receiving surface, these two structures are actually one and the same. The portion of *Juen* Apple cites to makes this clear: "an imaging element 13, **which is composed of** a CCD image sensor." *Juen* at 5:63-6:2 (emphasis added). This is further made plain by *Juen*'s description of imaging element 13 as having a "number of pixels," further showing that the term "imaging element" as used in *Juen* is synonymous with a CCD image sensor, rather than being a separate structure. Indeed, *Juen* identifies nothing else as making up or being contained

within imaging element 13. Thus, Apple has pointed to *Juen*'s image sensor as both the image sensing device and the light receiving sensor and thus *Juen* fails to satisfy elements 1(a)/5(a)/10(a).

Accordingly, *Casio* in view of *Juen* does not render these claim limitations unpatentable.

3. Petitioner fails to establish that *Casio* in view of *Juen* Discloses Elements 1(b)/5(b)/10(b).

Claim elements 1(b)/5(b)/10(b) recite "a signal processing unit that generates image signals by processing the output signals of the image sensing device."

Claims 1, 5, and 10 all require certain functions to be performed by the claimed signal processing unit, namely, (1) generating image signals for static image recording; (2) generating image signals for monitoring in static image mode; (3) generating image signals for moving video recording. Apple acknowledges this in the Petition (52-54), yet it provides no analysis attempting to show that the purported signal processing unit of either *Casio* or *Juen* perform the claimed functions required by the claims, only conclusory statements. This failure is fatal to Apple's contention that *Casio* or *Juen* disclose the claimed signal processing unit.

Apple's claim that *Casio* implicitly or at least inherently teaches a signal processing unit also fails. Petition at 28. Apple contends that a POSITA "would

have understood from the collective disclosures in *Casio* the digital camera includes a signal processing unit to generate image signals." *Id.* Apple then points to several disclosures in *Casio* that purportedly support this statement, converting or encoding images to a JPEG or AVI file format, converting images to a lower resolution for display on the monitor, and digital zoom. *Id.* citing *Casio* at 61, 118, 16, and 58-59. But completely absent from Apple's contention is whether these "collective disclosures," which allegedly comprise a signal processing unit, actually (1) generate image signals for static image recording, (2) generate image signals for monitoring in static image mode, and (3) generate image signals for moving video recording as required by the claims. It is not sufficient to allege an inherent disclosure of a "signal processing unit" where the claims require much more specificity as to the functions of that signal processing unit. *Guangdong Alison Hi-Tech Co. v. Int'l Trade Comm'n*, 936 F.3d 1353, 1364 (Fed. Cir. 2019) ("An element may be inherently disclosed only if it is necessarily present, not merely probably or possibly present, in the prior art.") (internal quotes omitted); *TLC Corp. v. Telefonaktiebolaget Lm Ericsson*, 2017 WL 504682, at *18 (PTAB Jan. 24, 2017) (holding the same and rejecting Petitioner's argument—that a POSITA would understand "the broader category" of a "term . . . to necessarily mean" the specific category and use of the term—as "tenuous and insufficient" to

prove "anticipation by a preponderance of the evidence").

Apple, again, asserts that "To the extent Maxell contends *Casio* does not teach a 'signal processing unit,' *Juen* teaches such. Petition at 28. Here, again, Apple's analysis with respect to *Juen* fails to show the claimed signal processing unit. Apple identifies a laundry list of discrete components in *Juen*, without actually explaining how any of them meet the claim limitations, which portions perform which claimed features, or what evidences supports their performance of the claimed functions of the claimed signal processing unit.

For example, Apple cites *Juen*'s "electronic camera 100 includes an imaging means 1 that images an object or living subject…and converts an image thereof to image information," *Juen*'s "still image recording means 4," "moving image recording means 3," "picture image signal processor 15," and "image density converter 16." Petition at 28-30. But completely absent from the analysis is any consideration of whether any of these components, for example, generate image signals by processing the output signals of the image sensing device. Are all of the components performing this function? Some? Apple fails to explain. Similarly, which if any of these components are recording static images as opposed to monitoring static images? The Petition contains no answers that show *Juen* discloses the claimed signal processing unit.

The only conclusory statement is a citation to its expert who offers a similarly conclusory statement: "A POSITA would have understood the combined image signal processor and image density converter satisfies the claimed 'signal processing unit." Petition at 30 citing Ex. 1003 at 116. But, even assuming this is correct (it is not), *Juen*'s image signal processor and image density converter cannot handle the claimed monitoring in static mode.

Accordingly, *Casio* in view of *Juen* does not render these claim limitations unpatentable.

4. Petitioner fails to establish that *Casio* in view of *Juen* Discloses Elements 1(d)/5(e)/10(f).

Claim elements 1(d)/5(e)/10(f) recite, among other things, "the signal processing unit generates the image signals by mixing or culling signal charges accumulated in the N number of vertically arranged pixels…." Apple argues that *Casio* alone or in combination with *Juen* teaches the mixing or culling limitations. Petition at 37, 58, 67. But *Casio* contains no such disclosure. Instead, Apple relies on its expert to speculate on how the *Casio* camera operates.

These claim elements contain specific limitations regarding the functionality of the signal processing unit. As detailed above, Apple failed to show that *Casio* in view of *Juen* discloses the signal processing unit. It further fails to show how the specific features of the signal processing unit are supposedly found in *Casio*. There

is no such detail in the Casio User Guide, and Apple's expert simply glosses over the specifics of these limitations. Indeed, Apple's analysis for these limitations is limited to a single conclusory sentence: "*Casio* teaches reducing the pixel resolution of the LCD, and a POSITA would have found it obvious the pixel resolution reduction is performed by, at the least, mixing the signal charges, as taught by *Juen*." Petition at 37. For support, Apple cites to only ¶126 of its expert's declaration, which contains a similarly conclusory statement:

> In my opinion, *Casio* in combination with *Juen* teaches the signal processing unit generates the image signals by "mixing or culling signal charges," as claimed. In forming my opinion, I apply the claim construction set forth at ¶ 29 that "mixing…signal charges accumulated in the N number of vertically arranged pixel lines" means "combining...signal charges from multiple pixels."

Ex. 1003, ¶126.

Neither *Casio* nor *Juen* contain any details about the operation of a single processing unit to "generate[] the image signals by using pixel lines that have been mixed or culled from the N number of vertically arranged pixel lines to only include pixel lines separated from one another by intervals of a first distance," per claim 5. Nor does Apple offer any proof of this similarly worded feature of the signal processing unit of claims 1 and 10.

Apple's attempt at showing these limitations in *Casio* and *Juen* likewise

fails. In particular, neither Apple nor its expert endeavor to rule out other downscaling operations that do not fall within the plain language of the claims' "mixing"/"culling" limitations. For example, Apple hasn't shown that other types of downscaling (such as cropping the edges of the image alone or mixing/culling at irregular intervals) is being used by *Casio*, instead of the specifically claimed scaling operations that recite mixing or culling at specified intervals. And, because *Juen*'s pixel converter is used only for recording videos—not monitoring static images—it cannot teach this claim element. *See, e.g.*, Juen at FIG. 1.

5. Petitioner fails to establish that *Casio* in view of *Juen* Discloses the "pixel intervals of K1 pixels" / "intervals of a first distance" of Elements 1(d)/5(e)/10(f) and the "pixel intervals of K2 pixels" / "intervals of a second distance" of Elements 1(e)/5(f)/10(g).

Each of the independent claims of the '493 Patent recite that the mixing/culling operations result in an output of pixels that include an "interval" that is stated in pixel lines:

- "to provide pixel lines only at pixel intervals of K1 pixels" / "to provide pixel lines only at pixel intervals of K2 pixels" (claim 1);
- "to only include pixel lines separated from one another by intervals of a first distance" / "to only include pixel lines separated from one another by intervals of a second distance" (claim 5); and

- "to provide only pixel lines separated from one another by intervals of a [first][2] distance" / "to provide only pixel lines separated from one another by intervals of a second distance" (claim 10).

By the claims' plain language, these intervals are stated in pixels. Indeed, claim 1 expressly refers to these intervals as "pixel intervals." Because pixels refer to specific components (the individual picture element circuits in an image sensor), they cannot be divided into fractions of themselves.

But Apple has nevertheless stated these intervals in fractions of pixels (*e.g.*, 4.36) in the Petition: "the pixel lines displayed on the LCD during monitoring in a static image mode are provided at pixel intervals of K1=960/220=4.36" (Petition at 44); "Casio teaches intervals of a first distance, where the first distance is 4.36" (*id.*at 58); *see id.* at 67 (relying on same analysis for claim 10).

Neither Apple nor its expert explain how mixing or culling can occur at intervals of fractions of a pixel. Indeed, none of the art cited here speaks in such terms. Even if Apple were to argue that the 4.36 interval it relies upon throughout the Petition could be rounded down to 4.0—and it does not make this argument—this too would fail because it would result in the first interval being identical to the second interval, which the claims each preclude. *See, e.g.*, '493 Patent at cl. 1 ("a

[2] This claim language was corrected in a certificate of correction. Ex. 1002, 5, 15.

value of K1 being different from a value of K2").

Simply put, the Petition fails to show how mixing or culling can occur using fractions of a pixel. This nonsensical result cannot be correct, and Apple's Petition must fail for this reason as well.

6. Petitioner fails to establish that *Casio* in view of *Juen* Discloses Claim 3.

Claim 3 depends directly from independent Claim 1. For the reasons expressed above, *Casio* in view of *Juen* does not disclose Claim 1. As such, neither is Claims 3 rendered unpatentable by *Casio* in view of *Juen*.

E. Ground 2: Petitioner Failed To Establish That Claim 4 Is Obvious Over *Casio* In View Of *Juen* And *Takase*

Claim 4 depends directly from dependent Claim 3 and indirectly from independent Claim 1. For the reasons expressed above with respect to Ground 1, *Casio* in view of *Juen* does not disclose Claim 1. As such, neither is Claim 4 rendered unpatentable by *Casio* in view of *Juen* and *Takase*.

Additionally, Apple has failed to show that POSITA would combine *Casio*, *Juen*, and *Takase*. On top of the challenges with combining *Casio* with *Juen* as detailed above, adding *Takase*'s additional hardware and functionalities to the mix would create a complex amalgamation of circuits. Apple has not adequately explained why a POSITA would stitch together numerous disparate references in this manner. Apart from a hindsight-driven desire to invalidate claim 4 of the '493

Patent, there would not be sufficient reason or motivation to have done so.

F. Ground 3: Petitioner Failed To Establish That Claims 6 and 11 Are Obvious Over *Casio* In View Of *Juen* And *Misawa*

Claims 6 and 11 depend from independent Claims 5 and 10, respectively. For the reasons expressed above with respect to Ground 1, *Casio* in view of *Juen* does not disclose Claims 5 and 10. As such, neither are Claims 6 and 11 rendered unpatentable by *Casio* in view of *Juen* and *Misawa*.

Additionally, Apple has failed to show that POSITA would combine *Casio*, *Juen*, and *Misawa*. On top of the challenges with combining *Casio* with *Juen* as detailed above, adding *Misawa*'s additional hardware and functionalities to the mix would create a complex amalgamation of circuits. Apple has not adequately explained how or why a POSITA would stitch together numerous disparate references in this manner. *See Alison*, Case IPR2017-00152, Paper 8 at 16. Apart from a hindsight-driven desire to invalidate claims 6 and 11 of the '493 Patent, there would not be sufficient reason or motivation to have done so. *See* Anderson at 9:19-36 (detailing at least four considerations a POSITA would need to account for when combining image processing circuitry, none of which Apple addresses).

IV. CONCLUSION

The Board should not institute *inter partes* review on any of the grounds set forth in the Petition. Application of the *General Plastic* and *Fintiv* factors weighs

heavily in favor of denial of institution. Also, as Patent Owner has shown, Petitioner has not established a reasonable likelihood that the cited references render any of the challenged claims of the '493 Patent unpatentable.

Dated: June 25, 2020

Respectfully submitted,

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CERTIFICATE OF SERVICE

I hereby certify that on this 25th day of June, 2020, a copy of the attached **PATENT OWNER'S PRELIMINARY RESPONSE** was served by electronic mail to the attorneys of record, at the following addresses:

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CERTIFICATION PURSUANT TO 37 C.F.R. § 42.24(d)

Pursuant 37 C.F.R. 42.24(d), the undersigned certifies that this Preliminary Response and complies with the type-volume limitation of 37 C.F.R. §42.24(a). The word count application of the word processing program used to prepare this Preliminary Response indicates that the Preliminary Response contains 13,893 words, excluding the parts of the brief exempted by 37 C.F.R. § 42.24(a).

Respectfully submitted,

Date: June 25, 2020

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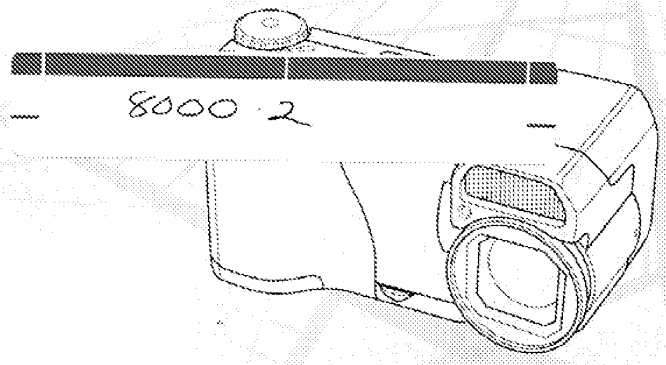
EXHIBIT 1004

LCD Digital Camera

QV-8000SX

DPOF

User's Guide



If you need help with your camera, please call: 1(800)435-7732

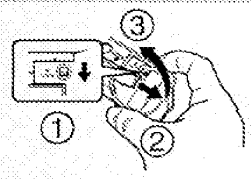
CASIO

QUICK REFERENCE

The section provides a general outline of operational procedures.

Loading Batteries (page 38)
Setting the Current Date and Time (page 44)

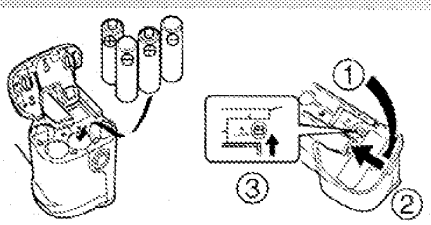
1



On the bottom of the camera, slide the battery compartment cover lock towards the front of the camera (①) to release the cover.

Grasping both sides of the battery compartment cover, swing it open (② ③).

2



Load batteries so their plus (+) and minus (–) ends are facing as shown in the illustration.

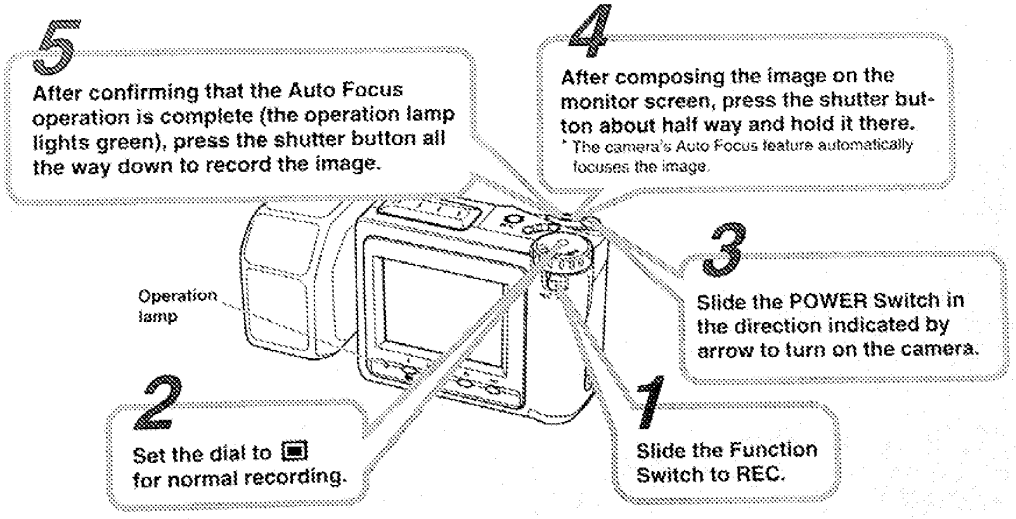
Close the battery compartment cover (① ②), and then slide the battery compartment cover lock towards the back of the camera to lock the cover in place (③).

3

- Be sure to use the procedure on page 44 to set the time and date before using the camera for the first time.
- File name assignment and time stamping will not be performed correctly if the time and date are wrong.

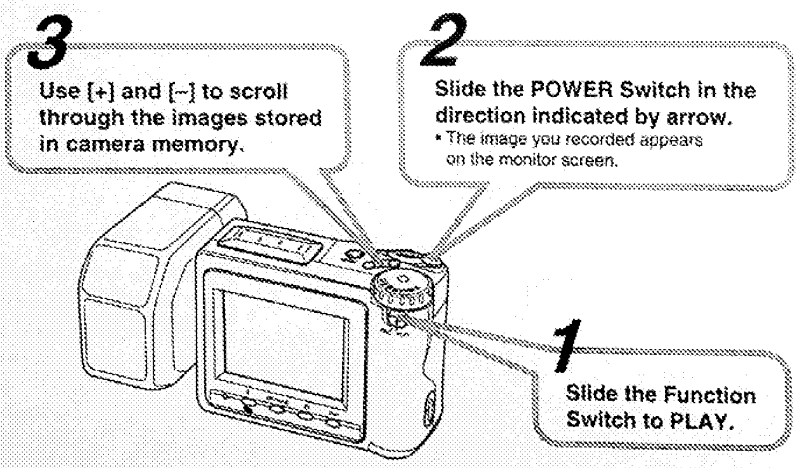
QUICK REFERENCE

Recording Images (page 46)



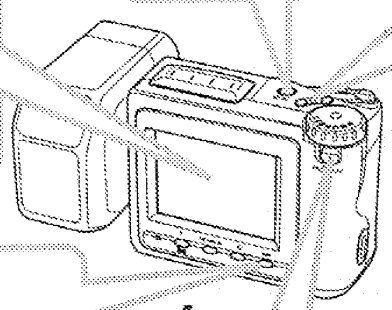
QUICK REFERENCE

Playing Back Images (page 79)



4

Deleting Images (page 92)



1 Slide the Function Switch to PLAY.

2 Press MENU.

3 Use [+] and [–] to select "Delete", and then press the shutter button.

⬇

Use [+] and [–] to select "Select", and then press the shutter button.

⬇

Use [+] and [–] to select an image you want to delete and then press the shutter button. Selected images are indicated by 🗑.

- Note that the first time you display an image its 🗑 icon is turned on.

4 Double check to make sure that you really want to delete the image you selected.

- Press MENU to exit the image delete operation.

5 Press DISP.

⬇

Use [+] and [–] to select "Yes", and then press the shutter button.

CONTENTS

INTRODUCTION

Congratulations upon your selection of the QV-8000SX LCD Digital Camera.
To get the most out of the QV-8000SX, be sure to carefully read this manual and follow the instructions contained in it.

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