US005798756A

United States Patent [19]

Yoshida et al.

[11] Patent Number: 5,798,756

[45] Date of Patent: Aug. 25, 1998

[54] **COORDINATE DETECTION DEVICE CAPABLE OF OBVIATING THE NEED OF FORMING CLOSED LOOP IN ELECTRODES THEREOF**

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[73] Assignee: **Sharp Kabushiki Kaisha**, Osaka, Japan

[21] Appl. No.: **460,251**

[22] Filed: **Jun. 2, 1995**

[30] **Foreign Application Priority Data**

Dec. 26, 1994 [JP] Japan 6-322126

[51] **Int. Cl.**[6] **G09G 5/00**

[52] **U.S. Cl.** **345/179**; 178/18

[58] **Field of Search** 345/104, 173–182; 178/18, 19

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Primary Examiner—Amare Mengistu

Attorney, Agent, or Firm—David G. Conlin; Brian L. Michaelis

[57] **ABSTRACT**

There is provided a coordinate detection device capable of preventing increase of development cost and reduction of yield and dispensing with additional investment for existing equipment. The coordinate detection device includes an LCD panel having electrodes and electrodes, an electric field generator which outputs an AC electric field from a tip end of its electrode, a differential amplifier, switching circuits which sequentially select electrodes of the LCD panel and connect the selected electrodes to the differential amplifier, and a coordinate detection circuit which detects coordinates of a position in which the electric field generator is located based on a timing at which the electrodes are selected and an output of the differential amplifier. A coordinate detection function can be achieved by means of the LCD panel having the same structure as that of an LCD panel provided specially for image display. Furthermore, there is no need to form a closed loop in the electrodes of the LCD panel, which obviates the need of providing any board opposite to four sides of the LCD panel.

15 Claims, 41 Drawing Sheets

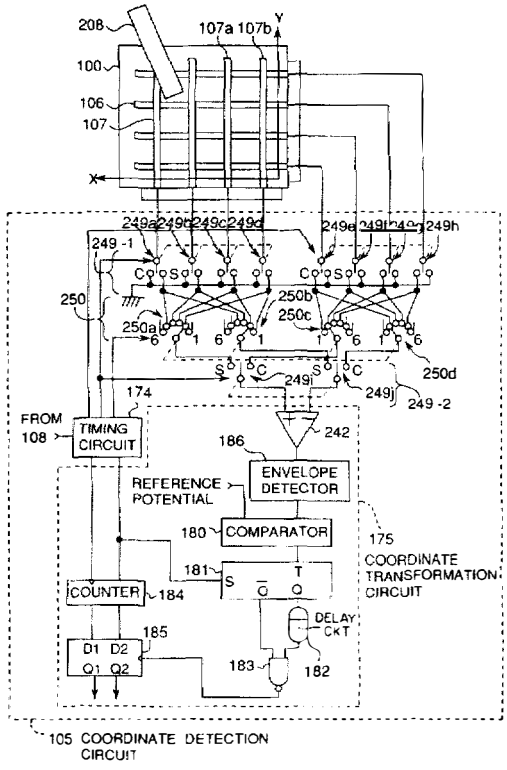


Fig. 1

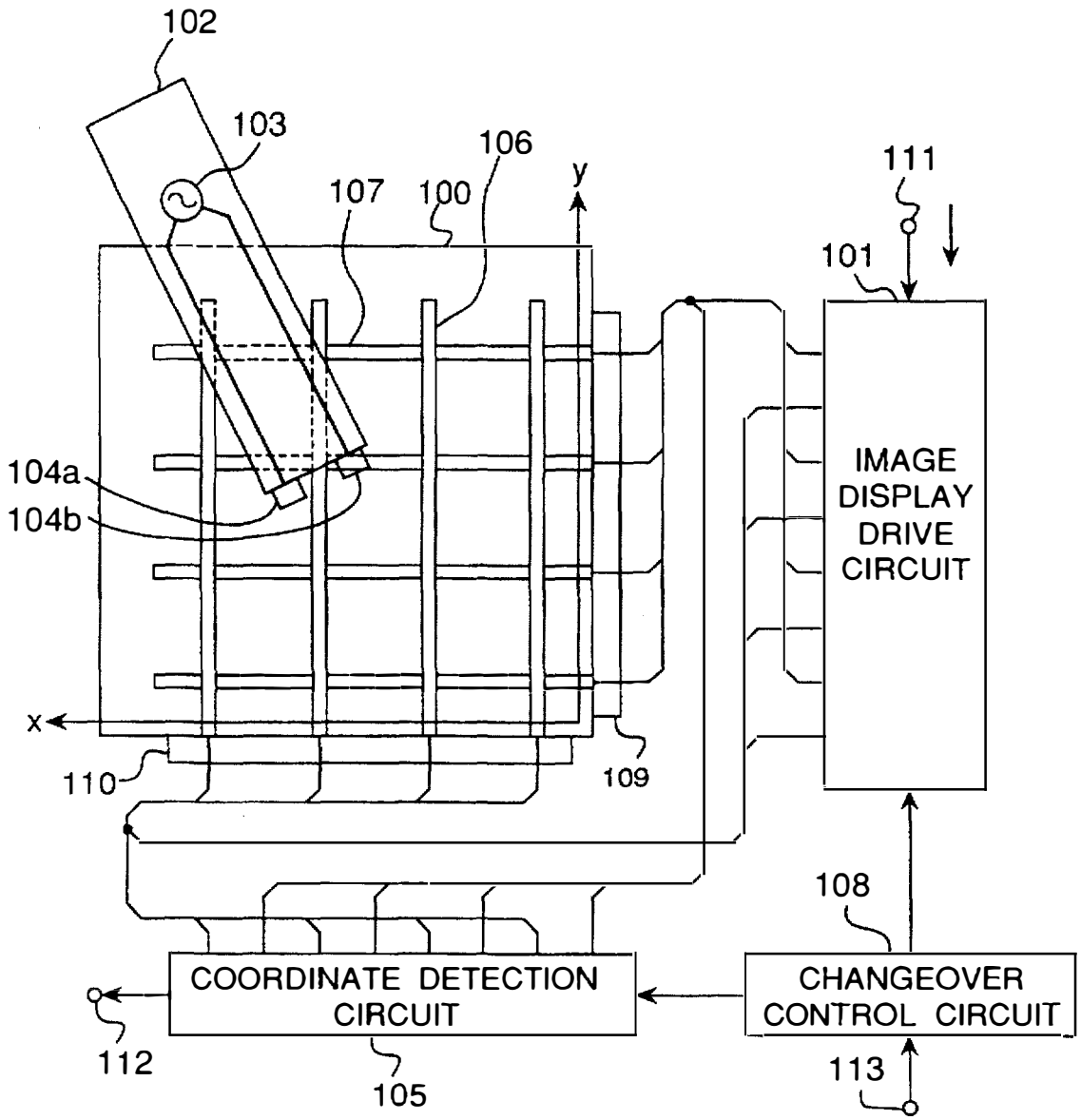

102
103
106
107
100
y
111
101
IMAGE DISPLAY DRIVE CIRCUIT
104a
104b
x
110
109
108
COORDINATE DETECTION CIRCUIT
CHANGEOVER CONTROL CIRCUIT
112
105
113

Fig.2

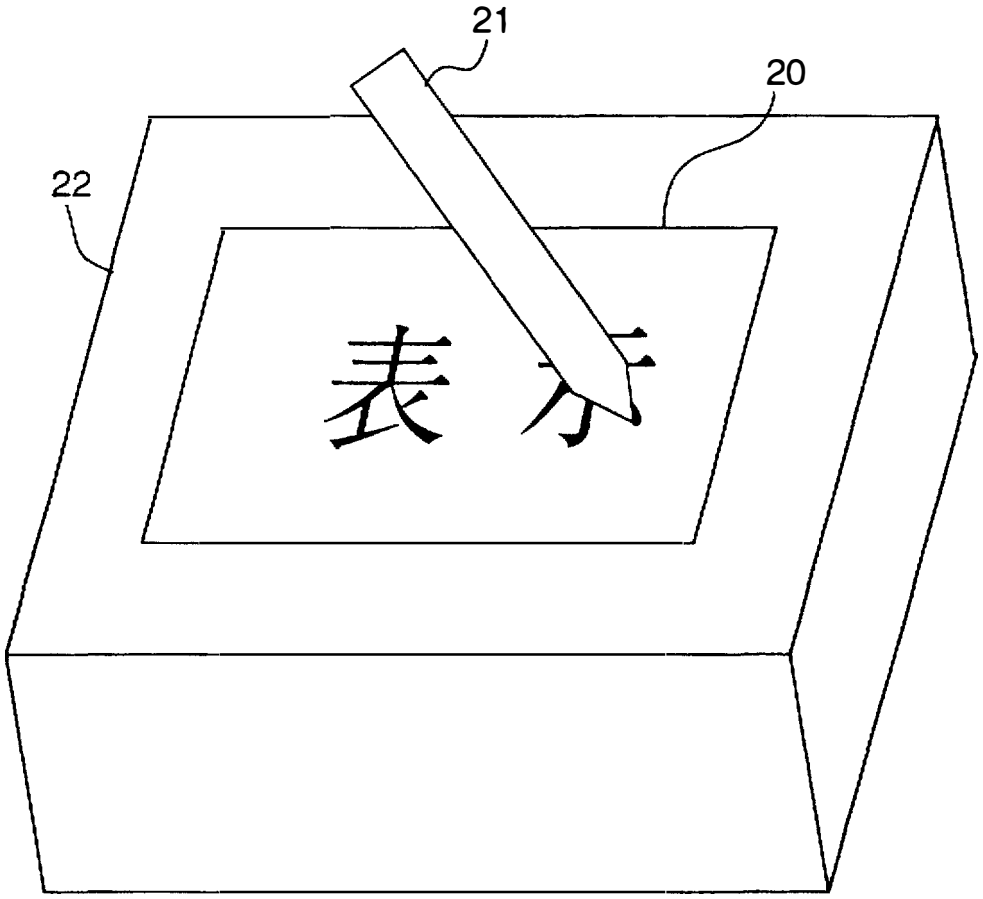
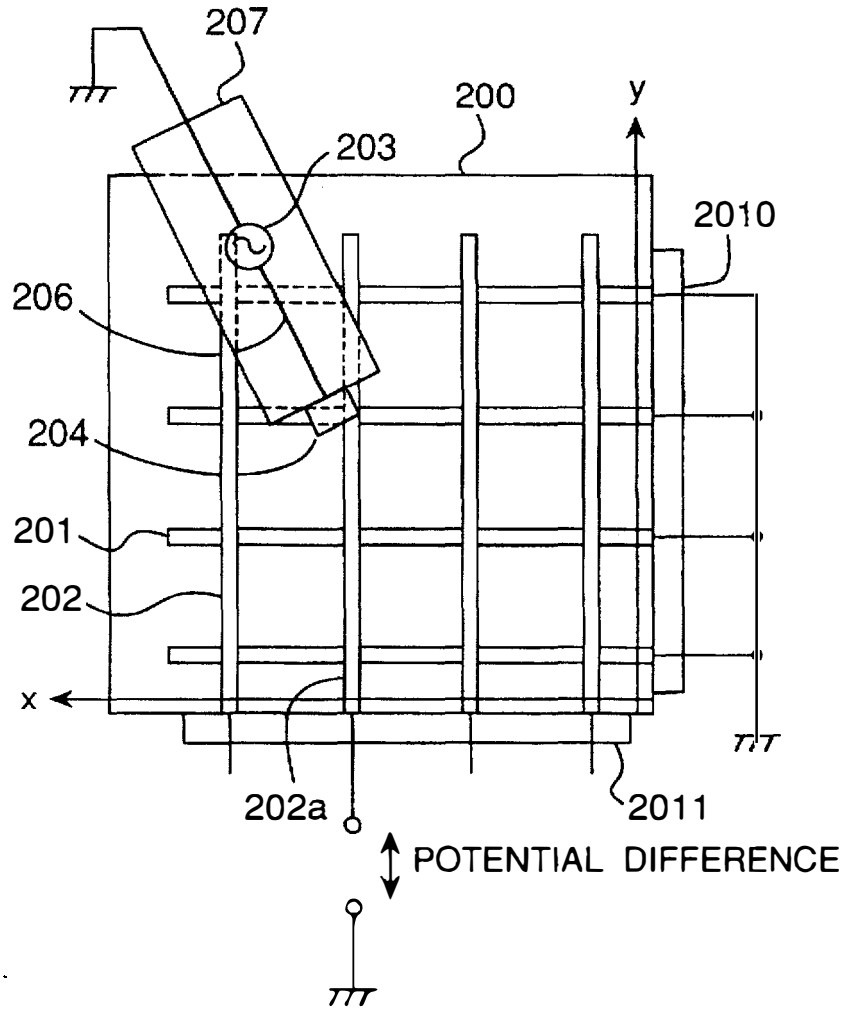


Fig.3


207
200
y
203
2010
206
204
201
202
x
202a
2011
POTENTIAL DIFFERENCE

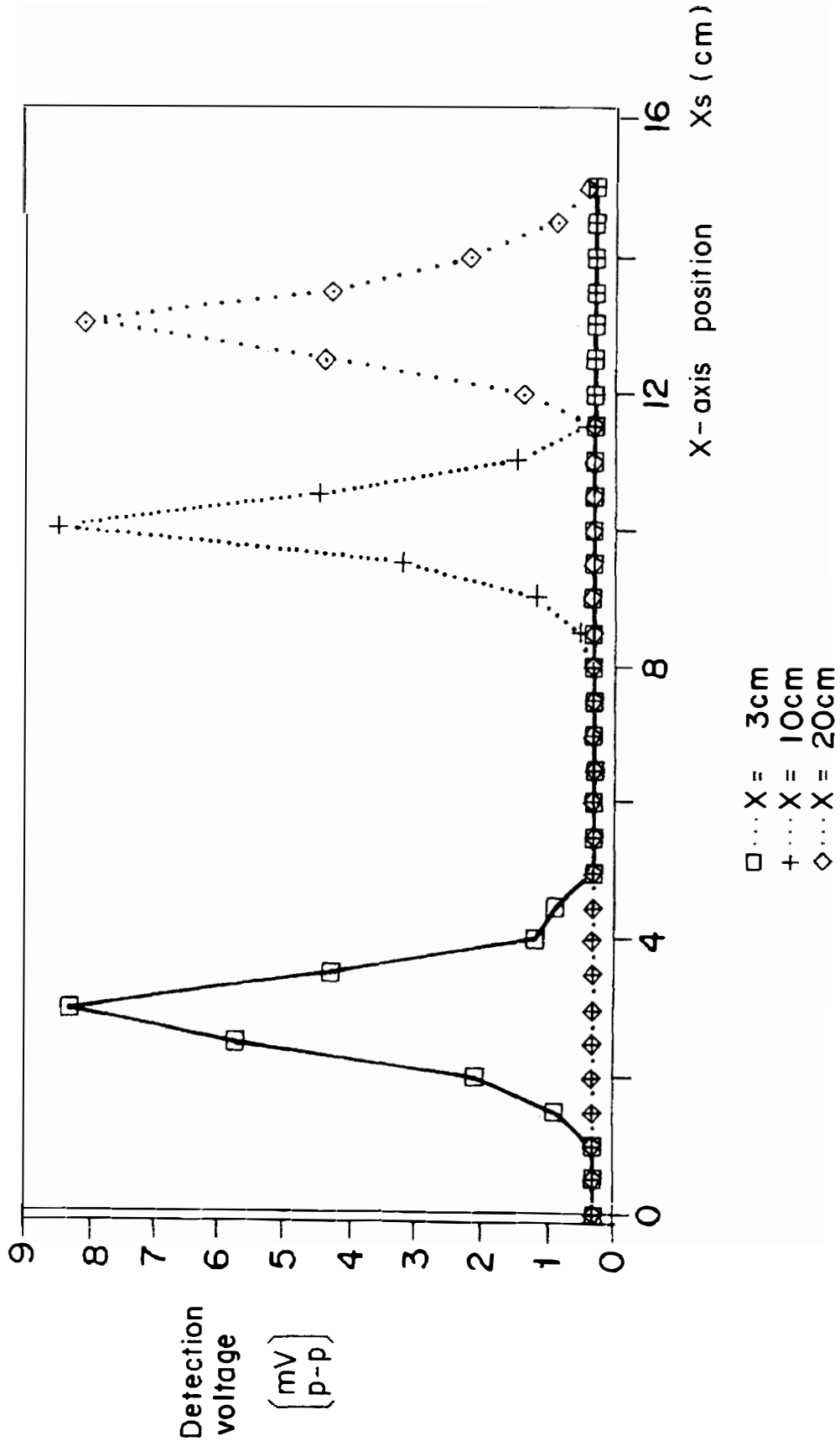

Detection voltage (mV p-p)
9
8
7
6
5
4
3
2
1
0
0
4
8
12
16
X-axis position Xs (cm)
□ X = 3cm
+ X = 10cm
◇ X = 20cm

Fig. 4

Fig.5

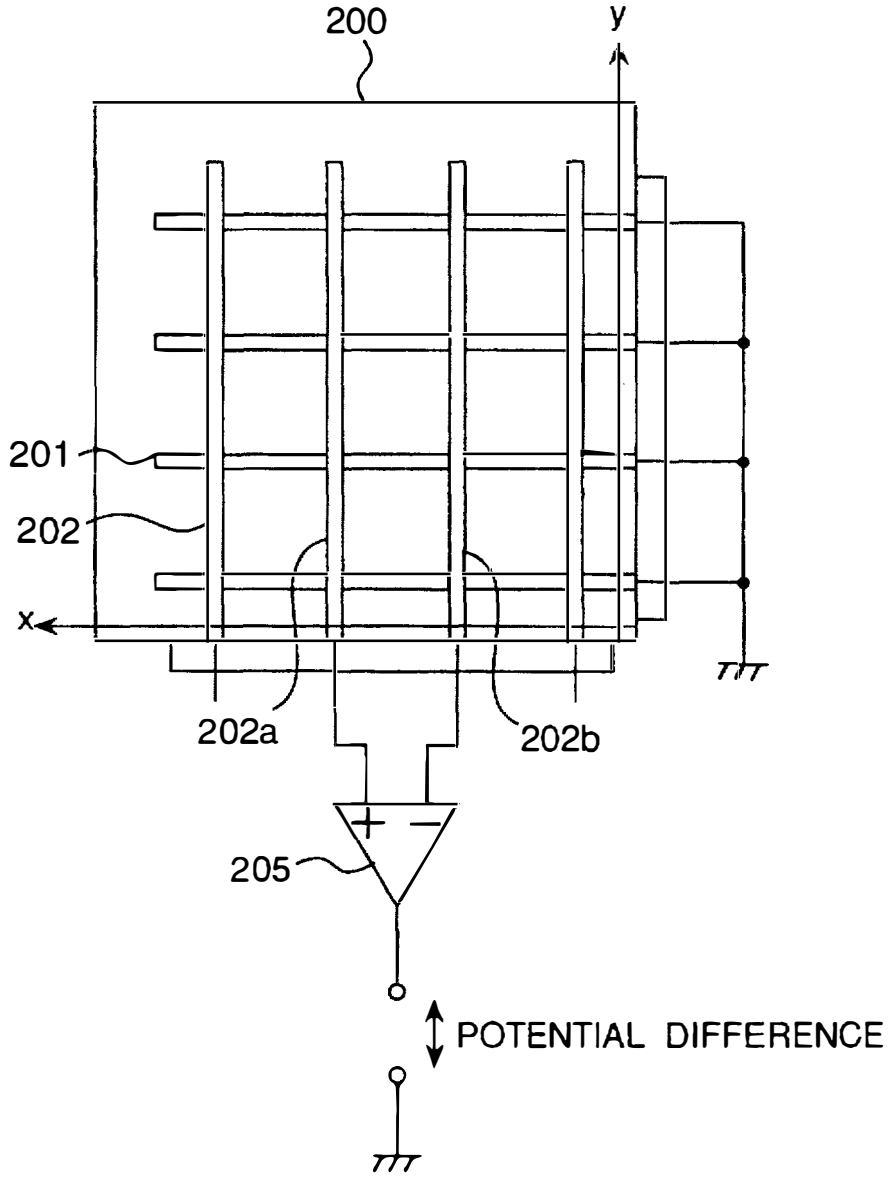


Fig.6A

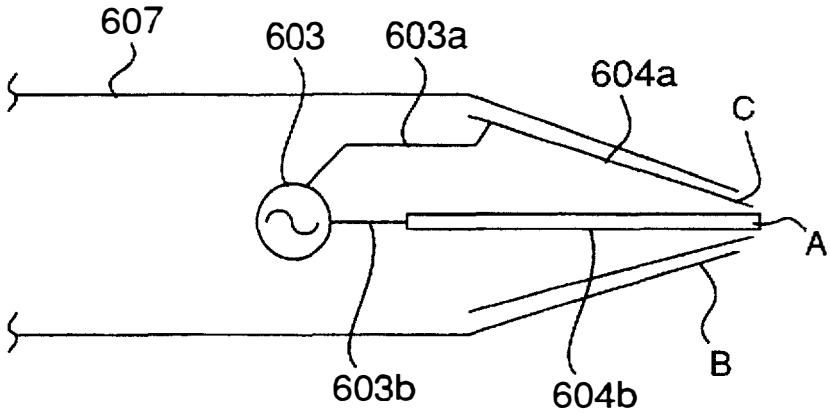
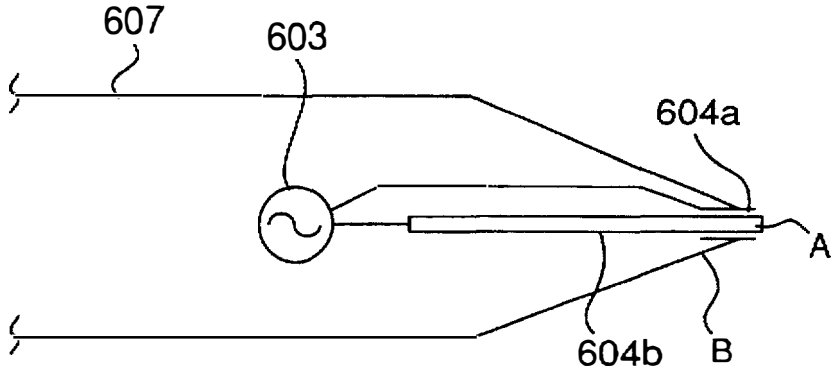


Fig.6B



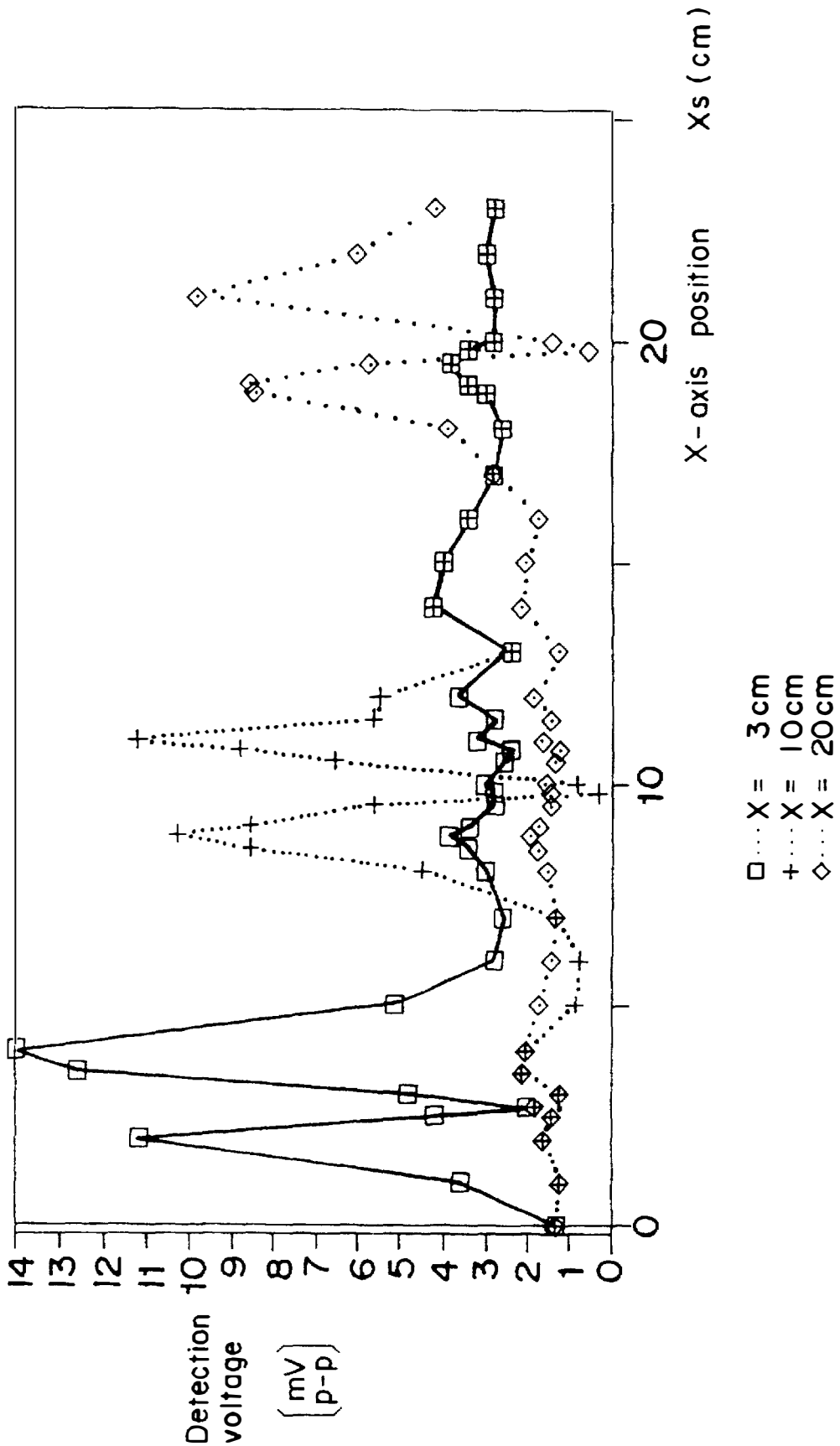

Detection voltage (mV p-p)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
10
20
X-axis position Xs (cm)
□ X = 3cm
+ X = 10cm
◇ X = 20cm

Fig. 7

Fig.8

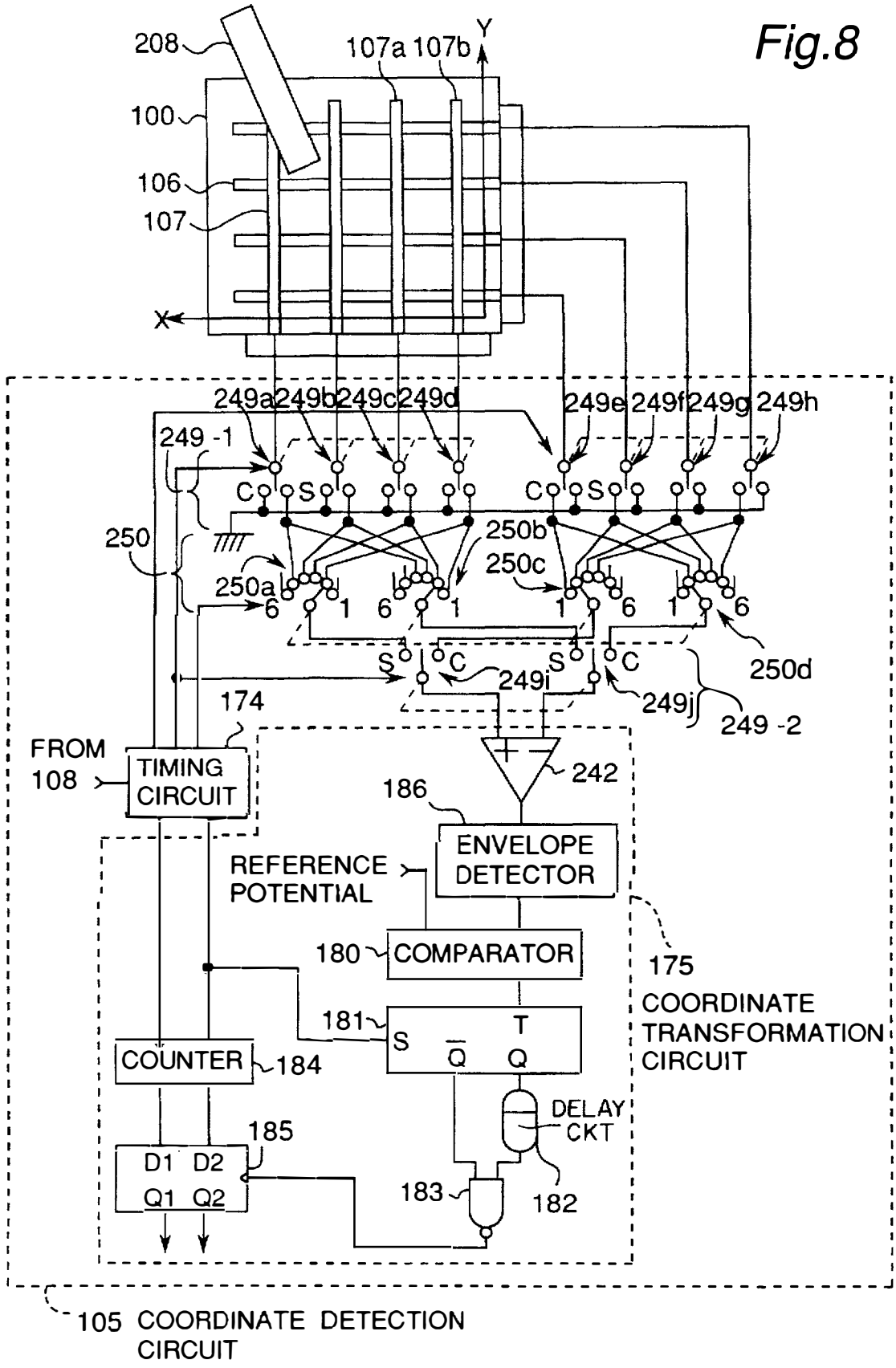

208
107a 107b
Y
100
106
107
X
249a 249b 249c 249d
249e 249f 249g 249h
249 -1
C S
C S
250
250a
250b
250c
250d
6 1 6 1
1 6 1 6
S C
S C
249i
249j
249 -2
174
FROM 108
TIMING CIRCUIT
242
186
ENVELOPE DETECTOR
REFERENCE POTENTIAL
180
COMPARATOR
175
COORDINATE TRANSFORMATION CIRCUIT
181
S T
Q Q
COUNTER
184
DELAY CKT
185
D1 D2
Q1 Q2
183
182
105 COORDINATE DETECTION CIRCUIT

Fig. 9A

Input of envelope detector 186

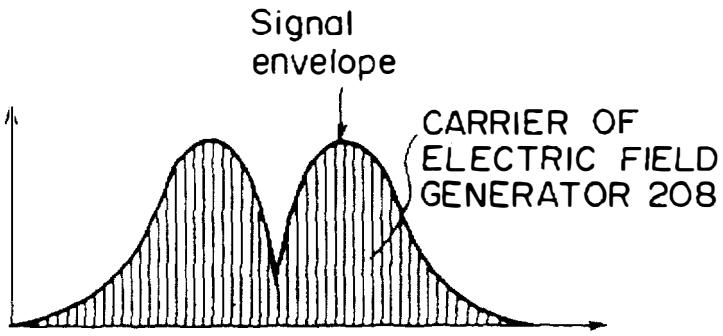


Fig. 9B

Input of comparator 180

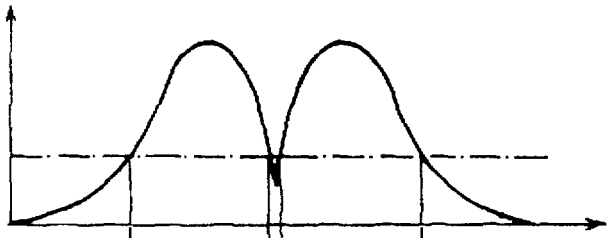


Fig. 9C

Output of comparator 180

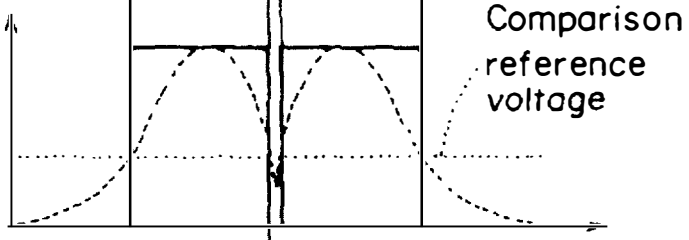


Fig. 9D

Output of T-filp-flop 181

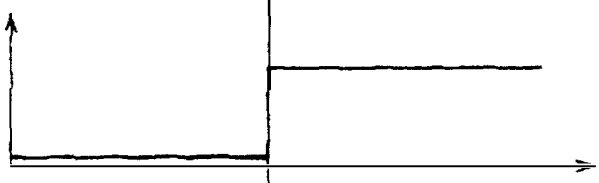


Fig. 9E

Output of delay circuit 182
(Input of NAND gate 183)

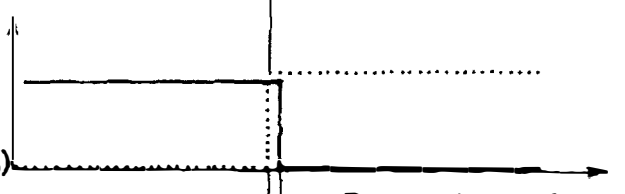
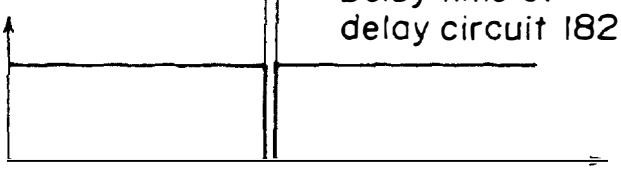


Fig. 9F

Output of NAND gate 183



(The axis of abscissas : Time
The axis of ordinates : Voltage)

Fig.10

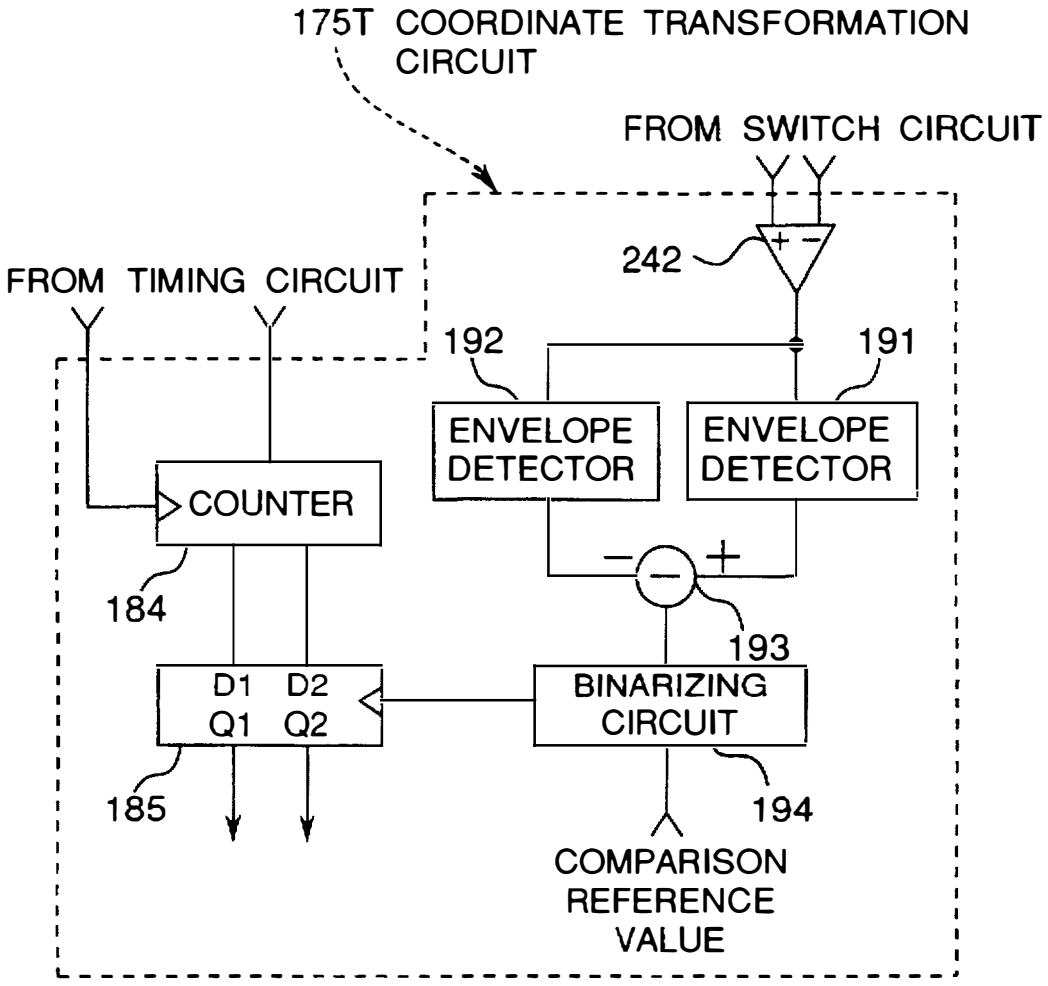

175T COORDINATE TRANSFORMATION CIRCUIT
FROM SWITCH CIRCUIT
242
FROM TIMING CIRCUIT
192
191
ENVELOPE DETECTOR
ENVELOPE DETECTOR
COUNTER
184
193
D1 D2
Q1 Q2
BINARIZING CIRCUIT
185
194
COMPARISON REFERENCE VALUE

Fig. 11A

Input of envelope detectors 191 and 192

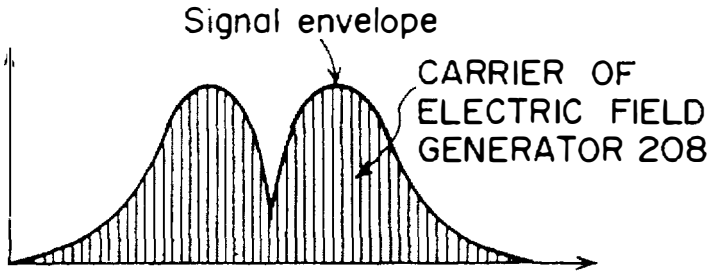


Fig. 11B

Output of detector 192

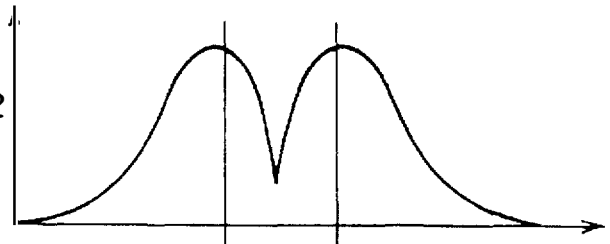


Fig. 11C

Output of detector 191

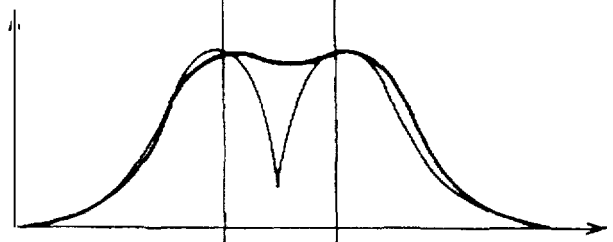


Fig. 11D

Input of binarizing circuit 194

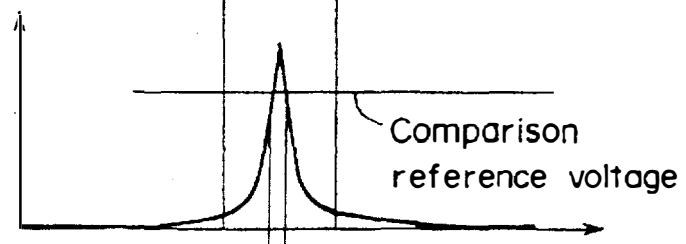


Fig. 11E

Output of binarizing circuit 194



(The axis of abscissas : Time
The axis of ordinates : Voltage)

Fig.12

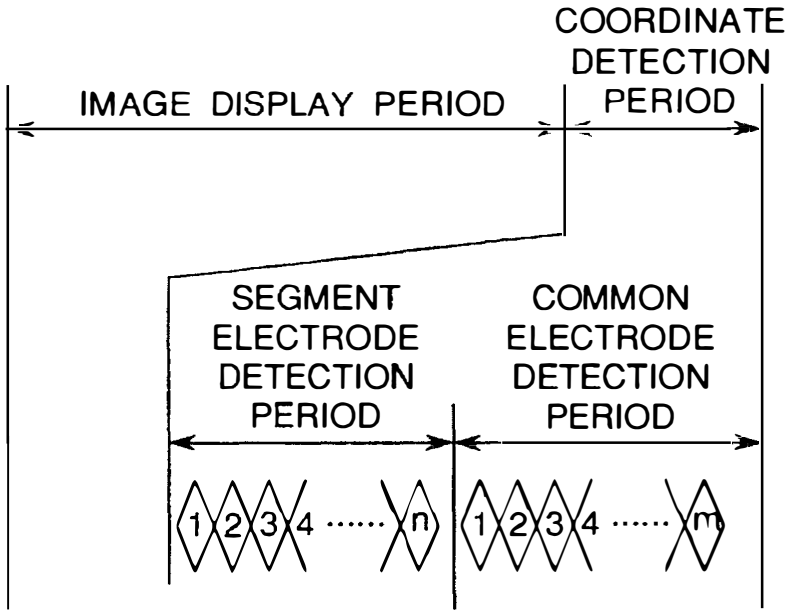

COORDINATE DETECTION PERIOD
IMAGE DISPLAY PERIOD
SEGMENT ELECTRODE DETECTION PERIOD
COMMON ELECTRODE DETECTION PERIOD
1 2 3 4 ..... n
1 2 3 4 ..... m

Fig.13

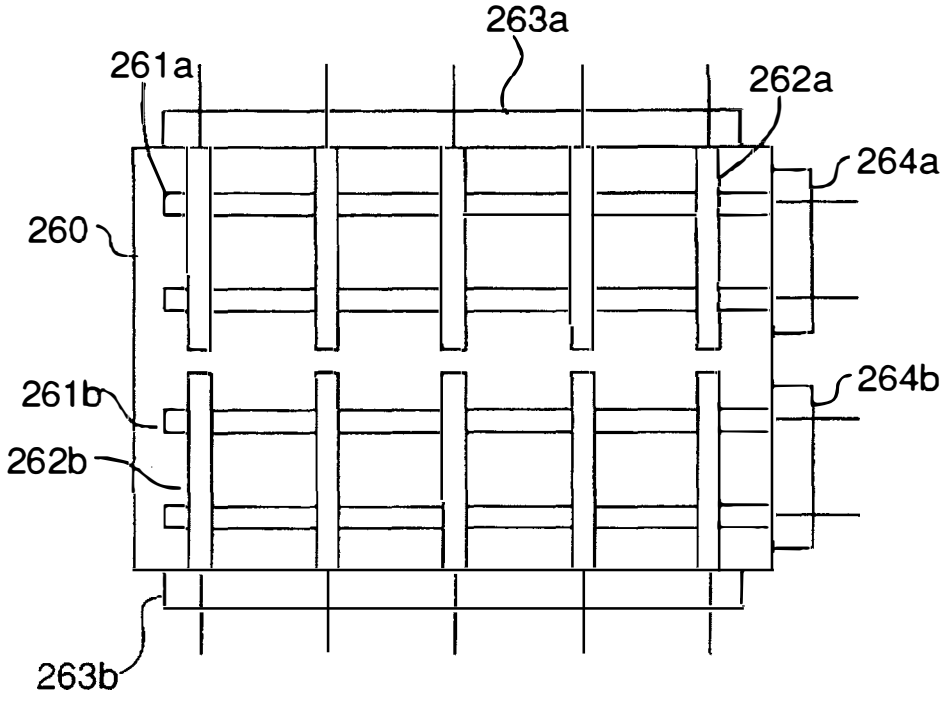

263a
261a
262a
264a
260
264b
261b
262b
263b

Fig. 14

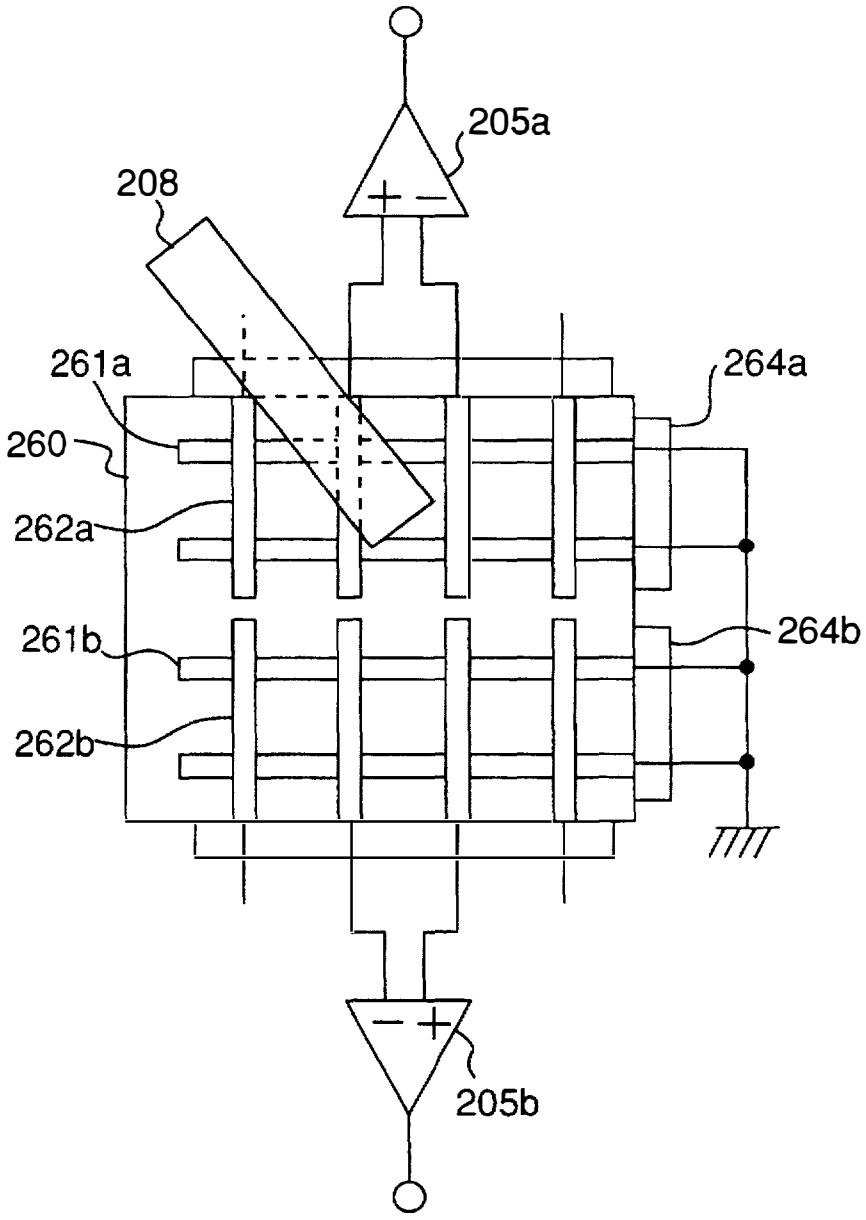


Fig.15

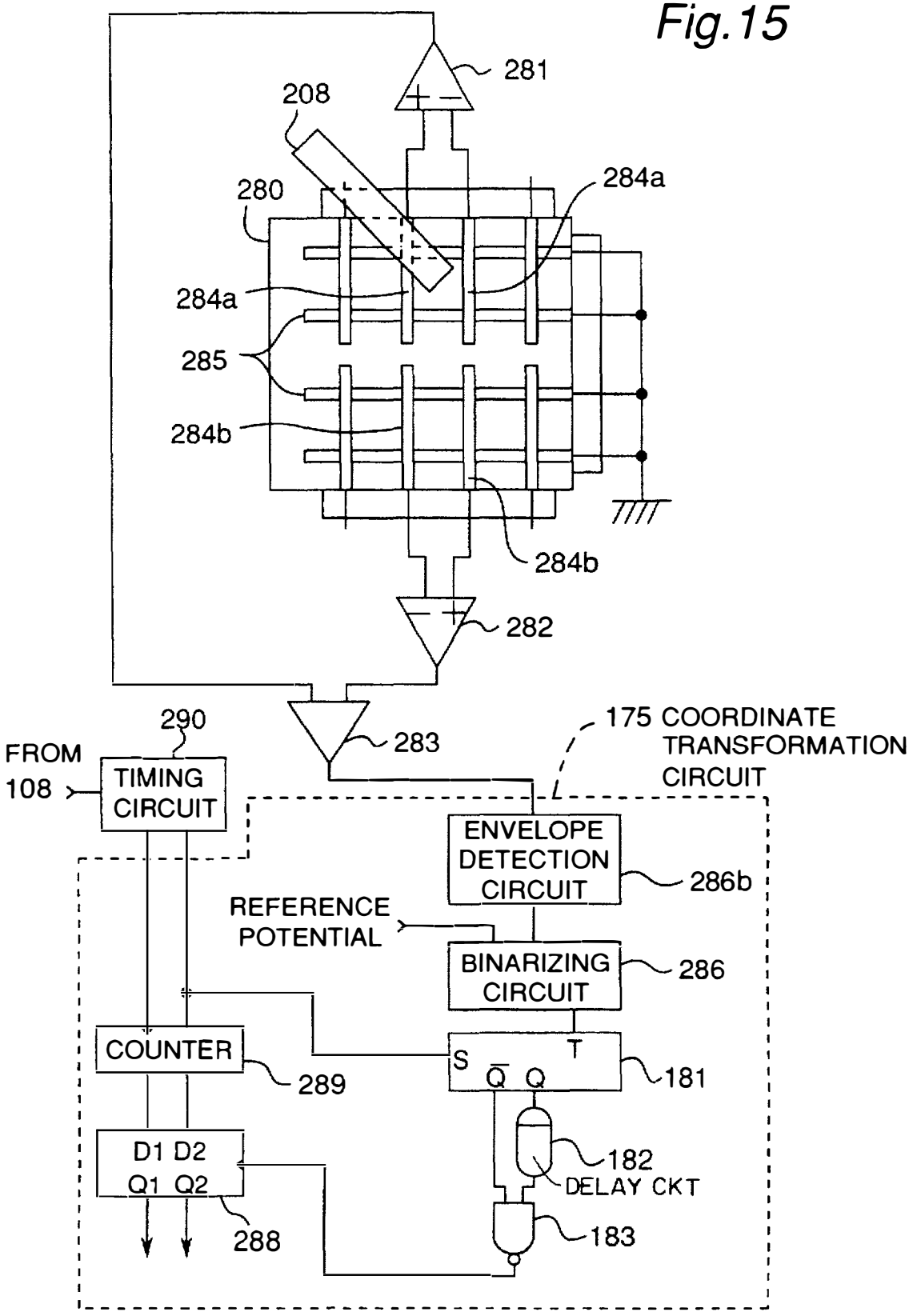

281
208
280
284a
284a
285
284b
284b
282
283
290
FROM
108
TIMING
CIRCUIT
175 COORDINATE
TRANSFORMATION
CIRCUIT
ENVELOPE
DETECTION
CIRCUIT
286b
REFERENCE
POTENTIAL
BINARIZING
CIRCUIT
286
COUNTER
289
S
T
Q
Q
181
D1 D2
Q1 Q2
288
182
DELAY CKT
183

Fig. 16

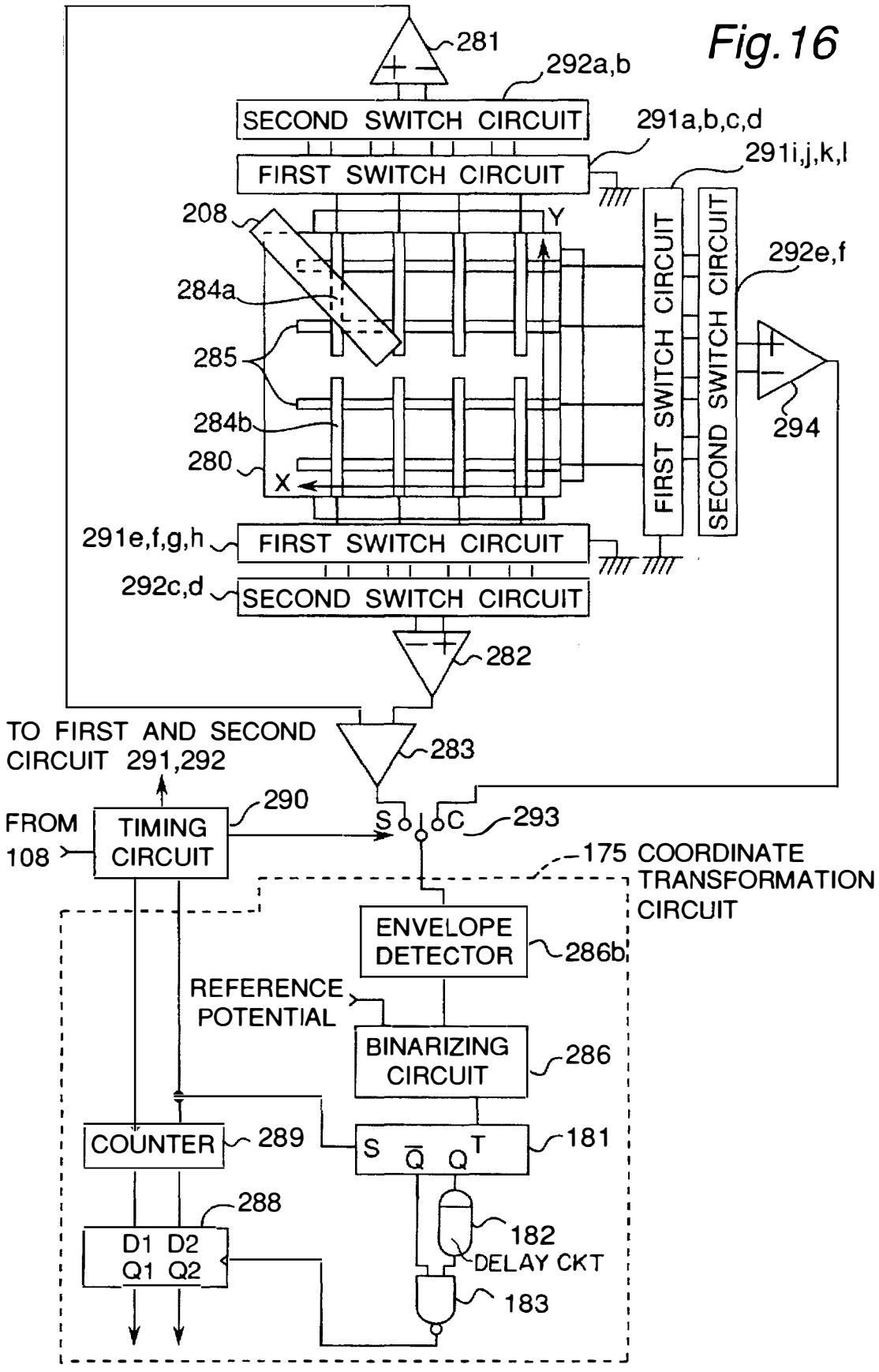

281
292a,b
SECOND SWITCH CIRCUIT
291a,b,c,d
FIRST SWITCH CIRCUIT
291i,j,k,l
208
Y
284a
285
284b
280
X
FIRST SWITCH CIRCUIT
SECOND SWITCH CIRCUIT
292e,f
294
291e,f,g,h
FIRST SWITCH CIRCUIT
292c,d
SECOND SWITCH CIRCUIT
282
283
TO FIRST AND SECOND CIRCUIT 291,292
FROM 108
TIMING CIRCUIT
290
S
C
293
175 COORDINATE TRANSFORMATION CIRCUIT
ENVELOPE DETECTOR
286b
REFERENCE POTENTIAL
BINARIZING CIRCUIT
286
COUNTER
289
S Q̄ Q T
181
288
D1 D2
Q1 Q2
182
DELAY CKT
183

Fig.17

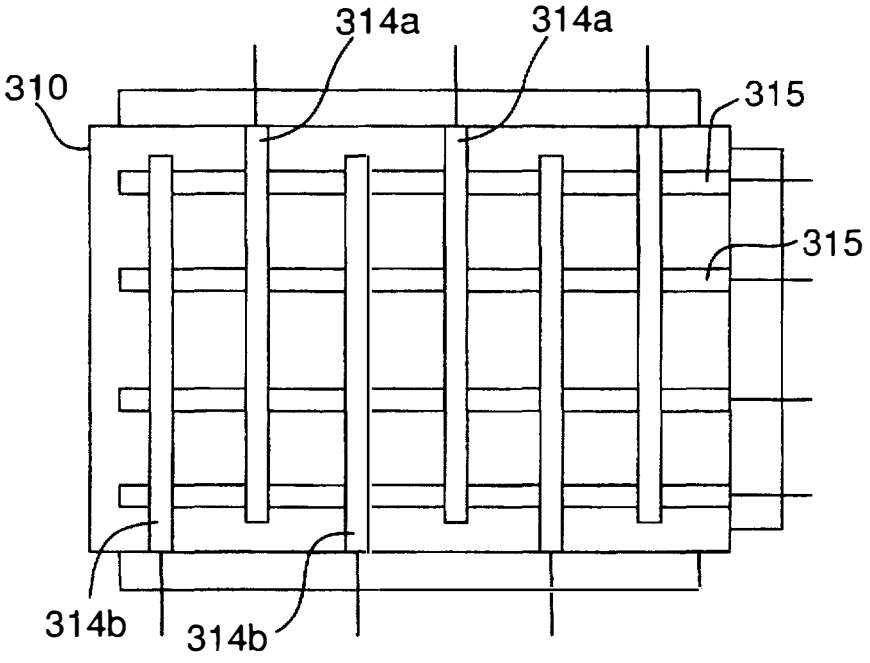


Fig.18

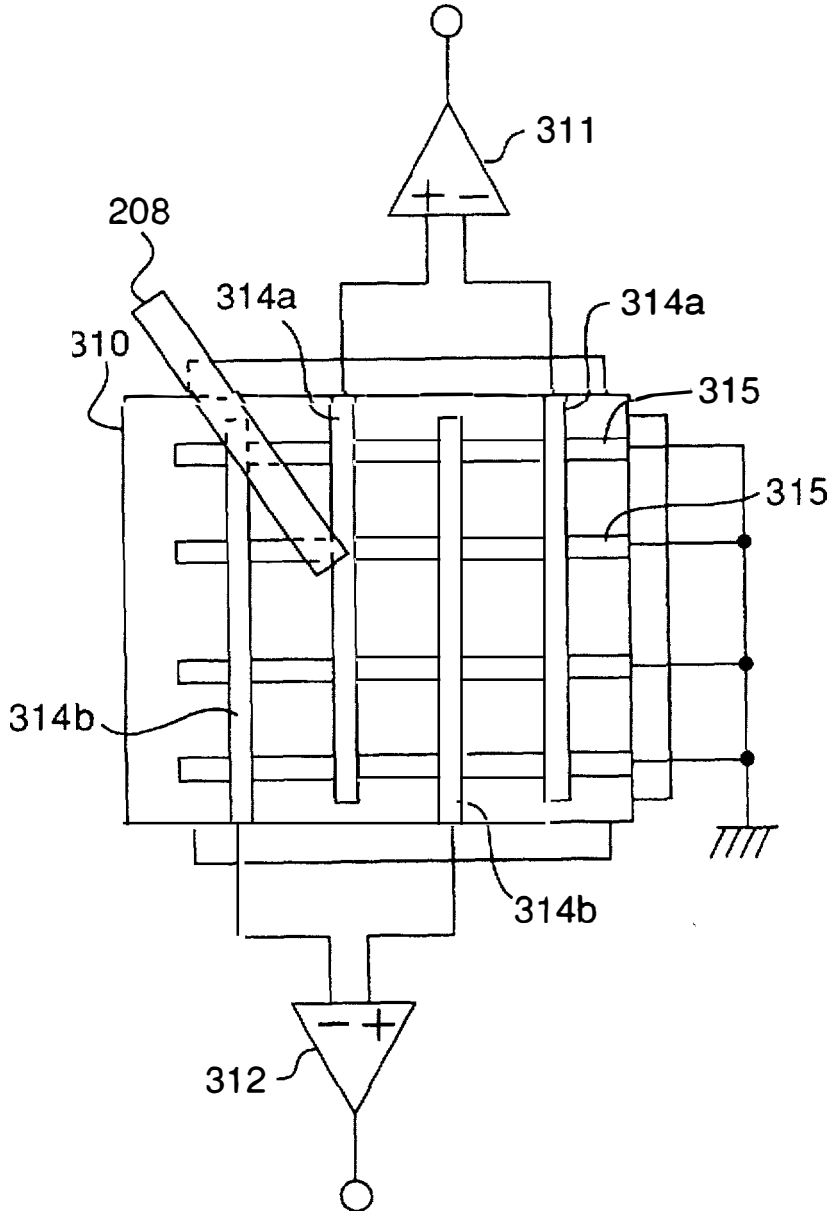
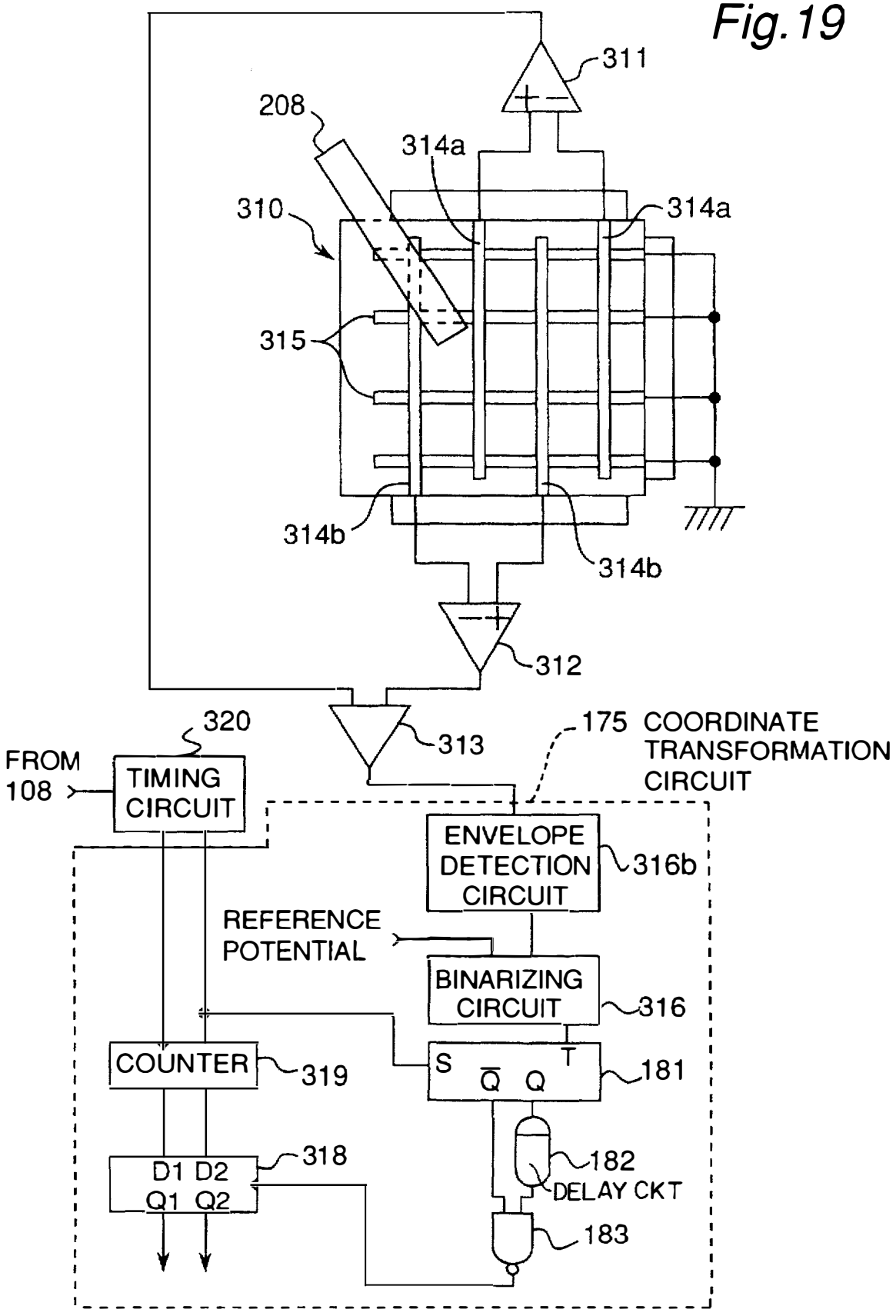


Fig.19


311
208
314a
310
314a
315
314b
314b
312
313
320
175 COORDINATE TRANSFORMATION CIRCUIT
FROM 108
TIMING CIRCUIT
ENVELOPE DETECTION CIRCUIT
316b
REFERENCE POTENTIAL
BINARIZING CIRCUIT
316
COUNTER
319
S
T
Q̄ Q
181
D1 D2
Q1 Q2
318
182
DELAY CKT
183

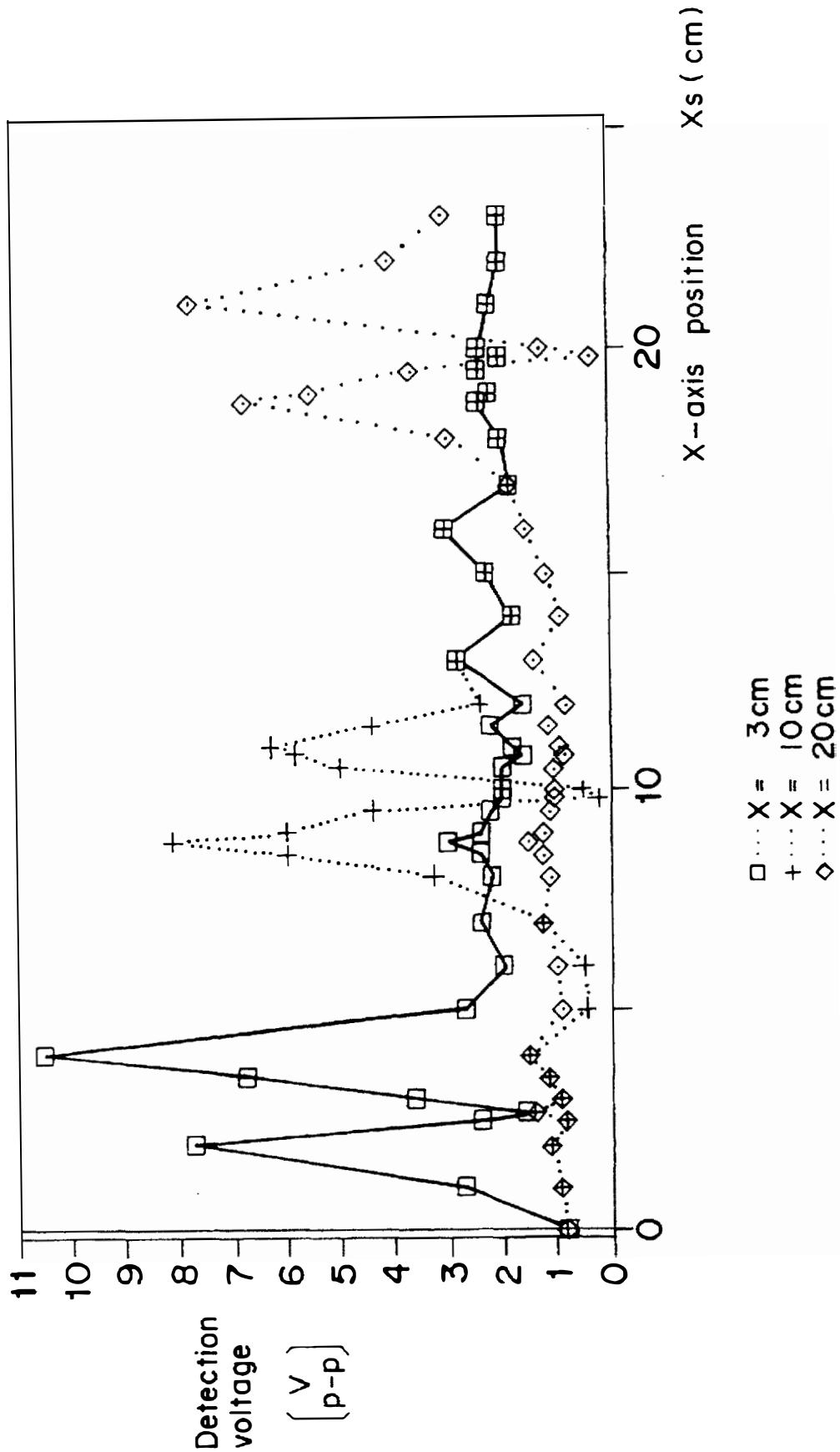

Detection voltage (V p-p)
11
10
9
8
7
6
5
4
3
2
1
0
0
10
20
X-axis position Xs (cm)
□ X = 3cm
+ X = 10cm
◇ X = 20cm

Fig. 20

Fig.21

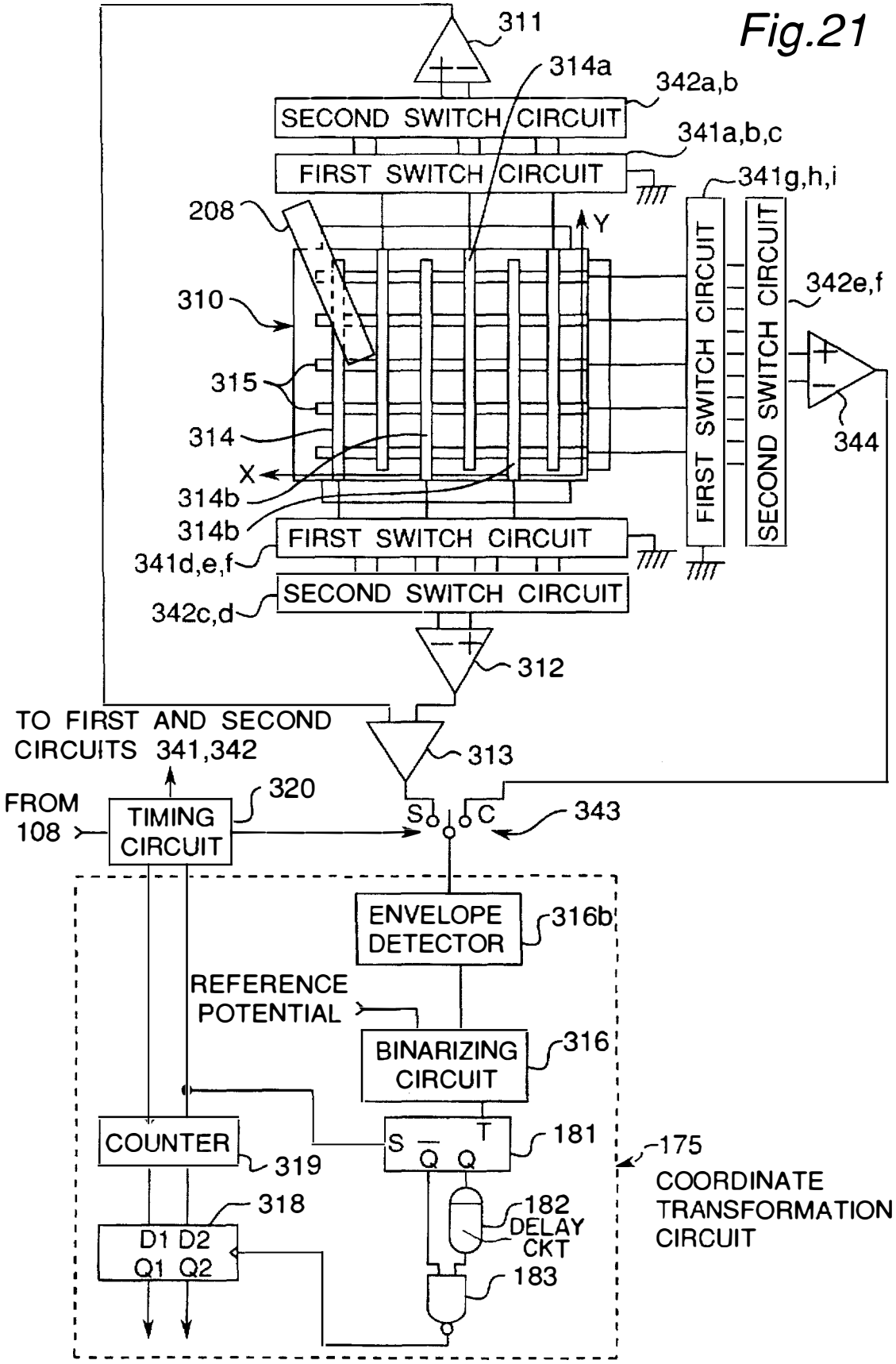

311
314a
342a,b
SECOND SWITCH CIRCUIT
341a,b,c
FIRST SWITCH CIRCUIT
341g,h,i
208
Y
310
315
314
X
314b
314b
341d,e,f
FIRST SWITCH CIRCUIT
342c,d
SECOND SWITCH CIRCUIT
312
FIRST SWITCH CIRCUIT
SECOND SWITCH CIRCUIT
342e,f
344
TO FIRST AND SECOND CIRCUITS 341,342
313
FROM 108
TIMING CIRCUIT
320
S
C
343
ENVELOPE DETECTOR
316b
REFERENCE POTENTIAL
BINARIZING CIRCUIT
316
COUNTER
319
S
T
Q
Q
181
175
COORDINATE TRANSFORMATION CIRCUIT
318
182
DELAY CKT
D1 D2
Q1 Q2
183

Fig.22

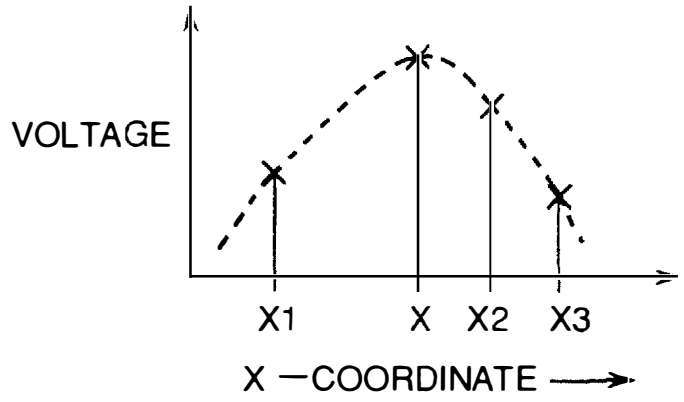

VOLTAGE
X1
X
X2
X3
X —COORDINATE

Fig.23

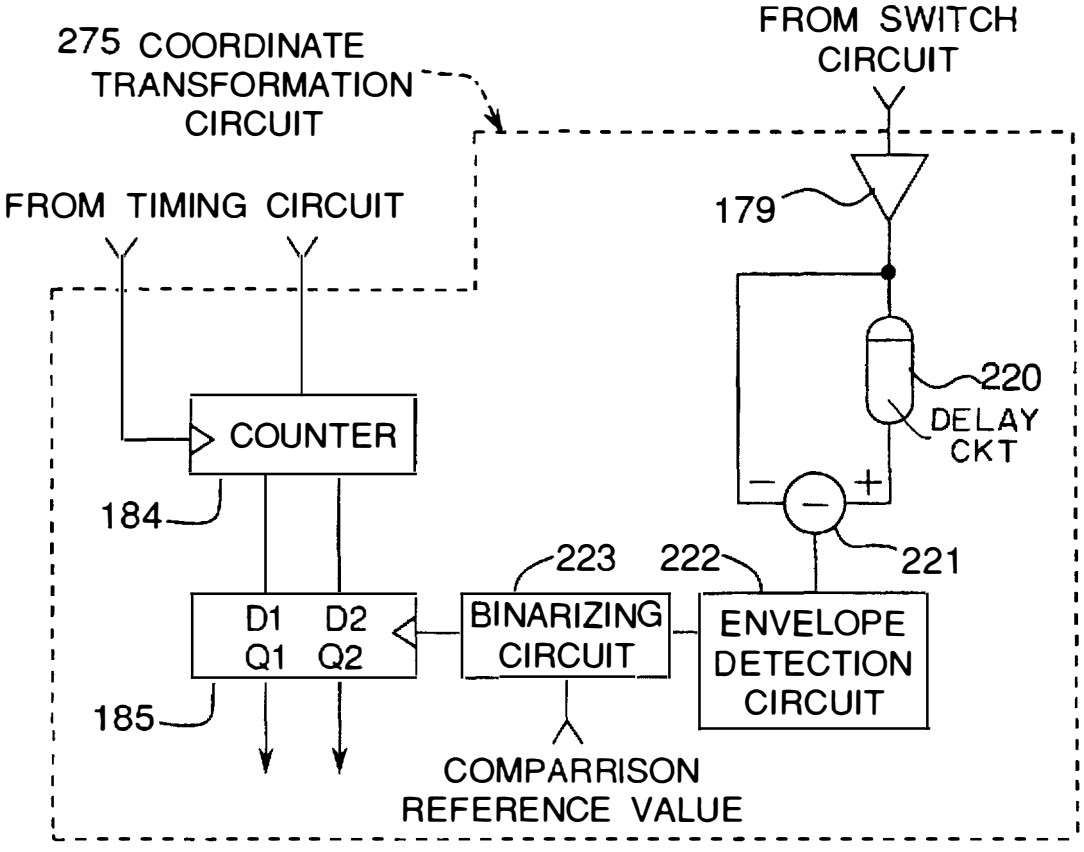
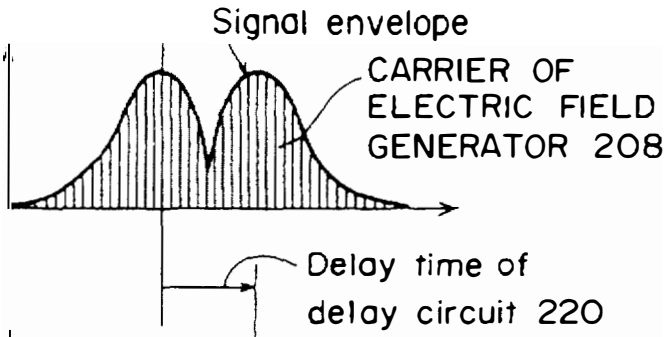

275 COORDINATE TRANSFORMATION CIRCUIT
FROM TIMING CIRCUIT
FROM SWITCH CIRCUIT
179
220
DELAY CKT
COUNTER
184
223
222
221
D1 D2
Q1 Q2
BINARIZING CIRCUIT
ENVELOPE DETECTION CIRCUIT
185
COMPARRISON REFERENCE VALUE

Fig. 24A

Output of amplifier 179



Delay time of delay circuit 220

Fig. 24B

Output of delay circuit 220

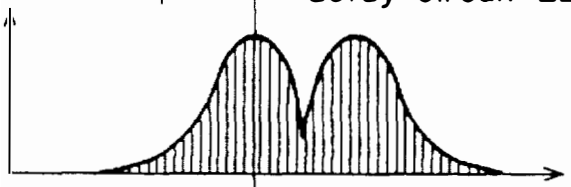


Fig. 24C

Output of subtracter 221

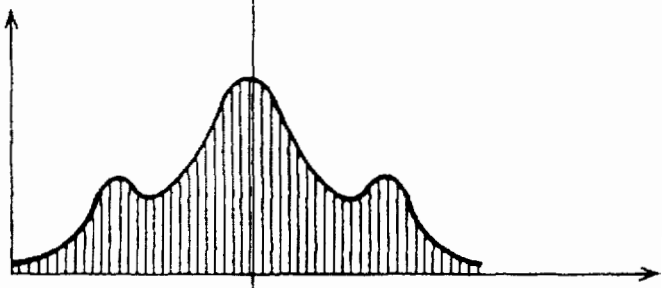


Fig. 24D

Output of detector 222 (Input of binarizing circuit 223)

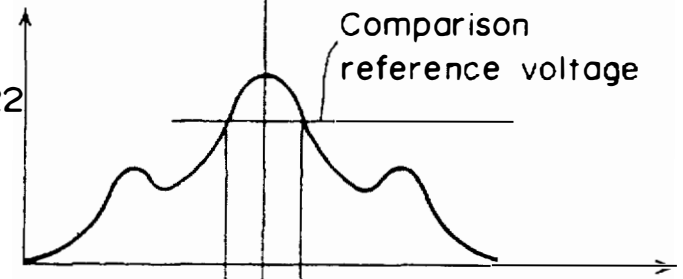
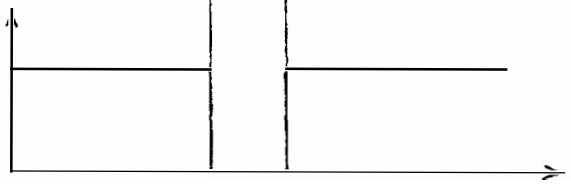


Fig. 24E

Output of binarizing circuit 223



The axis of abscissas : Time

The axis of ordinates : Amplitude

Fig.25

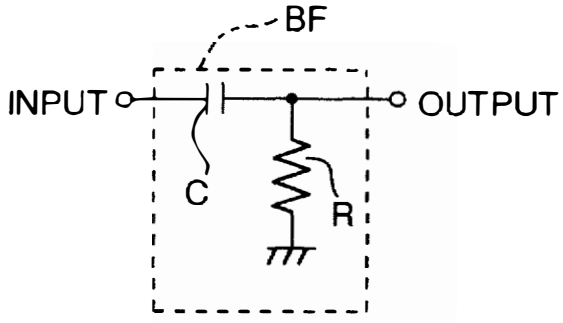

BF
INPUT
OUTPUT
C
R

Fig.26

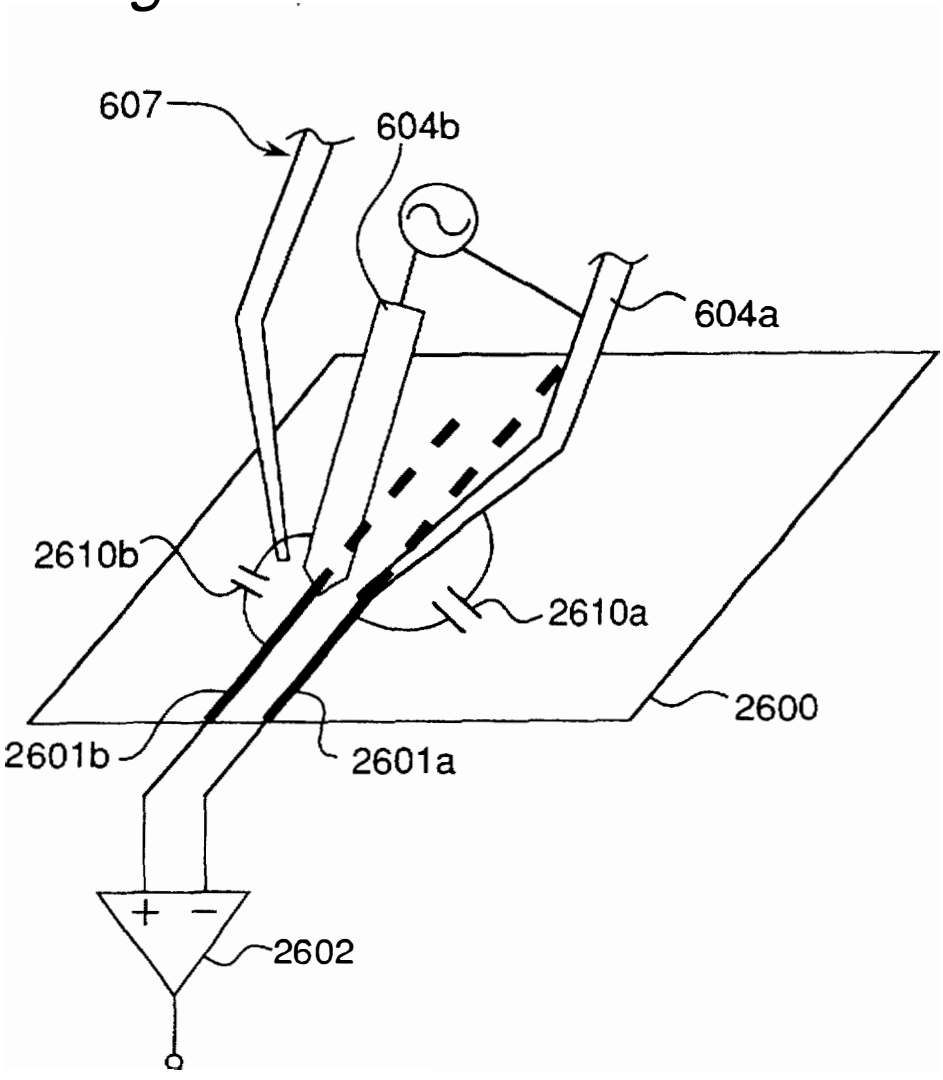

607
604b
604a
2610b
2610a
2600
2601b
2601a
+
−
2602

Fig.27

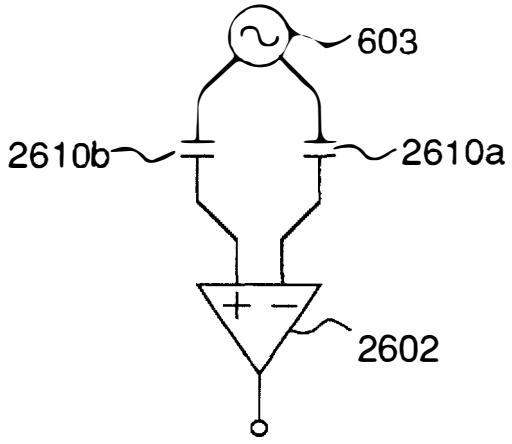
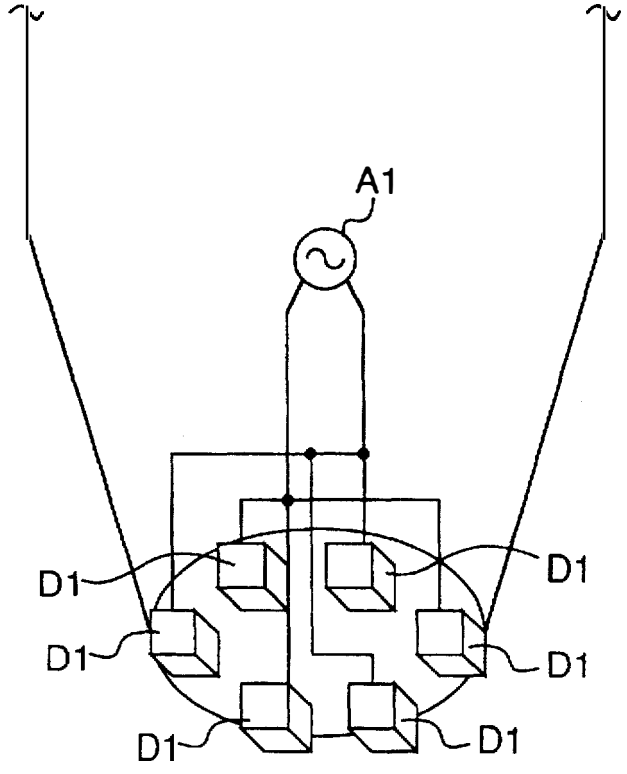


Fig.28



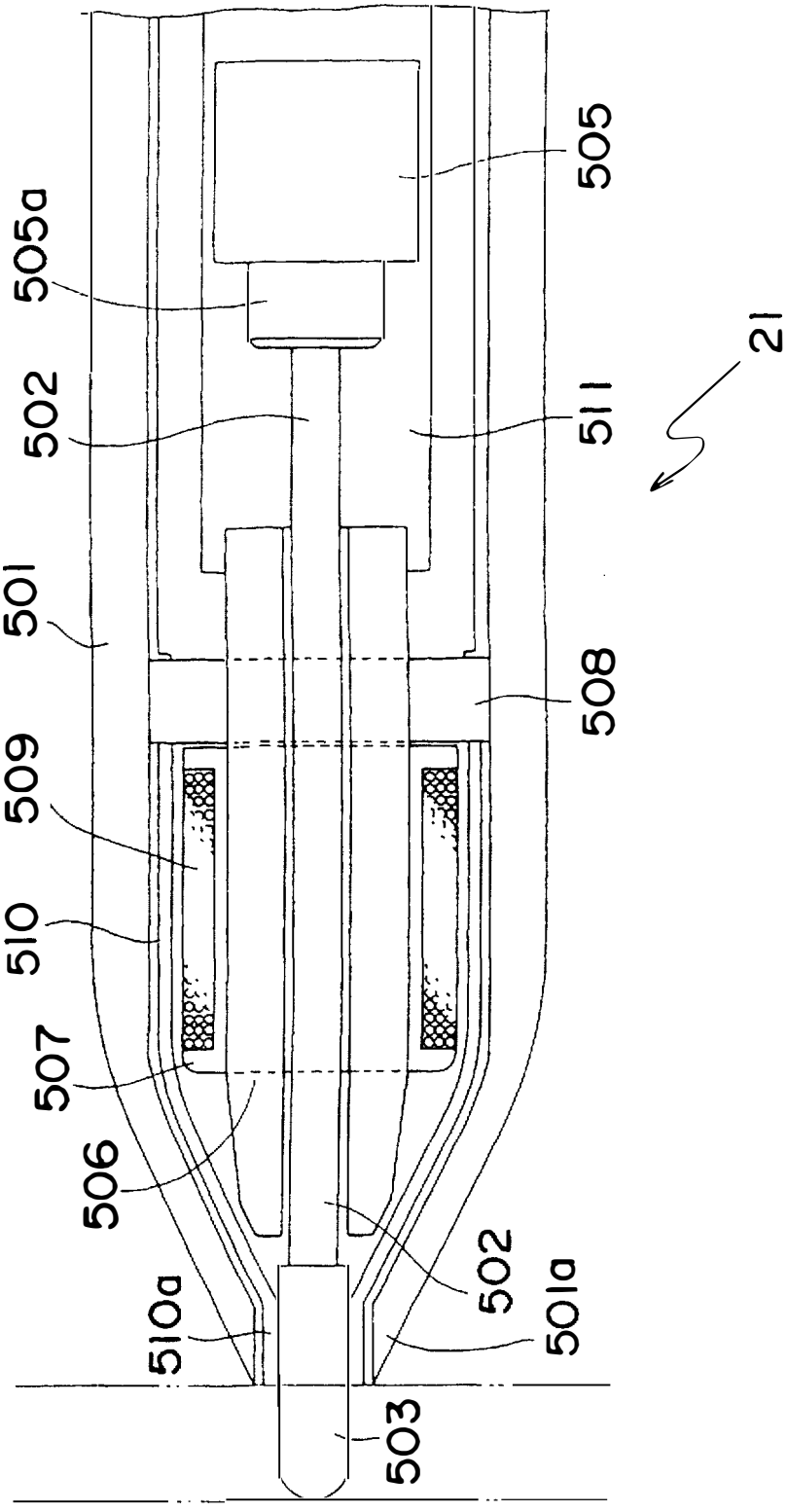


Fig. 29

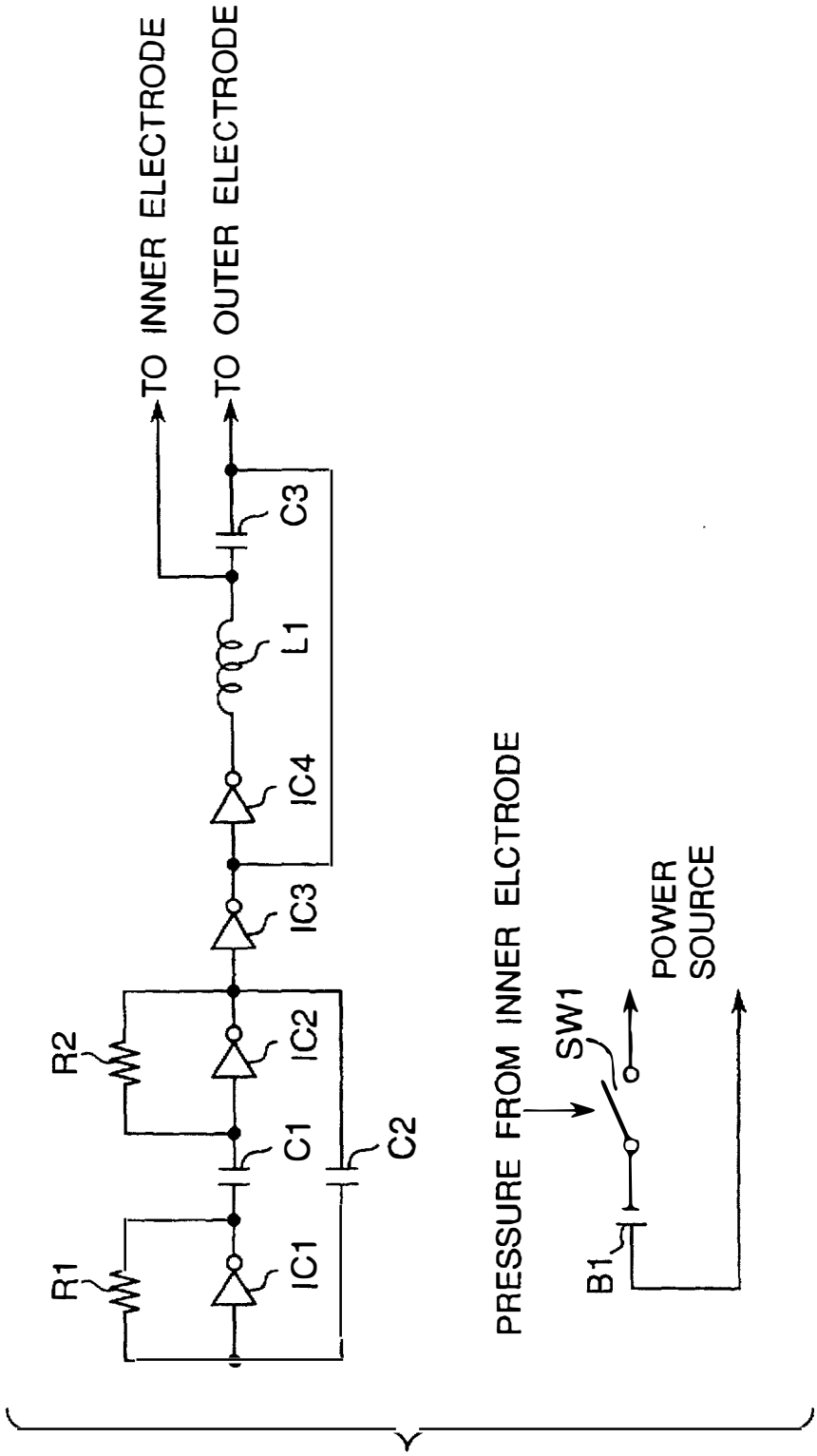

TO INNER ELECTRODE
TO OUTER ELECTRODE
C3
L1
IC4
IC3
R2
IC2
C1
C2
R1
IC1
PRESSURE FROM INNER ELCTRODE
SW1
POWER SOURCE
B1

Fig.30

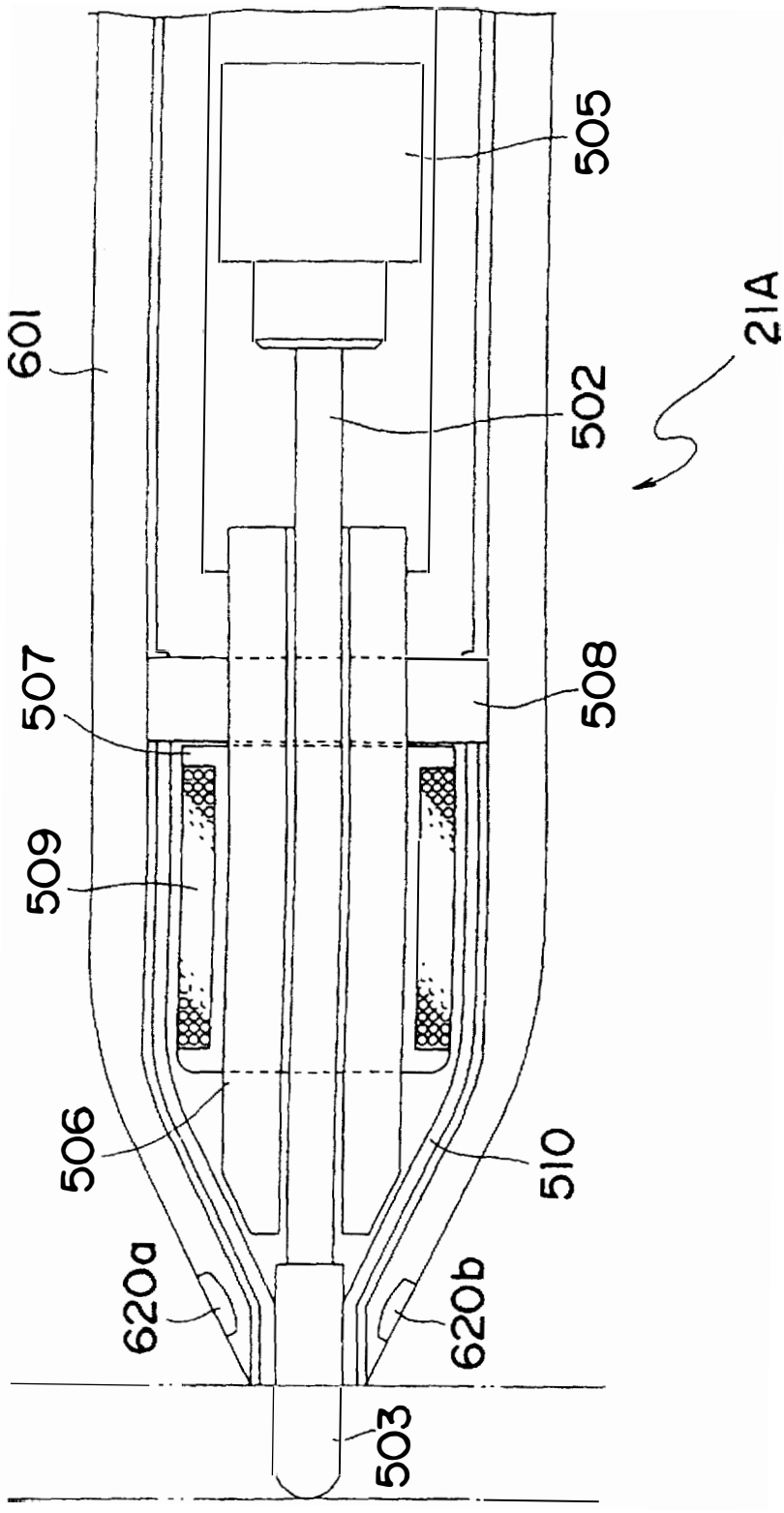


Fig. 31

Fig.32A

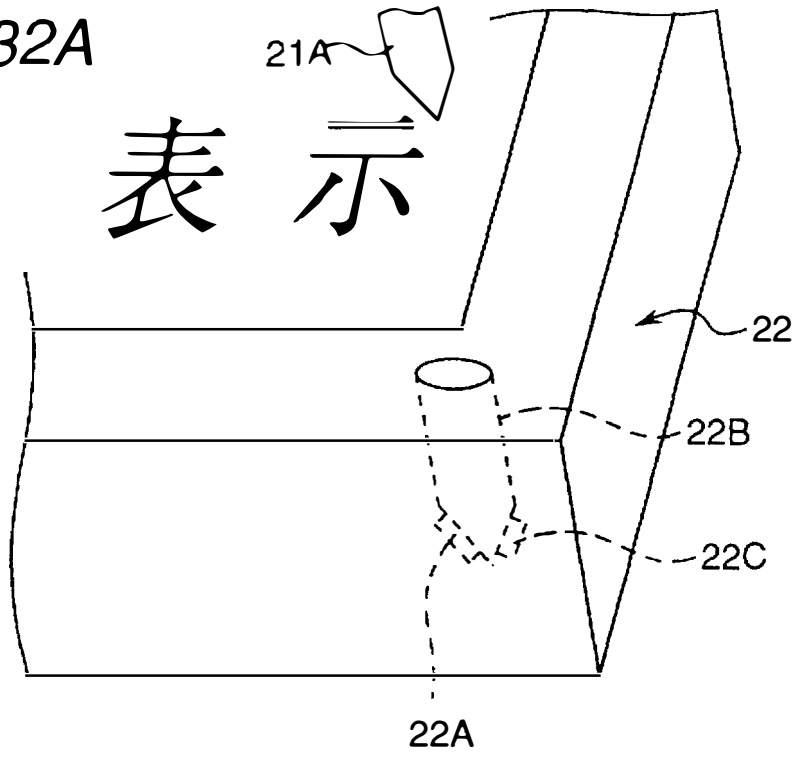


Fig.32B

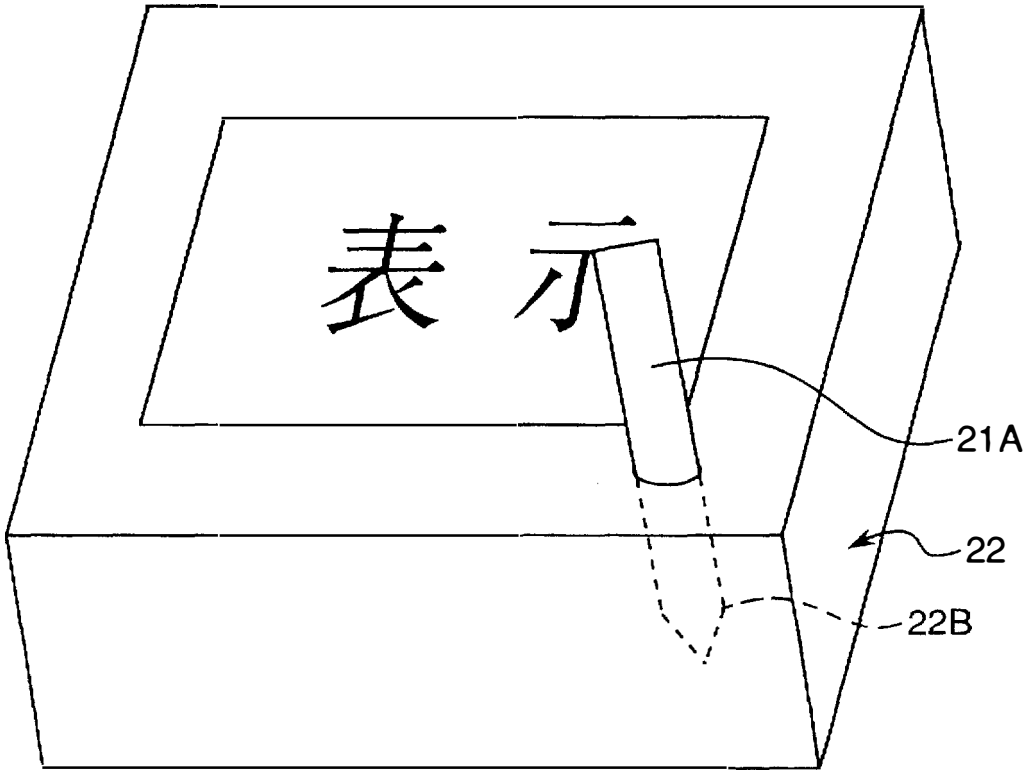


Fig.33A

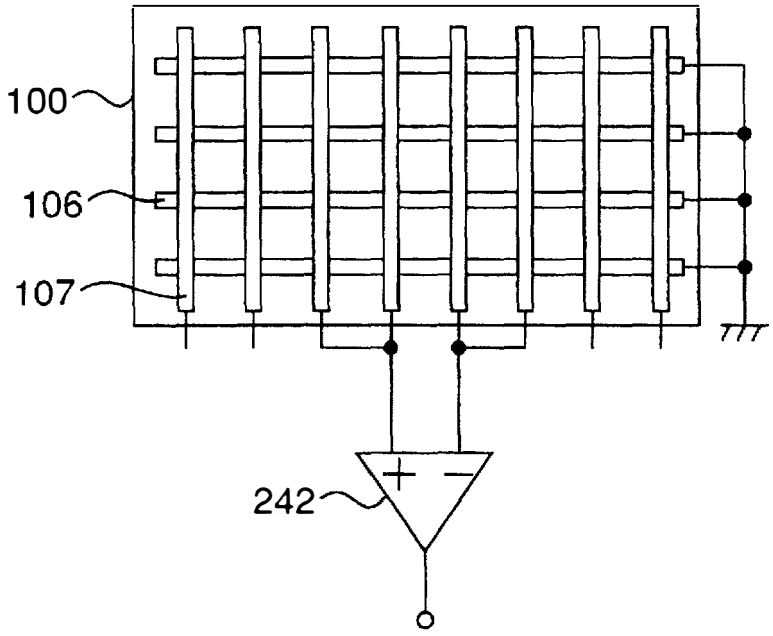


Fig.33B

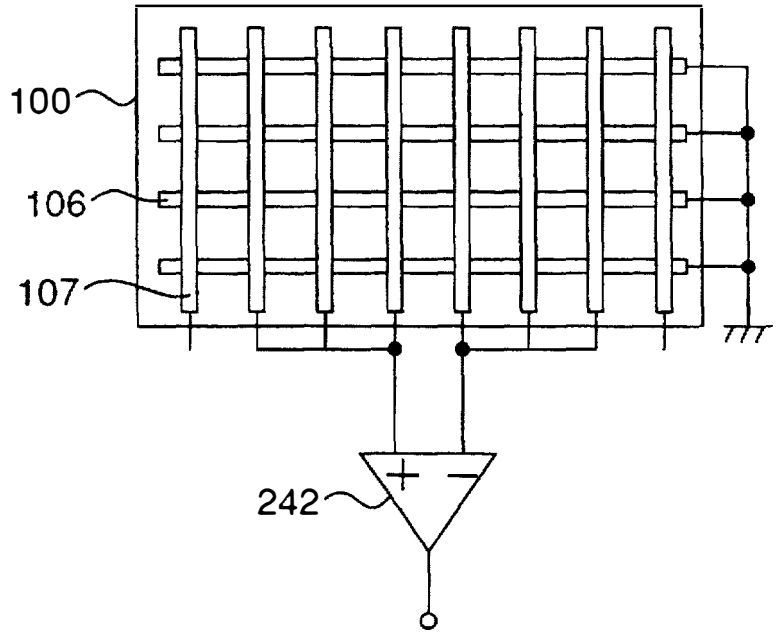


Fig.34A

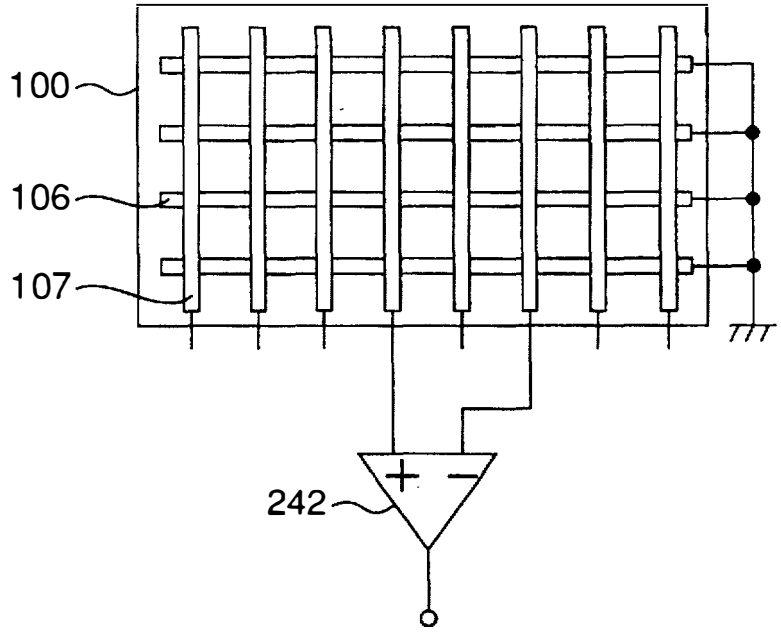


Fig.34B

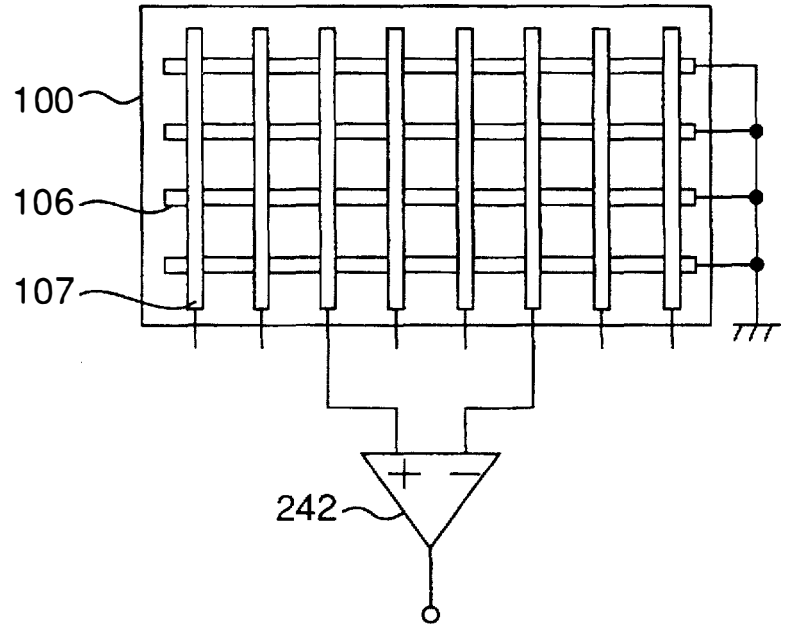


Fig.35A

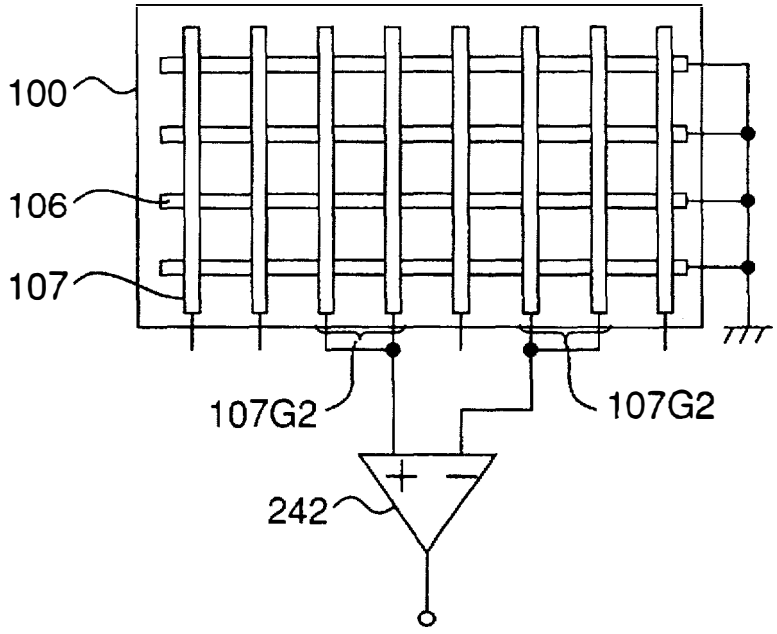


Fig.35B

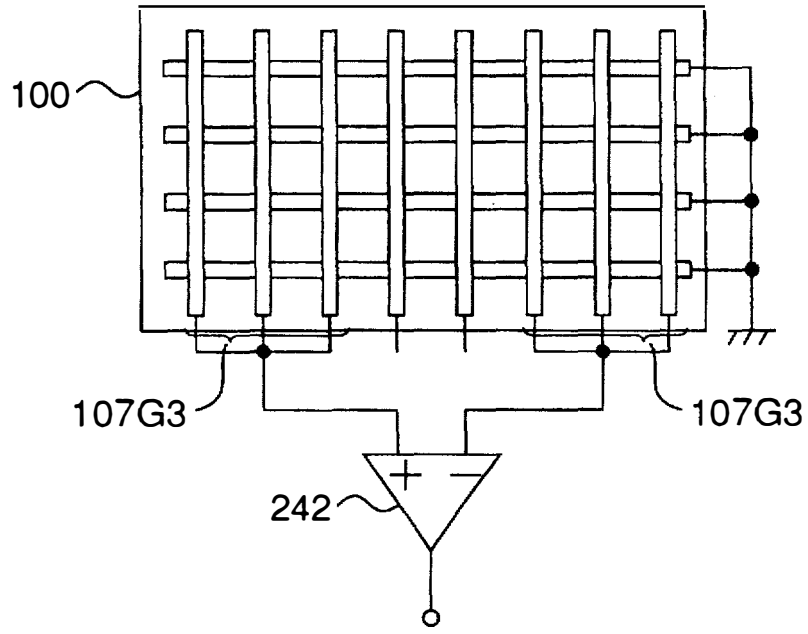
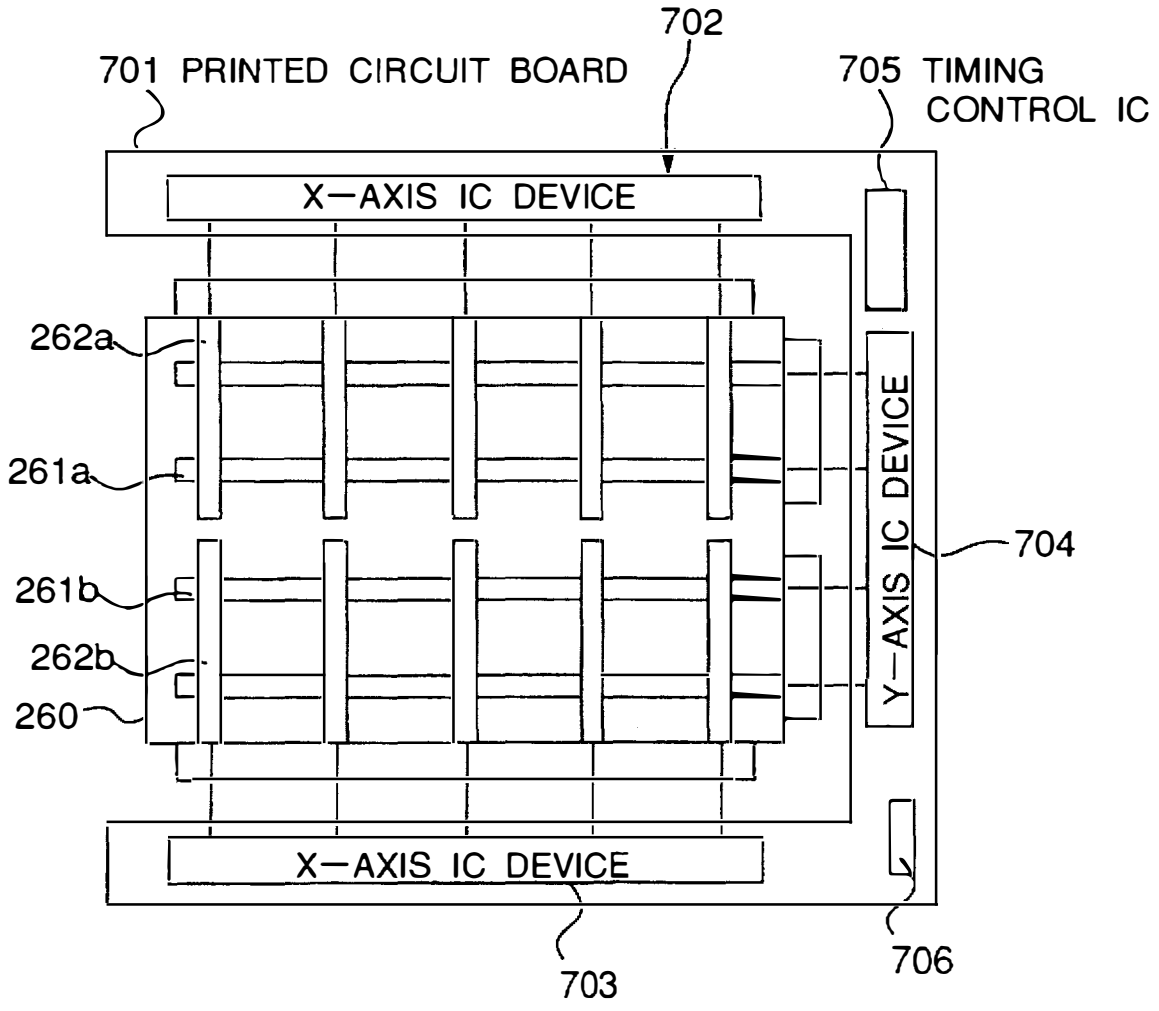


Fig.36


702
701 PRINTED CIRCUIT BOARD
705 TIMING CONTROL IC
X—AXIS IC DEVICE
262a
261a
261b
262b
260
Y—AXIS IC DEVICE
704
X—AXIS IC DEVICE
703
706

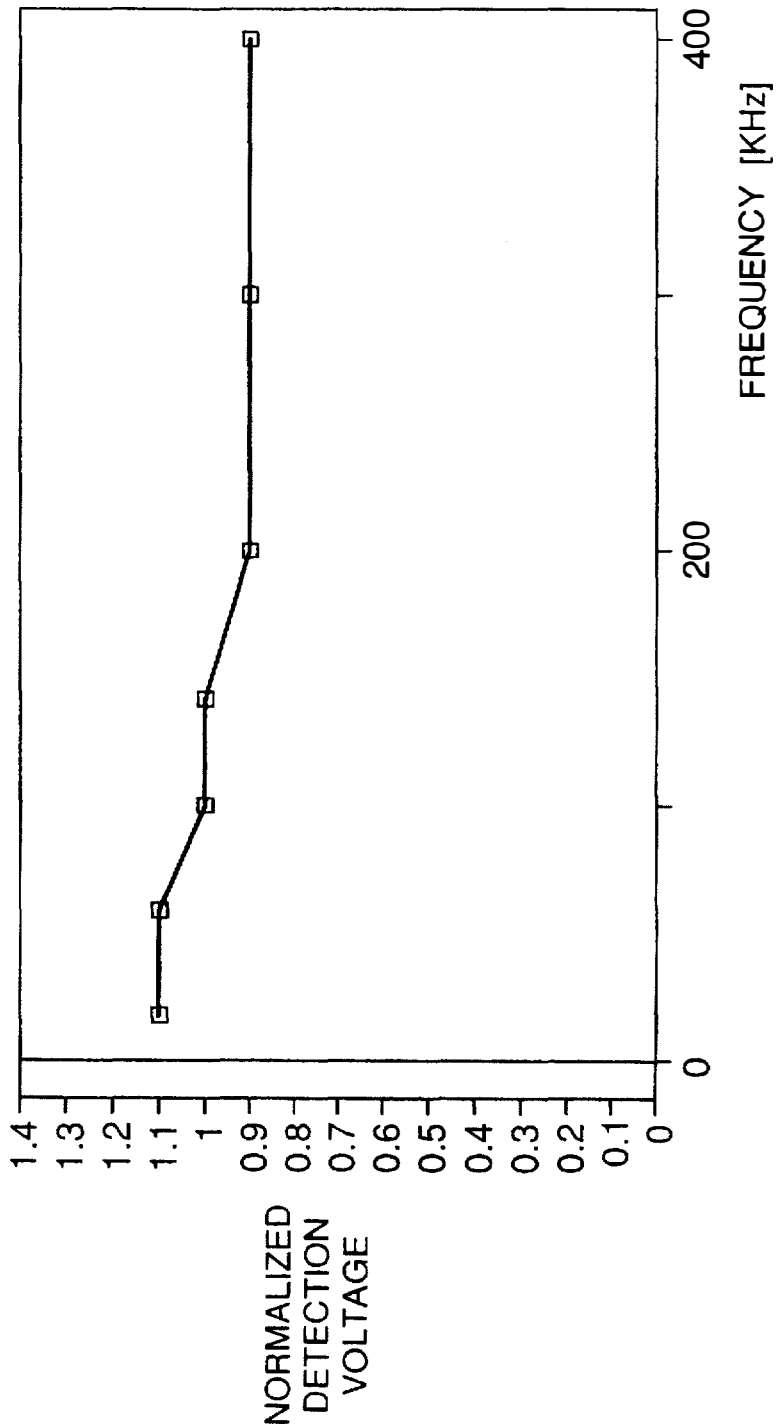

NORMALIZED DETECTION VOLTAGE
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
200
400
FREQUENCY [KHz]

Fig.37

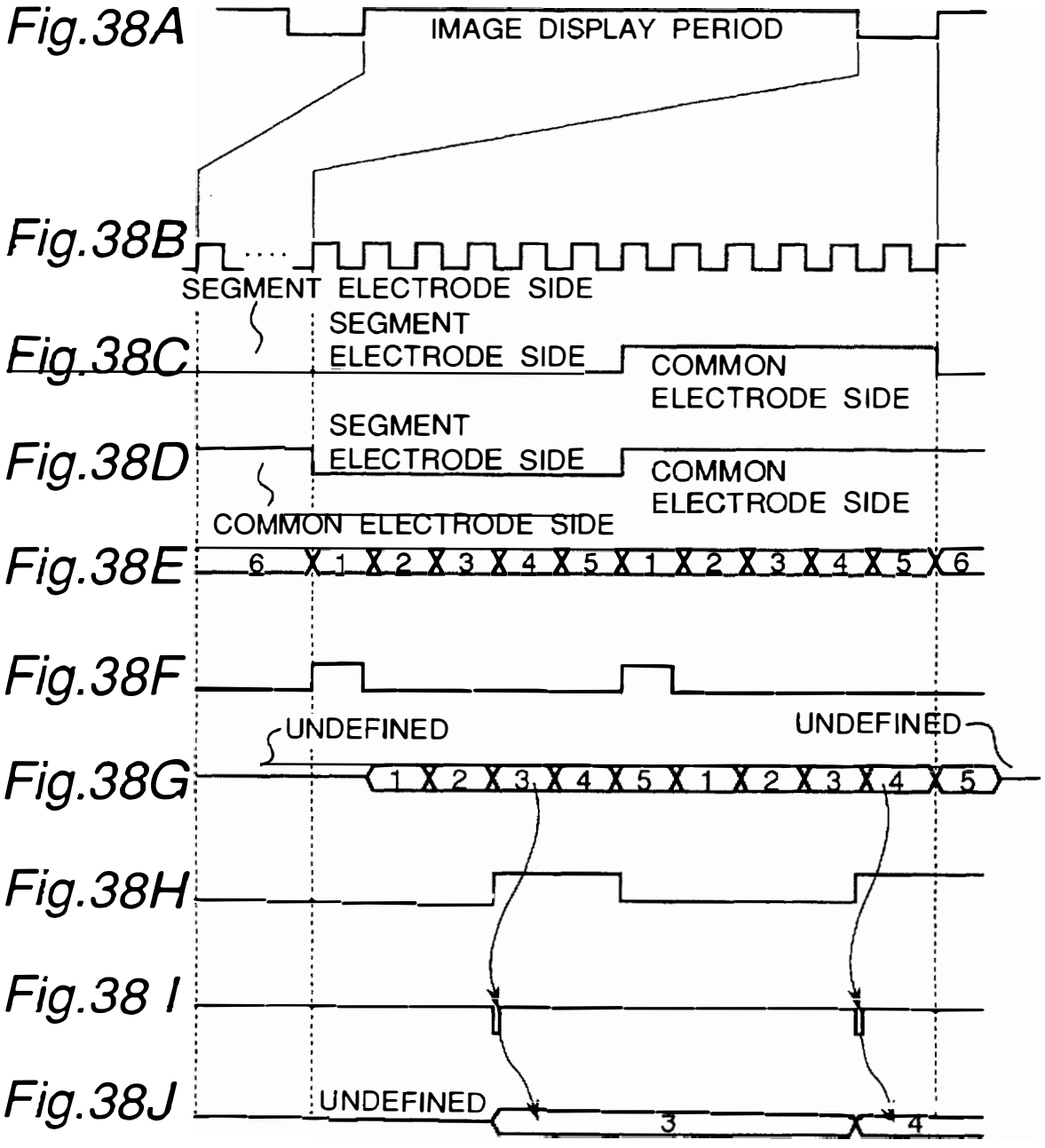

Fig.38A
IMAGE DISPLAY PERIOD
Fig.38B
SEGMENT ELECTRODE SIDE
Fig.38C
SEGMENT ELECTRODE SIDE
COMMON ELECTRODE SIDE
Fig.38D
SEGMENT ELECTRODE SIDE
COMMON ELECTRODE SIDE
COMMON ELECTRODE SIDE
Fig.38E
6 X 1 X 2 X 3 X 4 X 5 X 1 X 2 X 3 X 4 X 5 X 6
Fig.38F
Fig.38G
UNDEFINED
UNDEFINED
1 X 2 X 3 X 4 X 5 X 1 X 2 X 3 X 4 X 5
Fig.38H
Fig.38 I
Fig.38J
UNDEFINED
3
4

Fig.39

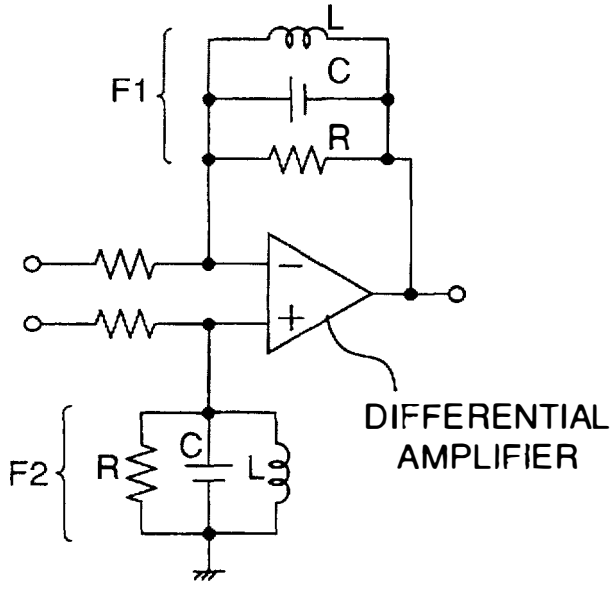

L
C
F1
R
DIFFERENTIAL
AMPLIFIER
F2
R
C
L

Fig.40

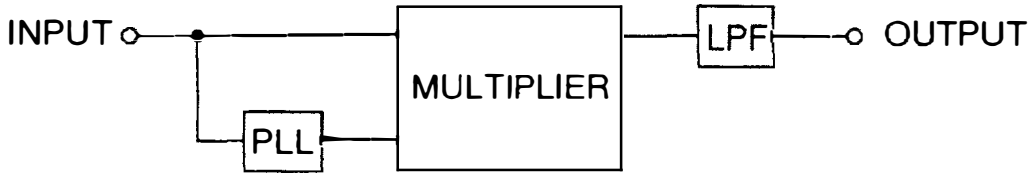

INPUT
MULTIPLIER
LPF
OUTPUT
PLL

Fig.41 PRIOR ART

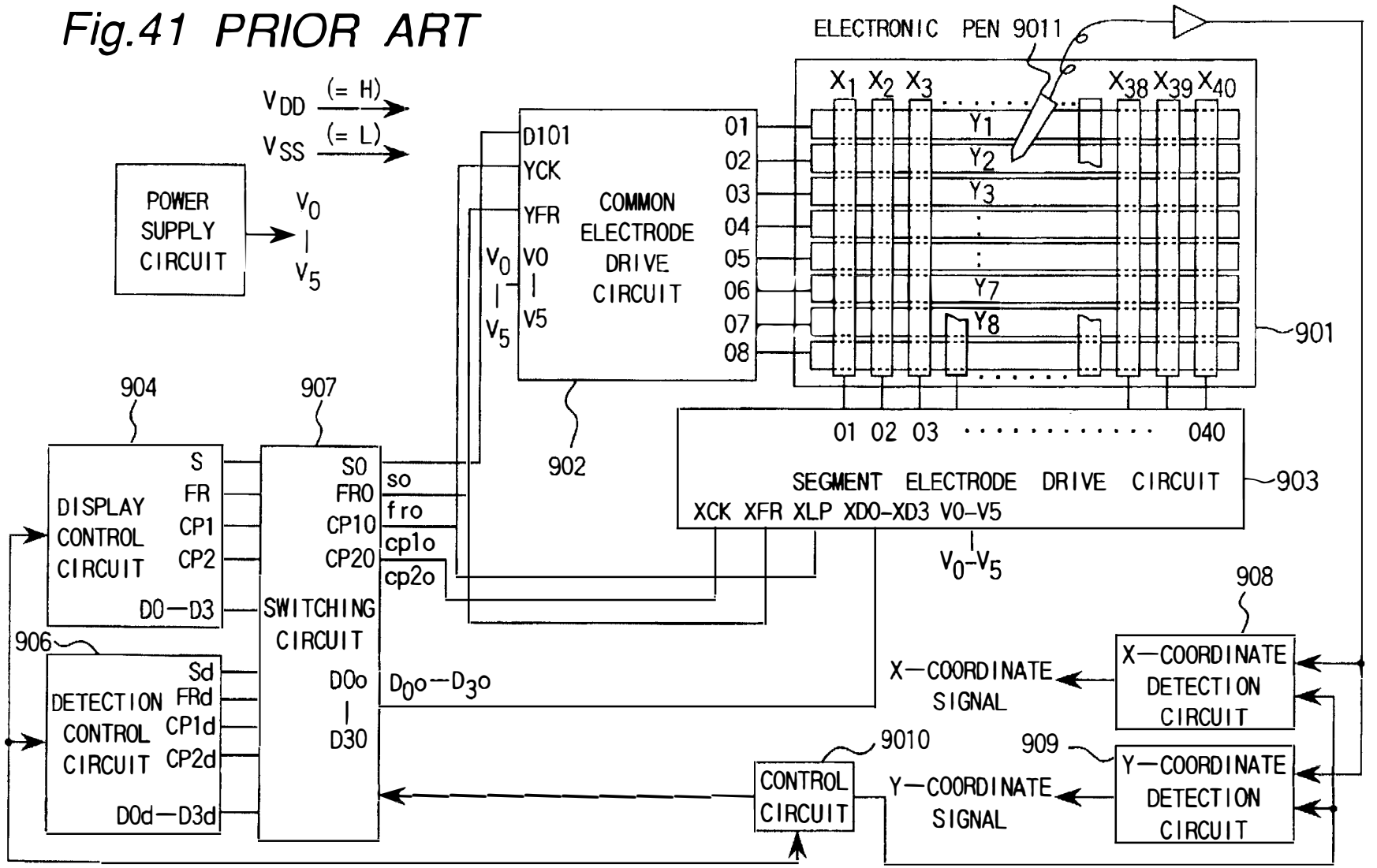


Fig.42 PRIOR ART

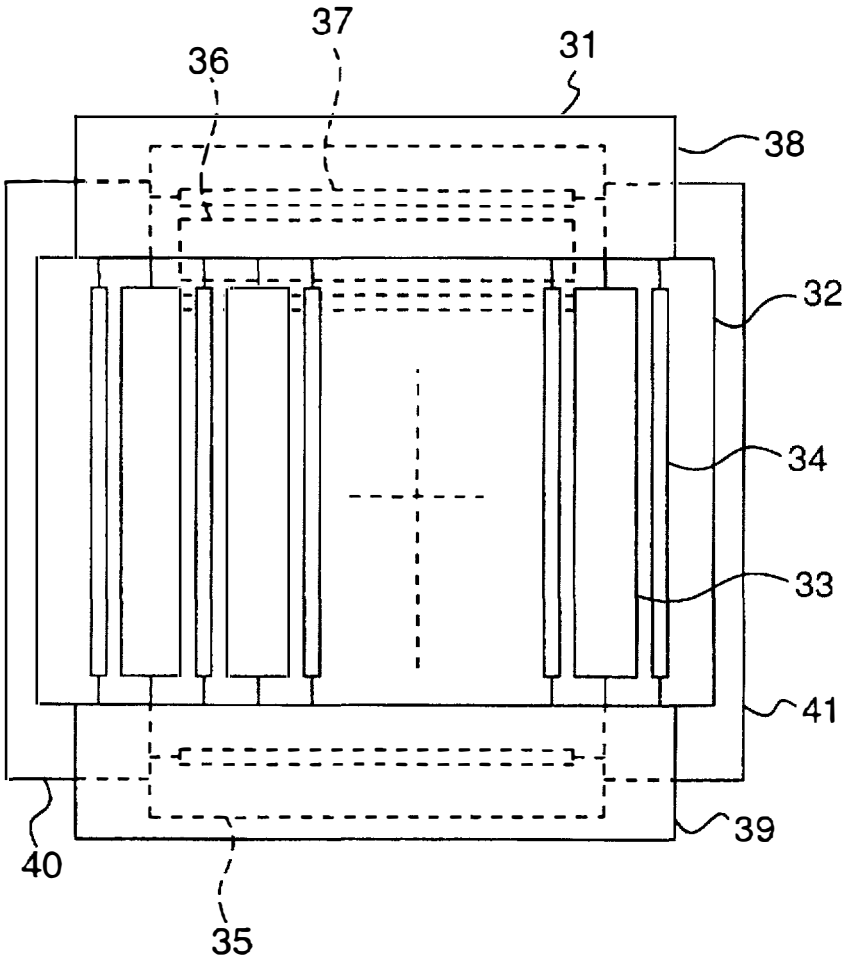


Fig.43 PRIOR ART

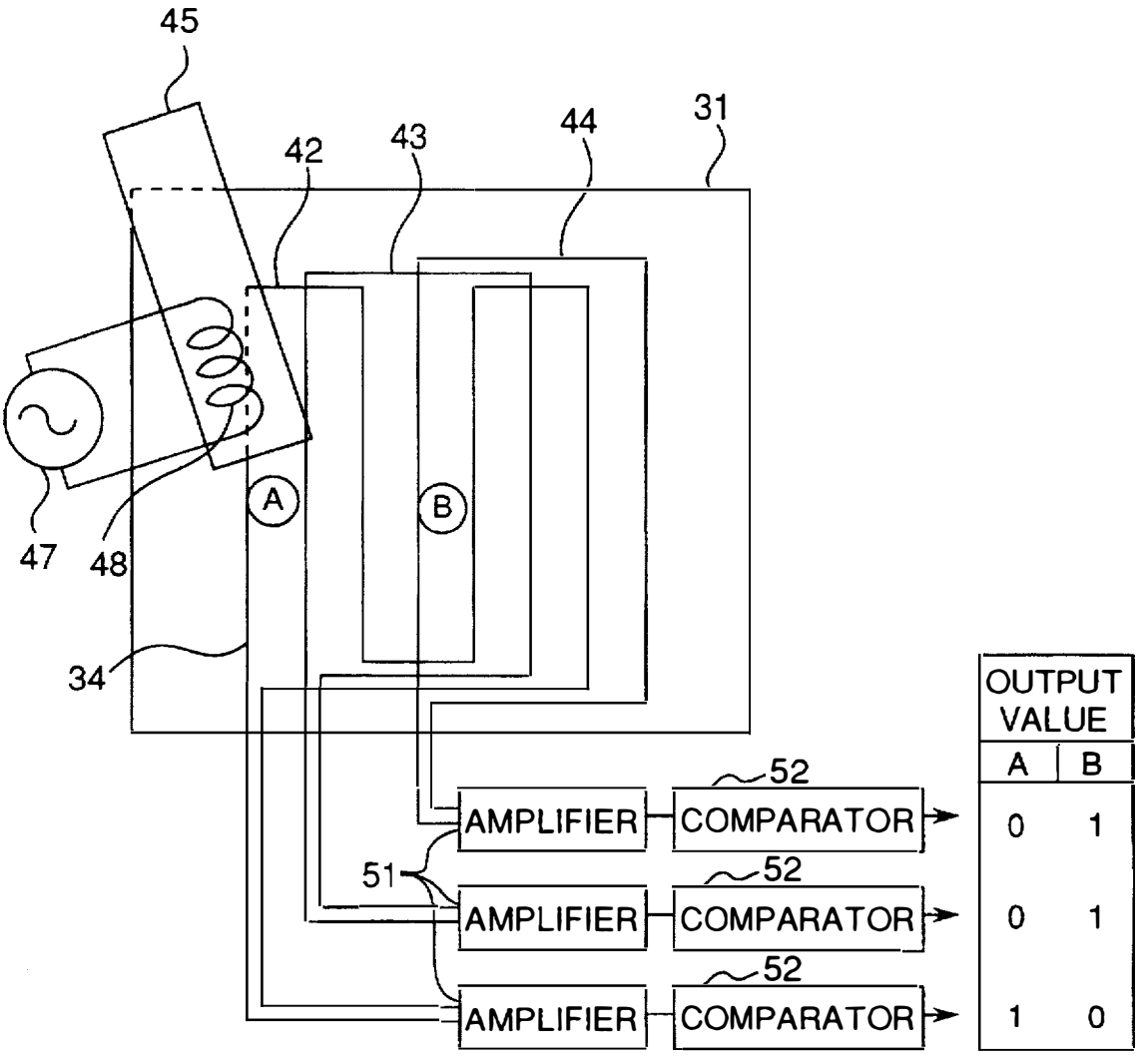


Fig.44 PRIOR ART

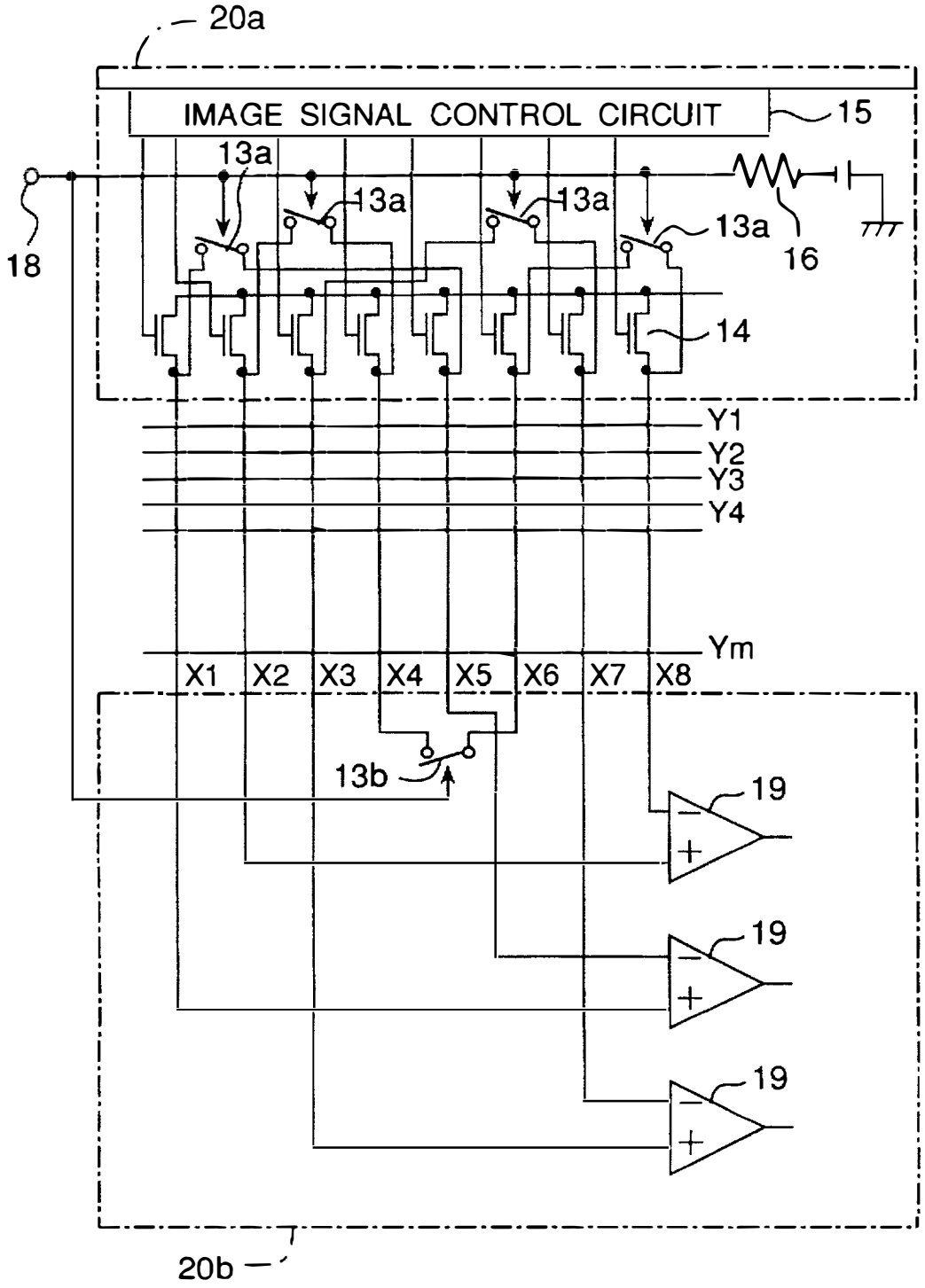


Fig.45 PRIOR ART

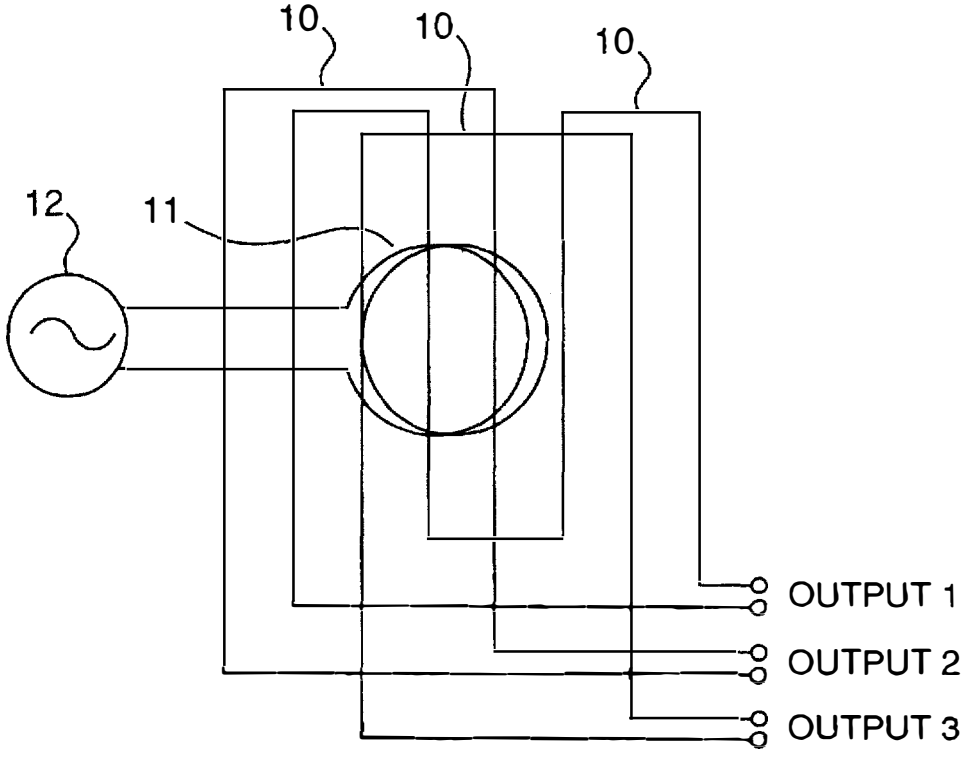


Fig.46A PRIOR ART



Fig.46B PRIOR ART



Fig.46C PRIOR ART



Fig.46D PRIOR ART

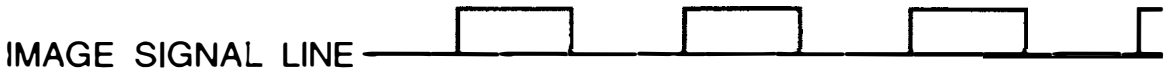
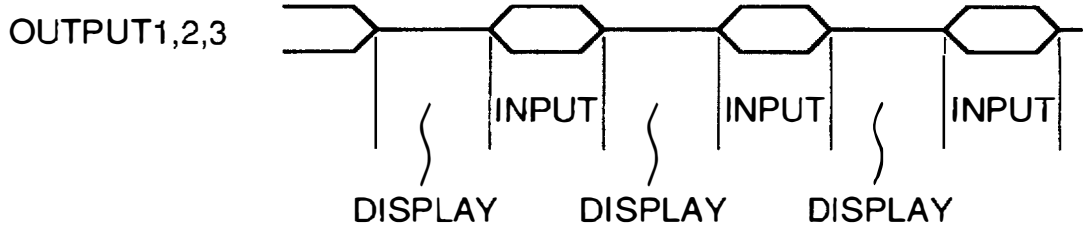


Fig.46E PRIOR ART



Fig.46F PRIOR ART



COORDINATE DETECTION DEVICE CAPABLE OF OBVIATING THE NEED OF FORMING CLOSED LOOP IN ELECTRODES THEREOF

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a coordinate detection device, and relates to a coordinate input function-integrated liquid crystal display (LCD) device for use as a man-machine interface provided by using, for example, an LCD panel having an electrode structure arranged in an x-y matrix form and making the LCD panel itself concurrently have a coordinate input function. In more detail, the present invention relates to a coordinate detection device which can be provided by using a conventionally used LCD panel as it is without making alterations. In particular, the present invention relates to a coordinate detection device which can concurrently use electrodes of an LCD panel as a part of a structure for using a coordinate input method with generation of an electric field. Further, the present invention relates to a coordinate detection means which effects an electric field generated from an electric field generating means provided separately from the LCD panel on the electrodes of the LCD panel and detects an induction voltage generated at the electrodes, thereby allowing the coordinates of the electric field generating means to be detected.

2. Description of the Prior Art

Man-machine interfaces in word processors and personal computers have achieved remarkable developments in recent years. In particular, there has been proposed a coordinate input function-integrated LCD device which uses a coordinate pointing device having an electronic structure as a pen and uses an LCD panel as a writing sheet, thereby allowing a letter or figure to be directly written on the display panel (refer to, for example, Japanese Patent Laid-Open Publication No. HEI 5-53726 as a first prior art).

The first prior art is a display-integrated type tablet device as shown in FIG. **41**. As shown in FIG. **41**, a switching circuit **907** is switched to a coordinate detection control circuit **906** side in a coordinate detection period under the control of a control circuit **9010** so as to select the control circuit **906**. Then, based on each signal from the detection control circuit **906**, a segment electrode drive circuit **903** generates a segment electrode operation signal to sequentially scan segment electrodes X of an LCD panel **901**. Subsequently, a common electrode drive circuit **902** generates a common electrode scanning signal to sequentially scan common electrodes Y. An x-coordinate detection circuit **908** and a y-coordinate detection circuit **909** detect respectively an x-coordinate value and a y-coordinate value at a tip end of an electronic pen **9011** based on an induction voltage induced at the tip end of the electronic pen **9011**. Meanwhile, in an image display period, the switching circuit **907** is switched to a display control circuit **904** side so as to select the display control circuit **904**. Consequently, an image is displayed on the LCD panel **901**.

Thus, according to the first prior art, a display-integrated type tablet device can be constructed.

In other words, according to the above-mentioned first prior art, a scanning voltage is applied to the LCD panel in the coordinate detection period so that the scanning voltage detects a voltage induced at the electronic pen to decide the coordinates of the electronic pen, and in the image display period, image display can be performed according to utterly the same principle of operation as that of the conventional LCD panel.

The above-mentioned arrangement enables incorporation of a coordinate input function by means of the electronic pen without making alterations in the conventional LCD panel.

Next, a second prior art (refer to Japanese Patent Laid-Open Publication No. SHO 54-24539) will be described. The second prior art is, as shown in FIG. **42**, exemplary of an LCD panel for use in a coordinate input function-integrated LCD device. In FIG. **42**, a reference numeral **31** denotes an LCD panel. The LCD panel **31** has a glass substrate **32** and a glass substrate **35**. On an inner surface of one glass substrate **32** are formed thick electrodes **33** for image display use and thin electrodes **34** for input coordinate detection use arranged alternately in an x-axis direction. On an inner surface of the other glass substrate **35** are formed thick electrodes **36** for image display use and thin electrodes **37** for input coordinate confirmation use arranged alternately in a y-axis direction perpendicular to the direction of the thick electrodes **33** and the thin electrodes **34**. A liquid crystal material is sealedly filled in a space between the two glass substrates **32** and **35**. Connectors **38** and **39** are attached to the glass substrate **32**, while connectors **40** and **41** are attached to the glass substrate **35**. The glass substrates **32** and **35** are connected to external circuits by way of the connectors **38**, **39**, **40** and **41**.

The second prior art is to concurrently perform coordinate input and image display by means of one LCD panel. The second prior art has two operation modes of an image display mode and an image input mode.

It can be considered that the second prior art operates in the image display mode by means of the thick electrodes **33** and **36** which are perpendicular to each other according to a principle of operation of a well-known dot matrix LCD. Now that LCD devices are widely used, it seems unnecessary to provide any special explanation for the image display.

Meanwhile, the second prior art operates in the coordinate input mode by forming, for example, three loops **42**, **43** and **44** in the x-direction in a manner as shown in FIG. **43** by means of the thin electrodes **34** and **37** formed on the LCD panel **31** shown in FIG. **42** and the connectors **38**, **39**, **40** and **41**. By forming the loops **42**, **43**, and **44**, x-coordinate values on the LCD panel **31** can be classified into 2^3 areas, i.e., eight areas.

When a magnetic field generator **45** including a coil **48** driven by an AC power source **47** is placed in a position denoted by a mark A in FIG. **43**, a magnetic field generated by the magnetic field generator **45** penetrates the loop **42**, resulting in generating an induction current through the loop **42**. Meanwhile, the above-mentioned magnetic field scarcely penetrates the other loops **43** and **44**, resulting in generating almost no induction current through the other loops **43** and **44**.

When the magnetic field generator **45** is placed in a position denoted by a mark B, a magnetic field generated by the magnetic field generator **45** penetrates the loops **43** and **44**, resulting in generating an induction current through the loops **43** and **44**. Meanwhile, the above-mentioned magnetic field scarcely penetrates the other loop **42**, resulting in generating almost no induction current through the other loop **42**.

Therefore, by connecting a specified amplifier **51** to each of the loops **42**, **43** and **44**, consistently observing the magnitude of an output current by means of a comparator **52**, and binarizing the magnitude of the output current from each loop by comparison with a threshold value to convert an I/O output obtained from each loop into a binary number,

Petitioner Shenzhen Qianfenyi Intelligent Technology Co., Ltd.
Exhibit 1005 Page 43

it can be decided which area of the aforementioned eight areas the magnetic field generator **45** is located in. For instance, the position denoted by the mark A is represented by 100, while the position denoted by the mark B is represented by 011, and therefore a table representing relationships between output values and positions is preferably used.

Position detection in the y-axis direction can be performed utterly in the same manner as in the above-mentioned position detection in the x-axis direction. Thus, by deciding two positions in the x-y-axes directions, the coordinates of the magnetic field generator **45** on the LCD panel can be detected.

As described above, in the second prior art, using the technique of forming a plurality of coils (loops), consistently observing the magnitude of the induction current induced in each coil (loop) from the magnetic field generator **45**, and specifying the position of the magnetic field generator, one LCD panel **31** can be concurrently used for coordinate input and image display.

As an improved device of the first and second prior arts, there is a third prior art ("coordinate input function-integrated LCD device" disclosed in Japanese Patent Laid-Open Publication No. SHO 61-286918). The coordinate input function-integrated LCD device of the third prior art includes, as shown in FIG. **44**, an LCD panel wherein electrodes X and Y are arranged in an x-y matrix form as a coordinate input display panel. FIG. **44** shows only eight electrodes X of the x-axis, and partially shows electrodes Y of the y-axis.

As shown in FIG. **44**, the third prior art includes bi-directional switching elements **13***a* and **13***b*. The switching elements **13** are used for the purpose of forming a loop-shaped coil with the electrodes on the device when the LCD panel is used as an input device. Control lines of the switching elements **13***a* and **13***b* are all connected to an I/O switching control line **18**.

The third prior art further includes switching elements **14** for use in a case where the LCD panel is used as an image display device. An image signal is supplied to the switching elements **14** by means of an image signal control circuit **15**, while a specific electric potential is applied to drain electrodes of all the switching elements **14** via a resistor **16**.

Differential amplifiers **19** amplify a weak induction current generated in the coil on the loop to a signal level which can be easily handled when the LCD panel is used as an input device.

The switching elements **13***a*, the switching elements **14**, and the image signal control circuit **15** are connected as an integrated circuit **20***a* to each electrode from an upper side of the panel, while the differential amplifiers **19** and the switching element **13***b* are connected as an integrated circuit **20***b* to each electrode from a lower side of the panel.

The third prior art also includes a structure of the electrodes of the y-axis similar to that of the electrodes of the x-axis.

Next, an operation of the coordinate input function-integrated LCD device of the third prior art will be described with reference to FIG. **44**. First, in an image display operation, the I/O switching control line **18** is turned off, while the switching elements **13***a* and **13***b* are all turned off. Consequently, x-axis electrodes X1, X2, X3 and Xm are all put in independent states. Then, an image signal is supplied to the gate electrodes of the switching elements **14** by the control circuit **15**, and an electric potential is given to an electrode connected to the switching element which is turned on by the image signal.

In synchronization with the above-mentioned operation, y-axis electrodes Y1, Y2, Y3 and Ym are controlled so that any one of them is put in a conductive or "on" state. In the above-mentioned stage, the LCD panel performs an image display operation according to the same principle of operation as that of the generic dot matrix type LCD device.

Next, in an input operation, the I/O switching control line **18** is turned on, and the switching elements **13***a* and **13***b* are all turned on. Consequently, the x-axis electrodes X1, X2, X3 and Xm form loop electrodes **10** arranged in a manner as shown in FIG. **45**. Further, all the image signals from the image signal control circuit **15** are outputted in a non-conductive or "off" state, and the switching elements **14** are all turned off.

In FIG. **45**, a reference numeral **11** denotes a cursor coil and a reference numeral **12** denotes an AC signal source. In the present case, when the cursor coil **11** is driven by the AC signal source **12**, an induction current flows through the electrode **10** connected in a loop form by an AC magnetic field exerted from the cursor coil.

By detecting the induction current, it can be detected which of the electrodes of the x-axis the cursor coil is located most nearly. A principle of operation similar to the principle of detection is also disclosed in the aforementioned second prior art (Japanese Patent Laid-Open Publication No. SHO 54-24539).

Furthermore, in the third prior art, it is proposed to time-sharingly use the input and the output so as to make the LCD panel have the above-mentioned structure inclusive of a peripheral circuit, thereby making it an input-output integrated device. FIG. **46** shows an exemplified timing chart of the above-mentioned structure.

In the above-mentioned example, a y-axis electrode Yp is turned on for image display. Then, while an adjacent electrode Yp+1 is turned on, an I/O switching control terminal is turned on, and the switching elements **14** are all turned off by the control circuit **15**, thereby allowing an input operation to be performed to obtain position data. Subsequently, the y-axis electrode Yp+1 is turned on to enter into an image display operation. Thus the image display operation and the input operation are repeated alternately time-sharingly.

As described above, the third prior art has a peripheral circuit which can perform a control operation so as to short-circuit the ends of the electrodes for image display of the LCD panel when the panel is used as an input device, thereby allowing the electrodes to be connected in an appropriate loop form. When the panel is used as an input device, the peripheral circuit is operated to form a plurality of electrode loops, and an induction current generated in each loop when a magnetic field generated from magnetic field generating means separately provided for each loop is effected is consistently observed so as to obtain the coordinates of the magnetic field generating means.

What is common to the third prior art and the second prior art is the scheme of using one LCD panel concurrently for coordinate input and image display as well as the principle of coordinate detection itself for dividing in position the panel by means of a plurality of loop-shaped coils, consistently observing at each coil an induction current generated when a magnetic field generator is effected on the coils, and representing the coordinates of the magnetic field generator by a string of binary numbers. A further common factor is a variety of problems (described hereinafter) which commonly occur due to use of the common principle of detection.

As shown in the third prior art, the coordinate input technique itself for detecting the coordinate position of the

magnetic field generator by detecting an induction current flowing through a loop when a magnetic field generated from the magnetic field generating means is effected on a plurality of electrode lines connected in loop forms is a well-known technique.

The third prior art differs from the second prior art if compared in that no special electrode for coordinate detection is required to be formed on the LCD panel in the third prior art and in that a special peripheral circuit is required for concurrent use of the electrodes for image display as a coordinate detection electrode in the third prior art.

The aforementioned first prior art and second prior art are common in the point that the coordinate detection is performed by means of an LCD panel and an electronic pen. However, they differ from each other in that the former utilizes signal transmission from the LCD panel to the electronic pen whereas the latter utilizes signal transmission from the electronic pen to the LCD panel.

The aforementioned first prior art uses the LCD panel as a signal generator, and detects a signal induced at the electronic pen from the LCD panel to detect the coordinates of the electronic pen on the LCD panel. Therefore, in the first prior art, it is indispensable to transmit an output signal induced at the electronic pen from the electronic pen to a signal processor. The above-mentioned matter is a serious obstacle in an attempt at compactly forming the electronic pen. The above is because the electronic pen is required to be provided with a wired or wireless signal transmission means in order to transmit the signal from the electronic pen to the signal processor. For instance, when the signal is transmitted by wire, an appropriate lead wire for signal transmission is necessary. It is apparent that the lead wire is a serious obstacle in use. When a wireless transmission is performed, there is also an advantage that no lead wire is necessary, however, a wireless transmitter for the signal must be incorporated for the above-mentioned purpose. In such a case, for example, when the electronic pen is entirely operated on a battery, it is apparent that a power consumption of the wireless transmitter is a weighty factor in regard to the operating life of the battery, thus being accompanied by a problem that a significant reduction of the operating life of the battery may be incurred. There is also a problem that it is difficult to mount a necessary wireless transmitter circuit into a small space inside the electronic pen.

In contrast to the above, in the second prior art, since a magnetic signal generated by the electronic pen is processed by the LCD panel, there is required no connection cable for transmitting the signal detected by the electronic pen.

However, in the second prior art, it is required to form a loop by short-circuiting the ends of the adjoining electrodes of the LCD panel in the input stage in order to achieve an input function and an image display function by means of a single LCD panel, and it is required to open the aforementioned loop in the image display stage. Therefore, an LCD panel control circuit owned by an image display/coordinate input function integrated device in the second prior art has a problem that a switching element having a specific bi-directionality which is not necessary in an LCD panel control circuit owned by an LCD device for performing only image display must be additionally incorporated.

It has been a long time since the industry relevant to the liquid crystal techniques is called an equipment industry. In other words, the liquid crystal techniques belong to an industry having a close relation to a manufacturing equipment. Thus, it tends to be considered that incorporation of a new element as described above can be put into practice very easily by concurrently fabricating such an element. However, the reason why a great amount of semiconductor elements have been conventionally able to be concurrently fabricated is because circuit requirements to the semiconductor elements have been on the same basis, and therefore the required characteristics are consistent. Conversely, it can be said that an expensive equipment can be effectively operated since such a great amount of semiconductor elements having consistent characteristics are concurrently fabricated.

In contrast to the above, the switching element to be newly incorporated, if it is to be incorporated through concurrent fabrication, not only requires circuit requirements significantly different from those of the semiconductor elements which have been conventionally incorporated through concurrent fabrication but also has characteristics quite different from those of the semiconductor elements. To incorporate such a specific semiconductor element newly into an LCD panel increases the amount of development processes of the LCD panel, and this directly connects to reduction of yield and significant cost increase.

Furthermore, according to the technique of the third prior art, it has been required to concurrently connect integrated circuits comprised of a switching element and a control circuit, as represented by the integrated circuits **20***a* and **20***b* in FIG. **44**, to the LCD panel at the four sides of the panel. (Although the integrated circuits are connected to the LCD panel longitudinally at two sides in FIG. **44** because only a structure related to the x-axis electrodes is shown. However, since a similar structure is required for the y-axis electrodes, consequently it is required to concurrently connect integrated circuits to the electrodes in four directions, i.e., from the upper, lower, right, and left sides of the panel.) Therefore, an LCD panel for use in such an image display/coordinate input function integrated device is required to be provided with tab connection terminals at the four sides.

In contrast to the above, a generally used LCD panel which performs only image display has a structure in which tab connection terminals are wired from two or three sides of the panel. Therefore, in the aforementioned second prior art, such a generally used LCD panel which performs only image display cannot be applied as it is to the image display/coordinate input function integrated device without making alterations.

Therefore, it is of course possible to develop specially for the image display/coordinate input function integrated device an LCD panel which can newly lead tab connection terminals in four directions from the four sides thereof and can be directly applied to the second prior art. However, for the above-mentioned purpose, a huge amount of investment for an equipment is of course required, which is a serious problem in developing the industry.

Collectively speaking, since the above-mentioned second prior art requires addition of a coordinate input function to a display panel, it is required to newly develop an LCD panel specially for an image display/coordinate input function integrated device by making alterations in the LCD panel itself. Furthermore, in the second and third prior arts, since the tab connection terminals wired from the LCD panel are connected to a printed circuit board mounted with an integrated circuit **20** and so forth, it is required to lead tab connection terminals in four directions from the four sides of the LCD panel. Therefore, in the LCD panel to be used in the third prior art, an occupation area of a printed circuit board included in the LCD panel, or so-called a peripheral edge portion of the LCD panel is dimensionally increased more

than in the conventional LCD panel which performs only image display while allowing tab connection terminals to be wired from only two or three sides. The above-mentioned arrangement results in a problem that the image display/coordinate input function integrated device as a product including the LCD panel is dimensionally increased.

Eventually, it can be considered that the techniques which have been conventionally proposed are all hardly implemented or wasteful in terms of both LCD panel manufacturing cost and application forms of final products.

SUMMARY OF THE INVENTION

The object of the present invention is therefore to provide a coordinate detection device capable of solving the aforementioned problems of the prior arts.

That is, the object of the present invention is to provide a coordinate detection device which obviates the need of newly incorporating into an LCD panel any switching element which has a specific bi-directionality and is capable of switching, and obviates the need of providing a tab connection terminal at four sides of the LCD panel.

That is, the object of the present invention is to provide a coordinate detection device capable of being applied to a device integrated with both an image display function and a coordinate input function without making alterations in an LCD panel which has been conventionally used specially for image display, preventing the increase of development cost and the reduction of yield, and dispensing with investment for equipment which may cause cost increase, thereby totally contributing to development of the industry.

In order to achieve the aforementioned object, there is provided a coordinate detection device comprising: a panel which is provided for coordinate detection and includes a first electrode and a second electrode extending in a direction crossing a direction in which the first electrode extends; a coordinate pointing device which includes an alternating current oscillator and an electrode and outputs from a tip end portion of the electrode an alternating current electric field generated by the alternating current oscillator; a differential amplifier; switching means for sequentially changing connection of the electrodes of the panel so as to sequentially select the electrodes and electrically connect each selected electrode to the differential amplifier; and coordinate detection means for detecting coordinates based on a timing at which the electrodes are selected and an output of the differential amplifier.

In the coordinate detection device of the present invention, the AC generator of the coordinate pointing device outputs an AC electric field from the tip end of the electrode. When the outputted AC electric field effects on the first and second electrodes of the panel, a voltage corresponding to the amplitude of the AC electric field is generated at the first and second electrodes.

Meanwhile, the switching means sequentially switches the connections of the first and second electrodes of the panel so as to connect the selected electrodes to the differential amplifier. Therefore, when the first and second electrodes at which the voltage is induced are each connected to the differential amplifier, the differential amplifier amplifies the induction voltage and outputs the resulting voltage.

The voltage outputted from the differential amplifier is inputted to the coordinate detection means. Then, the coordinate detection means detects the coordinates of the coordinate pointing device on the panel based on the timing at which the first and second electrodes are each selected and the output of the differential amplifier.

Therefore, according to the present invention, the coordinates of the coordinate pointing device can be detected without necessitating a signal line between the coordinate pointing device and the panel. Furthermore, the coordinates of the coordinate pointing device can be detected according to the voltage induced at the first and second electrodes by an electric field generated from the coordinate pointing device. Therefore, the first and second electrodes are not required to form a closed loop. Therefore, an LCD panel provided specially for image display can be used as the above-mentioned panel without making alterations. Furthermore, according to the present invention, the first and second electrodes are not required to form a closed loop, and therefore a coordinate detection function can be incorporated into the LCD panel provided specially for image display without providing an electric circuit opposite to the four sides of the LCD panel provided specially for image display. The above-mentioned fact means that the coordinate detection function can be incorporated into the image display device without increasing the size of the image display device having the LCD panel provided specially for image display, and also means that an image display device having a coordinate detection function can be manufactured without making great alterations in the existing manufacturing equipment for the image display device.

Therefore, according to the present invention, there can be provided a coordinate detection device capable of preventing the increase of development cost and the reduction of yield, and dispensing with investment for equipment which may cause cost increase, thereby totally contributing to development of the industry.

Furthermore, according to the present invention, a signal from the electrodes of the panel is amplified in the differential amplifier. The above-mentioned arrangement has an advantage that external noises which have entered evenly into two inputs of the differential amplifier can be effectively removed.

Furthermore, according to an embodiment, a material having an electro-optical effect is sealedly filled in a space between two substrates, and the first and second electrodes are arranged on the substrates while making the first and second electrodes concurrently serve as electrodes for image display.

With the above-mentioned arrangement, a display panel which has concurrently the coordinate detection function and the image display function can be provided.

Furthermore, according to an embodiment, the coordinate pointing device outputs electric fields which are opposite in phase to each other from its first and second electrodes to which electric fields being opposite in phase to each other are applied from the oscillator.

Therefore, the electrode of the panel receiving the electric field from the first electrode outputs an electric field opposite in phase to the electric field outputted from the electrode of the panel receiving the electric field from the second electrode. Therefore, electric fields which are opposite in phase to each other are applied to the differential amplifier. Therefore, the coordinate detection means can detect a state in which the electrodes of the coordinate pointing device are located in the position of the panel electrode selected by the switching means upon detecting a discontinuity of the signal outputted from the differential amplifier occurring when the electric fields which are opposite in phase to each other are applied to the differential amplifier.

Furthermore, according to an embodiment, the first electrode of the coordinate pointing device is a cylinder-shaped

electrode, while the second electrode of the coordinate pointing device is a rod-shaped electrode arranged inside the cylinder-shaped electrode. Therefore, even when the coordinate pointing device is rotated around center axis of the rod-shaped electrode, unchanged electric fields are applied from the coordinate pointing device to the electrodes of the panel. Therefore, the electric fields applied to the electrodes of the panel are not changed by the above-mentioned rotation irrelevant to the coordinates to be detected, thereby allowing an improved coordinate detection accuracy to be achieved.

Furthermore, according to an embodiment, the first electrode of the coordinate pointing device is arranged as separated apart at approximately regular intervals around the circumference of the second electrode. Therefore, the rotation of the coordinate pointing device around the center axis does not change the electric fields applied to the electrodes of the panel, thereby allowing an improved coordinate detection accuracy to be achieved.

Furthermore, according to an embodiment, the coordinate pointing device has a battery storing section for storing therein a battery which serves as a power source for the AC oscillator.

Therefore, by storing the battery in the battery storing section, there is no need to supply an electric power to the coordinate pointing device from outside the coordinate pointing device. Therefore, the coordinate pointing device is permitted to be connected to nothing. The above-mentioned arrangement allows a complete codeless coordinate pointing device to be achieved.

In an embodiment, the coordinate pointing device comprises a battery storing section for storing therein a secondary battery which serves as a power source for the alternating current oscillator and a charging terminal to be electrically connected to the secondary battery when the secondary battery is stored in the battery storing section, and wherein a casing to which the panel is mounted is provided with a storing portion for storing the coordinate pointing device, and a power supply terminal which can supply an electric power to the charging terminal while being electrically connected to the charging terminal of the coordinate pointing device when the coordinate pointing device is stored in the storing portion.

According to the above-mentioned embodiment, when the coordinate pointing device is stored in the storing portion provided at the casing to which the panel is mounted, the charging terminal owned by the coordinate pointing device and the power supply terminal of the casing are electrically connected to each other. Therefore, in the above-mentioned time, the secondary battery stored in the battery storing section of the coordinate pointing device is charged. Therefore, the operating life of the battery which is the power source of the coordinate pointing device can be remarkably increased.

Furthermore, according to an embodiment, a resonance circuit which resonates with the AC electric field generated by the AC oscillator is connected across the output terminal and the inverted input terminal of the differential amplifier.

Therefore, the differential amplifier can selectively amplify the AC electric field with a great gain. Therefore, an improved coordinate detection sensitivity can be achieved.

According to an embodiment, the switching means selects at least one pair of adjoining electrodes so as to connect the selected electrodes to the differential amplifier, and shifts the selected electrodes one by one in the direction in which the electrodes are arranged.

Therefore, by shifting the selected electrodes, the coordinate pointing device is, so to speak, searched to allow the position coordinates of the coordinate pointing device located in the area where the electrodes are arranged to be securely detected.

Furthermore, according to an embodiment, the switching means selects a pair of adjoining electrodes of the panel, and shifts the selected pair of electrodes one by one in the direction in which the electrodes are arranged.

Therefore, the selection can be achieved in a manner simpler than that of the above-mentioned embodiment, thereby allowing the structure of the switching means to be simplified.

In an embodiment, the switching means has a first terminal to be connected in parallel with two or more adjoining electrodes and a second terminal to be connected in parallel with two or more electrodes adjacent to the electrodes connected to the first terminal, and shifts connection of the electrodes to the first terminal and connection of the electrodes to the second terminal one by one in a direction in which the electrodes are arranged.

According to the above-mentioned embodiment, the switching means has the first terminal connected in parallel with two or more adjoining electrodes and the second terminal connected in parallel with two or more electrodes adjacent to the electrodes connected to the first terminal. Therefore, by electrically connecting the first terminal and the second terminal to the differential amplifier, four or more electrodes which are receiving the AC electric fields outputted from the electrodes of the coordinate pointing device can be connected to the differential amplifier. Therefore, an improved detection sensitivity can be achieved in comparison with the case where only two electrodes of the panel are connected to the differential amplifier.

In an embodiment, the coordinate detection means comprises: envelope extraction means for receiving an output from the differential amplifier and extracting an envelope of the output; bottom detection means for receiving a double-humped output from the envelope extraction means and detecting a bottom portion of the output; time counting means for specifying a bottom portion detection time at which the bottom detection means detects the bottom portion; and position coordinate specifying means for specifying coordinates representing a position of the coordinate pointing device on the panel based on the bottom portion detection time specified by the time counting means and a timing at which the electrodes are selected.

According to an embodiment, the envelope of the output from the differential amplifier is extracted by the envelope extraction means, and a bottom portion of the double-humped output from the envelope extraction means is detected. Then, based on the time at which the bottom portion is detected and the timing at which the switching means selects the electrodes of the panel, the coordinates representing the position of the coordinate pointing device are specified. Thus, according to the present embodiment, a characteristic double-humped signal is outputted from the envelope extraction means, and by detecting the bottom portion of the double-humped envelope waveform, coordinate detection can be achieved. Furthermore, in order to specify the coordinates, a signal obtained by removing unnecessary signal components therefrom and being subjected to an envelope detection process is used, and therefore the detection of the bottom portion can be easily achieved.

Furthermore, according to an embodiment, a synchronous detector is provided as the envelope extraction means. The

synchronous detector can extract the envelope of the signal without distortion more correctly than the envelope detector, and therefore an improved coordinate detection accuracy can be achieved.

In an embodiment, the coordinate detection means comprises: a first envelope detector which has a relatively great time constant and operates to receive an output from the differential amplifier and detect an envelope of the output; a second envelope detector which has a relatively small time constant and operates to receive an output from the differential amplifier and detect an envelope of the output; bottom detection means for subjecting a double-humped output from the first envelope detector and a double-humped output from the second envelope detector to a subtraction process so as to detect a bottom portion of the double-humped output outputted from the second envelope detector; time counting means for specifying a bottom portion detection time at which the bottom detection means detects the bottom portion; and position coordinate specifying means for specifying coordinates representing a position of the coordinate pointing device on the panel based on the bottom portion detection time specified by the time counting means and a timing at which the electrodes are selected.

According to the above-mentioned embodiment, the coordinate detection means includes a first envelope detector which has a relatively great time constant and operates to receive the output from the differential amplifier and detect the envelope of the output as well as a second envelope detector which has a relatively small time constant and operates to receive the output from the differential amplifier and detect the envelope of the output. By subjecting the double-humped output from the first envelope detector and the double-humped output from the second envelope detector to a subtraction process, the bottom portion of the double-humped output outputted from the second envelope detector is detected.

The output of the first envelope detector having a great time constant becomes a double-humped signal where the bottom portion is shallowed, while the output of the second envelope detector having a small time constant becomes a double-humped signal where the bottom portion is not shallowed. Therefore, by subjecting the output of the first envelope detector and the output of the second envelope detector to a subtraction process, a signal having a peak at the bottom portion can be obtained. With the above-mentioned signal, the bottom portion can be detected.

In an embodiment, the coordinate detection means comprises: an envelope detector which receives an output from the differential amplifier and detects an envelope of the output; bottom detection means for receiving a double-humped output from the envelope detector to binarize the output and detecting a bottom portion of the double-humped output according to the binarized output; time counting means for specifying a bottom portion detection time at which the bottom detection means detects the bottom portion; and position coordinate specifying means for specifying coordinates representing a position of the coordinate pointing device on the panel based on the bottom portion detection time specified by the time counting means and a timing at which the electrodes are selected.

According to the above-mentioned embodiment, the bottom detection means detects the bottom portion of the double-humped output according to the output obtained by binarizing the double-humped output from the envelope detector. By the above-mentioned binarizing operation, an output in which a difference between the bottom portion and the peak portion of the double-humped output is ascertained can be obtained. Therefore, the bottom portion can be easily detected by means of the output, and through detection of the bottom portion, a coordinate detection operation can be performed.

In an embodiment, the coordinate detection means comprises: a delay circuit which receives an output of the differential amplifier and delays the output by a specified time; a subtracter which subjects the output of the differential amplifier and an obtained delayed output to a subtraction process; bottom detection means for binarizing a signal outputted from the subtracter and detecting a bottom portion of the double-humped output according to an obtained binarized signal; time counting means for specifying a bottom portion detection time at which the bottom detection means detects the bottom portion; and position coordinate specifying means for specifying coordinates representing a position of the coordinate pointing device on the panel based on the bottom portion detection time specified by the time counting means and a timing at which the electrodes are selected.

According to the above-mentioned embodiment, the coordinate detection means includes the delay circuit which receives the output from the differential amplifier and delays the output by a specified time, the subtracter which subjects the output of the differential amplifier and the delayed output to a subtraction process, and the bottom detection means which binarizes the signal outputted from the subtracter and detects the bottom portion of the double-humped output according to the binarized signal. According to the present embodiment, a preceding peak of the double-humped signal outputted from the differential amplifier and a subsequent peak of the delayed double-humped signal are added together. With the above-mentioned operation, a signal which has three peaks comprised of a highest peak and two low peaks located besides the highest peak obtained through the addition is outputted from the subtracter. Then, by binarizing the signal having the three peaks, a difference between the highest peak portion and the low peak portions is ascertained. The highest peak portion is delayed by the above-mentioned delay time from the bottom portion of the double-humped output which is not delayed. Therefore, the bottom portion can be easily detected according to the binarized signal of which highest peak portion is ascertained, and a coordinate detection operation can be performed through the detection of the bottom portion.

According to an embodiment, there is provided a coordinate detection device comprising: a flat display panel in which a material having an electro-optical effect characteristic is sealedly filled in a space between two substrates, and a plurality of x-axis electrodes and a plurality of y-axis electrodes which are intersecting each other are provided on the substrates; x-axis drive circuit and y-axis drive circuit which are provided for image display use and electrically drive the x-axis electrodes and the y-axis electrodes of the flat display panel respectively; a coordinate pointing device including alternating current electric field generating means having therein an alternating current power source and an electrode connected to an output terminal of the alternating current electric field generating means; a coordinate detection circuit including a differential amplifier, a connection switching circuit which selects two adjoining x-axis electrodes or a pair of x-axis electrodes constituted by two adjoining electrode groups of the x-axis electrodes as well as two adjoining y-axis electrodes or a pair of y-axis electrodes constituted by two adjoining electrode groups of the y-axis electrodes, connects the selected electrodes to the differen-

tial amplifier, and shifts the selected electrodes one by one in a direction in which the selected electrodes are arranged, bottom detection means for obtaining a signal which is supplied from the coordinate pointing device to the electrodes by shifting the selected electrodes as a double-humped signal from the differential amplifier and detecting a bottom portion of the double-humped signal, and position coordinate specifying means for specifying coordinates based on a time at which the bottom detection means detects the bottom portion and a timing at which the electrodes are selected; and an image display-coordinate detection changeover circuit which time-sharingly complementarily operates the x-axis drive circuit, the y-axis drive circuit, and the coordinate detection circuit.

According to the above-mentioned embodiment, the flat display panel wherein the material having an electro-optical effect characteristic is sealedly filled in the space between the two substrates, and the plural number of x-axis electrodes and the plural number of y-axis electrodes which are intersecting each other are provided on the substrates can be time-sharingly changed over so as to be used for either image display or coordinate detection by means of the image display-coordinate detection changeover circuit. When the flat display panel is used for image display, the x-axis electrodes and the y-axis electrodes are driven by the drive circuit to electrically drive the panel so as to display an image. When coordinate detection is performed, a voltage induced at the x-axis electrodes and the y-axis electrodes by an electric field generated from the coordinate pointing device which is provided separately with a function of generating an AC electric field is detected by the coordinate detection circuit which utilizes a change in voltage of the signal, thereby allowing the coordinates of the coordinate pointing device to be detected.

According to an embodiment, there is provided a coordinate detection device comprising: a flat display panel in which a material having an electro-optical effect characteristic is sealedly filled in a space between two substrates, and a plurality of x-axis electrodes and a plurality of y-axis electrodes which are intersecting each other are provided on the substrates; x-axis drive circuit and y-axis drive circuit which are provided for image display use and electrically drive the x-axis electrodes and the y-axis electrodes of the flat display panel respectively; a coordinate pointing device including alternating current electric field generating means having therein an alternating current power source and an electrode connected to an output terminal of the alternating current electric field generating means; a coordinate detection circuit including a differential amplifier, a connection switching circuit which selects two adjoining x-axis electrodes or a pair of x-axis electrodes constituted by two adjoining electrode groups of the x-axis electrodes as well as two adjoining y-axis electrodes or a pair of y-axis electrodes constituted by two adjoining electrode groups of the y-axis electrodes, connects the selected electrodes to the differential amplifier, and shifts the selected electrodes one by one in a direction in which the selected electrodes are arranged, bottom detection means for obtaining a signal which is supplied from the coordinate pointing device to the electrodes by shifting the selected electrodes as a double-humped signal from the differential amplifier and detecting a bottom portion of the double-humped signal by detecting a phase inversion point of the double-humped signal through calculation of an input signal and an output signal of a delay circuit, and position coordinate specifying means for specifying coordinates based on a time at which the bottom detection means detects the bottom portion and a timing at which the electrodes are selected; and an image display-coordinate detection changeover circuit which time-sharingly complementarily operates the x-axis drive circuit, the y-axis drive circuit, and the coordinate detection circuit.

According to the above-mentioned embodiment, the flat display panel wherein the material having an electro-optical effect characteristic is sealedly filled in the space between the two substrates, and the plural number of x-axis electrodes and the plural number of y-axis electrodes which are intersecting each other are provided on the substrates can be time-sharingly changed over so as to be used for either image display or coordinate detection by means of the image display-coordinate detection changeover circuit. When the flat display panel is used for image display, the x-axis electrodes and the y-axis electrodes are driven by the drive circuit to electrically drive the panel so as to display an image. When coordinate detection is performed, a voltage induced at the x-axis electrodes and the y-axis electrodes by an electric field generated from the coordinate pointing device which is provided separately with a function of generating an AC electric field is detected by the coordinate detection circuit which utilizes a change in phase of the signal, thereby allowing the coordinates of the coordinate pointing device to be detected.

In a coordinate detection device of an embodiment, a band-pass filter or a high-pass filter for selectively allowing only a signal at and around the frequency of the AC electric field to pass is connected to an input terminal of the coordinate detection circuit.

Therefore, the coordinate detection circuit can consistently detect a stabilized voltage from the x-axis electrodes and the y-axis electrodes without being influenced by noises.

In a coordinate detection device of an embodiment, an electrode which is provided at the tip end of the coordinate pointing device provided with a function of generating an AC electric field is a coaxial electrode comprised of a center electrode and a peripheral electrode.

Therefore, not depending on which circumferential direction the coordinate pointing device is directed in use, a stabilized voltage can be consistently induced at the x-axis electrodes and the y-axis electrodes.

In a coordinate detection device of an embodiment, the x-axis drive circuit and the y-axis drive circuit for image display use, the coordinate detection circuit, and the image display-coordinate detection changeover circuit are arranged along two or three sides of the peripheries of the display panel.

According to the present embodiment, a coordinate detection function can be incorporated into the image display device without increasing the size of the display device having an LCD panel provided specially for image display, and a display device having a coordinate detection function can be manufactured without making great alterations in the existing manufacturing equipment for the display device. Therefore, according to the present embodiment, there can be provided a coordinate detection device capable of preventing the increase of development cost and the reduction of yield, and dispensing with investment for equipment which may cause cost increase, thereby totally contributing to development of the industry.

As described above, according to the present invention, a signal which is generated by an electric field generated from the electrodes of the coordinate pointing device at the electrodes of the panel coupled through an electrostatic capacitive coupling with the coordinate pointing device is detected. Therefore, according to the present invention,

coordinate detection can be achieved even through the ends of the electrodes of the panel are opened.

There has been conventionally utilized an electromagnetic coupling in order to obviate the need of a connection cable, and therefore it has been required to form a loop-shaped circuit composed of panel electrodes of which ends are surely short-circuited. The above is because, in order to detect an induction current based on an inductive electromotive force induced by an effect of a magnetic field, a loop-shaped closed circuit must be formed by surely short-circuiting the ends of the circuit to be subjected to detection. In other words, it has been considered that no induction current flows through the electrodes of which ends are opened and therefore achievement of coordinate detection has been impossible with the above-mentioned arrangement.

In contrast to the above, the inventor and others have proved through experiments described as follows that a voltage can be induced at the electrodes of an LCD panel to allow coordinate detection to be achieved according to the principle of operation utilizing electrostatic capacitive coupling even through the panel electrodes of which ends are opened are used.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

FIG. **1** is an explanatory view of a basic structure of a coordinate detection device according to a first embodiment of the present invention;

FIG. **2** is an explanatory view of an operation related to the first embodiment;

FIG. **3** is an explanatory view of a fundamental experiment relevant to the first embodiment performed by the inventor and others;

FIG. **4** is a graph showing a result of the fundamental experiment;

FIG. **5** is an explanatory view of a second experiment relevant to the first embodiment performed by the inventor and others;

FIGS. **6**A and **6**B are explanatory views of structures of an electronic pen (electric field generator) of the first embodiment;

FIG. **7** is a graph showing a result of the experiment shown in FIG. **5**;

FIG. **8** is an explanatory view of a structure of the first embodiment;

FIGS. **9**A, **9**B, **9**C, **9**D, **9**E and **9**F are charts of signal waveforms at several points of the first embodiment;

FIG. **10** is a block diagram of a modification of a coordinate transformation circuit **175** of the first embodiment;

FIGS. **11**A, **11**B, **11**C, **11**D and **11**E are charts of signal waveforms at several points of a coordinate transformation circuit of the modification;

FIG. **12** is an explanatory view of a coordinate detection period;

FIG. **13** is an explanatory view of an electrode structure of a high-density LCD panel owned by a second embodiment of the present invention;

FIG. **14** is an explanatory view of a principle of operation of the second embodiment;

FIG. **15** is an explanatory view of a structure of the second embodiment;

FIG. **16** is an explanatory view of a detailed structure of the second embodiment;

FIG. **17** is an explanatory view of an electrode structure of a TFT LCD panel included in a third embodiment of the present invention;

FIG. **18** is an explanatory view of a principle of operation of the third embodiment;

FIG. **19** is an explanatory view of a structure of the third embodiment;

FIG. **20** is a graph showing a result of an experiment relevant to the third embodiment performed by the inventor and others;

FIG. **21** is an explanatory view of a detailed structure of the third embodiment;

FIG. **22** is an explanatory view of an exemplified coordinate detection method which can be commonly used in the first through third embodiments of the present invention;

FIG. **23** is a block diagram of a coordinate transformation circuit according to a fourth embodiment of the present invention;

FIGS. **24**A, **24**B, **24**C, **24**D and **24**E are charts of signal waveforms at several points of the coordinate transformation circuit of the fourth embodiment;

FIG. **25** is a circuit diagram of a band-pass filter characteristic of a fifth embodiment of the present invention;

FIG. **26** is a view for simply explaining an interaction between electrodes of an electronic pen which serves as an electric field generator of the first and second embodiments of the present invention and electrodes of an LCD panel;

FIG. **27** is an electric equivalent circuit diagram of the structure shown in FIG. **26**;

FIG. **28** is a schematic view of a structure of a modification of the electronic pen of the embodiment;

FIG. **29** is a structural drawing showing a mechanical structure of the electronic pen of the embodiment;

FIG. **30** is an electric equivalent circuit diagram of the electronic pen;

FIG. **31** is a structural drawing of a modification of the electronic pen;

FIGS. **32**A and **32**B are perspective views for explaining an operation of storing the electronic pen of the modification in a storing portion to charge the electronic pen;

FIGS. **33**A and **33**B are schematic views for explaining a modification of the first embodiment wherein a pair of electrode groups each being comprised of two or three electrodes are connected to a differential amplifier;

FIGS. **34**A and **34**B are schematic views for explaining a modification of the first embodiment wherein one or two electrodes are existing between a pair of electrodes connected to the differential amplifier;

FIGS. **35**A and **35**B are schematic views for explaining a modification of the first embodiment wherein a pair of electrode groups arranged with interposition of one or two electrodes are connected to a differential amplifier;

FIG. **36** is a view of a printed circuit board arranged in a bracket-like form alongside the LCD panel of the second embodiment;

FIG. **37** is a graph showing a frequency characteristic of the experiment related to the first embodiment;

FIGS. **38**A, **38**B, **38**C, **38**D, **38**E, **38**F, **38**G, **38**H, **38**I and **38**J are timing charts for explaining an operation of the first embodiment;

FIG. **39** is a circuit diagram wherein the differential amplifier of the embodiment is provided with a feedback circuit;

FIG. **40** is a circuit diagram of a synchronous detector which can substitute for an envelope detector of the embodiment;

FIG. **41** is an explanatory view of a structure of a display panel which concurrently performs coordinate detection and image display operations of a first prior art;

FIG. **42** is an explanatory view of an LCD panel of a second prior art;

FIG. **43** is an explanatory view of a coordinate detection technique of the second prior art;

FIG. **44** is a circuit diagram of an essential part of a third prior art;

FIG. **45** is an explanatory view of a coordinate detection technique of the third prior art; and

FIGS. **46**A, **46**B, **46**C, **46**D, **46**E and **46**F are timing charts of the third prior art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be described in detail based on several embodiments thereof with reference to the accompanying drawings.

First embodiment

First. FIG. **1** shows a dot matrix type duty ratio drive LCD panel as a coordinate detection device according to a first embodiment of the present invention. In the first embodiment, an STN (Supertwisted Nematic) LCD panel **100** is used, however, an active matrix type LCD panel having a TFT (Thin Film Transistor) can be also used.

FIG. **1** shows a basic structure of the first embodiment. For simplicity of explanation, there are shown four pixels in the x-axis direction by four pixels in the y-axis direction. That is, in the first embodiment, a duty ratio drive LCD panel **100** having a total of 16 pixels is used concurrently for image display and coordinate input operations. Of course, a generic LCD panel which has more pixels and availed on the market can be used in utterly the same manner as described above.

As described hereinafter, the LCD panel **100** to be used can be of course implemented by an LCD panel having the same structure as that of the LCD panel provided specially for image display (this point is one of remarkable features of the present invention).

The first embodiment includes an LCD panel **100**. The LCD panel **100** is used concurrently for image display and coordinate input operations.

The first embodiment includes an image display drive circuit **101**. The image display drive circuit **101** is an additional circuit for making the LCD panel **100** display an image. It is to be noted that the image display drive circuit **101** has a varied structure when the LCD panel **100** is a duty ratio drive TFT type in contrast to the case where the LCD panel **100** is an STN LCD panel.

In the first embodiment, the image display drive circuit **101** drives the LCD panel **100** to make the LCD panel **100** display an image having contents that an operator desires. The above-mentioned function is an image display function.

The first embodiment includes an electric field generator **102**. The electric field generator **102** is provided with an AC signal source **103** and electrodes **104***a* and **104***b* connected to the AC signal source **103**, and the electrodes **104***a* and **104***b* generate an AC electric field. In the first embodiment, a function of detecting the coordinates of the electric field generator **102** on the LCD panel **100** is a coordinate detection function. In detail, as shown in FIG. **1**, when an x-axis is defined in a lateral direction and a y-axis is defined in a longitudinal direction in an image display section of the LCD panel **100**, to detect which position of coordinates (x,y) the electric field generator **102** is located in is the coordinate detection function. In order to achieve the coordinate detection function, the first embodiment has a coordinate detection circuit **105**. The coordinate detection circuit **105** has a function such that, when an electric field outputted from the electric field generator **102** effects on a segment electrode **106** and a common electrode **107** on the LCD panel **100**, it detects an induction voltage generated at the segment electrode **106** and the common electrode **107** so as to detect the coordinates of the position in which the electric field generator **102** is located.

The first embodiment further includes a function changeover control circuit **108**. The function changeover control circuit **108** controls the image display drive circuit **101** and the coordinate detection circuit **105** so that the functions of the LCD panel **100** are used by time-sharingly changing over between the coordinate input function and the image display function.

The LCD panel **100** is connected to the image display drive circuit **101** and the coordinate detection circuit **105** via a connector **109** and a connector **110**. To the image display drive circuit **101** is externally supplied an image signal to be displayed via a drive terminal **111**. From the coordinate detection circuit **105** is outputted outwardly a coordinate signal through a coordinate output terminal **112**. To the function changeover control circuit **108** is supplied a function changeover signal through a terminal **113**.

Though not shown, a clock signal and so forth for operating the system are supplied to the first embodiment.

The first embodiment has a basic structure as shown in FIG. **1**. The first embodiment achieves both the image display function and the coordinate detection function by using a conventional LCD panel provided specially for image display and newly incorporating a coordinate input function into the LCD panel.

In the first embodiment, the image display function is achieved by the conventional technique without making alterations. The image display function is achieved by the LCD panel **100** and the image display drive circuit **101** shown in FIG. **1**. The image display drive circuit **101** takes a variety of forms according to the type or system of the LCD panel **100**. For instance, when a duty ratio drive LCD panel is used, the image display drive circuit **101** is provided with a common electrode drive circuit (not shown) and a segment electrode drive circuit (not shown). An operation of the LCD panel **100** when it is driven by the image display drive circuit **101** is utterly the same as that of the LCD panel used popularly. Therefore, no description is provided therefor herein, and a description will be provided at need hereinafter.

Meanwhile, the coordinate input function of the first embodiment includes a feature of the present invention. The first embodiment includes the electric field generator **102** and the coordinate detection circuit **105** to achieve the coordinate input function. An electric field generated from the electric field generator **102** effects on the LCD panel **100** to cause an electrical change (voltage) in the segment electrode **106** and the common electrode **107**. Then, the electrical change generated in the electrodes **106** and **107** is

detected by the coordinate detection circuit **105**. Upon detecting the coordinate position in which the electric field generator **102** is located, the coordinate detection circuit **105** outputs a signal representing the coordinate position from the coordinate output terminal **112**. The coordinate position signal outputted from the coordinate output terminal **112** can be used for a variety of purposes such as display of the above-mentioned position on the LCD panel **100**.

The first embodiment can be provided with a coordinate input function by incorporating the coordinate detection circuit **105** and the electric field generator **102** into a conventional LCD panel **100** without making alterations in the panel. The coordinate detection circuit **105** and the image display drive circuit **101** are provided with a function changeover switch (not shown, but described in detail hereinafter). Then, the function changeover control circuit **108** controls the operation of the function changeover switch to set a changeover timing. The function changeover control circuit **108** controls the coordinate detection circuit **105** and the image display drive circuit **101** so that the LCD panel **100** time-sharingly executes the coordinate input function and the image display function.

Thus, the basic principle of operation of the first embodiment, i.e., a basic principle of operation of the present invention is as follows. By means of the LCD panel **100** and the electric field generator **102**, an electric field generated from the two electrodes **104***a* and **104***b* of the electric field generator **102** is effected on the LCD panel **100**, and an electrical change (voltage) generated at the time in the segment electrode **106** and the common electrode **107** of the LCD panel **100** is detected by the coordinate detection circuit **105**. Meanwhile, a necessary image is displayed on the LCD panel **100** by the image display drive circuit **101**, and furthermore the image display and the coordinate input operations are time-sharingly alternately performed under the control of the function changeover control circuit **108**.

According to the first embodiment, a basic application example as shown in FIG. **2** can be achieved. The application example has a display panel **20** including the LCD panel **100**, the other circuits of the first embodiment, a casing **22** having therein a power supply and so forth, and an electronic pen **21** having therein the electric field generator **102**. The present application example is operated in a manner as follows. When an operator holds in his or her hand the electronic pen **21** having therein the electric field generator **102** as if the pen were a writing pen and puts the electronic pen **21** close to the display panel **20** including the LCD panel **100** which serves as an image display panel, an AC electric field is outputted from the electric field generator **102** to effect the AC electric field on the electrodes **106** and **107** of the LCD panel **100**. By detecting a voltage generated at the electrodes **106** and **107** by means of the coordinate detection circuit **105**, the coordinates of a position in which the electrodes **104***a* and **104***b* provided at the tip end of the electric field generator **102** are located can be detected (specified) on the LCD panel **100**. Then, the detected coordinates can be displayed on the display panel **20** including the LCD panel **100**. For instance, an appropriate mark or a trace of movement of the electronic pen **21** having therein the electric field generator **102** can be displayed on the display panel **20**. Therefore, when the operator who is holding the electronic pen **21** in his or her hand writes, for example, Chinese characters of "Hyoji" meaning display on the display panel **20**, the characters of "Hyoji" as shown in FIG. **2** can be displayed on the panel.

In the application example shown in FIG. **2**, the electric field generator **102** shown in FIG. **1** is incorporated in a pen-shaped electronic pen **21**. The electronic pen **21** is of course codeless having no connection cord for connection with the display panel **20**, and therefore the electronic pen **21** is completely independent of the display panel **20**. According to the application example shown in FIG. **2**, when the operator traces the surface of the display panel **20** with the electronic pen **21**, the coordinates at the tip end of the electronic pen **21** can be detected. Then, by lighting the above-mentioned coordinates on the display panel **20**, the trace of the tip end of the electronic pen **21** can be displayed on the display panel **20**. In other words, an image can be written on the display panel **20** as if it were written on a paper sheet.

A structure of the electronic pen **21** will be described in more detail below. As shown in FIG. **29**, the electronic pen **21** includes an outermost cylindrical casing **501** having a tapered fore end portion, a rod-shaped inner electrode **502** arranged in an appropriate center portion of the casing **501**, a cap-shaped cover **503** which covers the tip end of the inner electrode **502**, and an outer electrode **510**. The outer electrode **510** has a cylindrical configuration along an inner peripheral surface of the casing **501**, and a hind end portion thereof is fixed to a support member **508** fixed to the inner peripheral surface. A tip end portion **510***a* of the outer electrode **510** is put in contact with an outer peripheral surface of the cover **503**, and the cover **503** can freely slide in the tip end portion **510***a* of the outer electrode **510**.

The cover **503** is protruding from an opening **501***a* at the tip end of the casing **501**. Meanwhile, a hind end of the inner electrode **502** is connected to a movable portion **505***a* of an operation switch **505**. The operation switch **505** is fixed to an electric circuit board **511** screwed to a boss (not shown) formed on the inner peripheral surface of the casing **501**. A contact point of the operation switch **505** operates when the inner electrode **502** axially presses the movable portion **505***a*. When the movable portion **505***a* is not pressed, the operation switch **505** repels the inner electrode **502** in a direction in which the inner electrode **502** protrudes by an operation of a spring incorporated in the switch so as to hold the inner electrode **502** in a specified position.

A ferrite core **506** which has a tapered cylindrical fore end portion and serves as a core, a bobbin **507** provided around the ferrite core **506** and a coil **509** comprised of an enameled wire wound around the bobbin **507** are arranged around an appropriate axial center of the inner electrode **502**. An outer diameter of the ferrite core **506** and an inner diameter of the bobbin **507** are approximately equal to each other, and the bobbin **507** is fixed to the ferrite core **506**. The ferrite core **506** and the bobbin **507** are fixed inside the casing **501** by means of the support member **508** adjacent to the bobbin **507**. The casing **501** has therein a battery which serves as a power source.

FIG. **30** shows an electric circuit of the electronic pen **21**. As shown in FIG. **30**, integrated circuits IC1 and IC2, resistors R1 and R2, and capacitors C1 and C2 provided for the electric circuit are constituting a well-known oscillator circuit. An oscillation frequency is determined by a combination of the resistors R1 and R2 and the capacitors C1 and C2. The electric circuit further includes buffer amplifiers IC3 and IC4. The electric circuit further includes a serial resonance circuit comprised of an inductance L1 and a capacitor C3. The resonance circuit resonates at a frequency synchronized with the oscillation frequency of the oscillator circuit. The inductance L1 is implemented by the coil **509**.

Further, an electric power is supplied from a battery B1 to the integrated circuits IC1 through IC4. The electric power

of the battery B1 is supplied when a switch SW1 comprised of the operation switch **505** is turned on.

Parts constituting the above-mentioned electric circuit are all mounted on the electric circuit board **511** except for the coil L1 (i.e., the coil **509**) and the battery B1. As shown in FIG. **30**. both terminals of the capacitor C3 are connected to the inner electrode **502** and the outer electrode **510** by way of lead wires.

In the electronic pen **21** having the above-mentioned structure, when the switch SW1 is closed to supply an electric power to the electric circuit to start operating, the oscillator circuit oscillates to supply signals which are opposite in phase to each other to the serial resonance circuit comprised of the inductance L1 and the capacitor C3. Since the resonance frequency of the serial resonance circuit and the oscillation frequency of the oscillator circuit are coinciding with each other, there is generated a voltage Q times as high as an oscillation voltage supplied to the serial resonance circuit. It is to be noted that Q represents a Q-value of the coil **509**. Assuming that the Q-value is 20 and the supply voltage is 5 Vp-p, there is generated a voltage of about 100 Vp-p across both the terminals of the capacitor C3. Then the voltage is transmitted to the inner electrode **502** and the outer electrode **510**.

Since the operation switch **505** is so constructed that its contact point is closed when pressed by the inner electrode **502**, the inner electrode **502** presses the operation switch **505** by its pressure force when the electronic pen **21** is pressed against the surface of the LCD panel **100**. With the above-mentioned operation, an electric power is supplied to the integrated circuits IC1 through IC4 provided in the electronic pen **21**. In other words, the electronic pen **21** operates only when the electronic pen **21** is pressed against the LCD panel **100**, and does not operate in any other time so as to prevent the wasteful consumption of the electricity of the battery B1. The above-mentioned arrangement is effective for prolonging the operating life of the battery B1. The above is because the battery B1 is implemented by a battery such as a disk-shaped button battery having a very small capacity so that the battery can be stored in the thin pen-shaped casing **501**.

Next, FIG. **31** shows a structure of an electronic pen **21**A provided with a rechargeable battery in place of the above-mentioned battery B1 together with a charging mechanism for the battery. According to the electronic pen **21**A, the operating life of the battery can be remarkably prolonged.

As shown in FIG. **31**, the electronic pen **21**A further includes charging power supply terminals **620***a* and **620***b* for charging the battery B1 at a tip end of a casing **601** constituting the fore end portion of the pen. On the other hand, as shown in FIG. **32**A, terminals **22**A and **22**C for supplying electric power to the electronic pen **21**A are provided in a pen storing portion **22**B provided in a casing **22** of a word processor or the like. As shown in FIG. **32**B, when the electronic pen **21**A is not used, the electronic pen **21**A is stored in the pen storing portion **22**B, thereby allowing the battery B1 of the electronic pen **21**A to be automatically charged via the power supply terminals **620***a* and **620***b* of the pen **21**A when the power supply terminals **620***a* and **620***b* are put in contact with the terminals **22**A and **22**C of the casing **22**.

According to the electronic pen **21**A, so long as the electronic pen **21**A is stored in the above-mentioned specified pen storing portion **22**B even when the coordinate detection device is kept unused, the battery B1 is regularly charged. Furthermore, even when the coordinate detection device is used, by storing the electronic pen **21**A in the above-mentioned specified pen storing portion **22**B while the electronic pen **21**A is not used, the battery B1 can be charged. Since the electronic pen **21**A operates only when an inner electrode **502** is pressed against the LCD panel **100** similarly to the electronic pen **21**, the working power is very small. Furthermore, since the electronic pen **21**A can be charged while it is stored in the above-mentioned specified pen storing portion **22**B, the quantity of used power can be restored to allow the operating life of the battery to be remarkably prolonged.

It is to be noted that a power source necessary for charging the battery is of course connected to the power supplying terminals **22**A and **22**C provided in the pen storing portion **22**B of the casing **22** of a word processor or the like. It is also acceptable to turn on and off the power source for the charging use by detecting a charge state of the battery from the terminals **22**A and **22**C.

The power consumption of the electronic pen **21** or **21**A is about 2 mW. In contrast to the above, when a transmitter is provided in the pen, at least an oscillator and a modulator are necessary, and therefore the power consumption is about 10 mW.

Next, a principle of operation of detecting the coordinates of the electrodes **104***a* and **104***b* at the tip end of the electric field generator **102** in the first embodiment of the present invention shown in FIG. **1** will be described.

The principle of operation of coordinate detection in the first embodiment is basically as follows. Electric fields generated from the electrodes **104***a* and **104***b* of the electric field generator **102** are effected on the segment electrode **106** and the common electrode **107** of the LCD panel **100** to couple the electrodes **104***a* and **104***b* of the electric field generator **102** with the segment electrode **106** and the common electrode **107** of the LCD panel **100** through an electrostatic capacitive coupling. Then an induction voltage generated at the segment electrode **106** and the common electrode **107** is detected.

Therefore, according to the first embodiment which does not necessitate a connection cord extending from the electric field generator **102** to the LCD panel **100**, the electric field generator **102** can be easily handled in contrast to the first prior art which indispensably necessitates a connection cable for connecting the pen with the panel. Furthermore, according to the first embodiment, there is no need to make alterations in the LCD panel itself in contrast to the second prior art which requires formation of loops in the LCD panel.

Thus, according to the first embodiment, the problem of the second prior art which adopts a system taking advantage of a magnetic coupling for the purpose of eliminating the connection cable from the electronic pen (the problem that a loop-shaped coil is required to be formed by short-circuiting the ends of the electrodes of the LCD panel in the coordinate detection stage) can be solved.

The first embodiment can detect the coordinates of the pen without necessitating neither the loop-shaped coil of which ends are short-circuited nor the connection cable. Therefore, a structure simpler than that of any prior art can be achieved, and the pen for coordinate input use can be easily handled.

Next, a fundamental experiment conducted by the inventor and others will be described with reference to FIG. **3**. In FIG. **3**, an LCD panel **200** is a dot matrix type duty ratio drive LCD panel using STN liquid crystals. A display section of the LCD panel **200** has a lateral dimension×

longitudinal dimension of 230 mm×140 mm. For simplicity, there are shown only four common electrodes **201** and four segment electrodes **202** in FIG. **3**. however, there are practically included laterally 640 pixels×longitudinally 480 pixels in the above-mentioned display section. A pixel pitch is about 360 μm, while a width of each electrode is about 330 μm. Further, each of transparent electrodes constituting the common electrodes **201** and the segment electrodes **202** has a thickness of about 1 μm.

Two glass plates (not shown) owned by the LCD panel **200** are arranged as separated apart from each other by a gap of about 7 μm, and a liquid crystal material is interposed between the two glass plates.

The common electrodes **201** and the segment electrodes **202** are connected to peripheral circuits via a connector **2010** and a connector **2011** provided on the glass plates constituting the LCD panel **200**.

One end of the common electrodes **201** (extending laterally) owned by the LCD panel **200** is collectively connected to a ground. Meanwhile, one end of the segment electrodes **202** (extending longitudinally) is entirely opened.

An AC power source **203** provided in the electric field generator **207** has its one output terminal connected to the ground, and the other output terminal **206** of the AC power source **203** is connected to a tip electrode **204**. Therefore, the electric field generator **207** and the common electrodes **201** of the LCD panel **200** are electrically connected to each other through the ground.

An output frequency of the AC power source **203** was set at 100 kHz. A voltage at the output terminal **206** of the AC power source **203** was 20 Vp-p.

When the electric field generator **207** is put close to the LCD panel **200**, an intense electric field was generated across the electrode **204** of the electric field generator **207** and the segment electrode **202***a* of the LCD panel **200**.

When the electrode **204** of the electric field generator **207** is put close to the LCD panel **200**, a potential difference took place across the segment electrode **202***a* to which the electrode **204** is put close among the segment electrodes **202** and the ground. The potential difference was a sort of alternating current and its frequency coincided with the frequency of the AC power source **203**.

With an x-axis and a y-axis set in a manner as shown in FIG. **3** and the electrode **204** placed at each of coordinates of (x,y)=(3,5)[cm], (x,y)=(10,3)[cm], and (x,y)=(13,5)[cm], it was actually measured how much degree of potential difference was generated across the segment electrode **202** located in a position of xs=0 to 16 cm and the ground. A result of the measurement is shown in FIG. **4**. The axis of ordinates of FIG. **4** represents a measured AC potential difference. The frequency of the measured alternating current coincided with the frequency of the AC power source **203**.

Referring to FIG. **3**, it can be understood that a detected potential difference across the ground and the segment electrode **202** takes its peak value at the segment electrode **202***a* located just below the electrode **204** of the electric field generator **207**. Furthermore, it can be understood that the detected potential difference abruptly reduces according as the measurement point is apart from the x-coordinate position where the peak exists. Furthermore, the reduction of the potential difference at and around the peak is very steep, however, the reduction of the potential difference becomes gradual according as the measurement point is apart from the peak position. The above-mentioned tendency can be observed at the three points (x=3 cm, 10 cm, 13 cm) at which the electrode **204** of the electric field generator **207** is located, meaning that substantially same tendency is observed regardless of the x-coordinate position.

Since the detected potential difference depends on the position of the electrode **204** of the electric field generator **207**, the potential difference can be considered to be a signal representing the position of the electrode **204**. Therefore, by detecting the peak position Xs |cm| of the maximum point (peak) of the peak-shaped potential difference signal while observing a variation in amplitude of the detected potential difference signal, the x-coordinate value of the position in which the electrode **204** of the electric field generator **207** is located can be ascertained.

In the above-mentioned experiment, the potential difference across the segment electrodes **202** and the ground is detected with the common electrodes **201** all connected to the ground. However, a potential difference across the common electrodes **201** and the ground can be also detected with the segment electrodes **202** all connected to the ground. Though a detection result is not shown, a peak characteristic similar to that shown in FIG. **4** can be obtained in the present case.

In the experiment shown in FIG. **3**, a potential difference signal having a peak at and around the segment electrode **202** located in the position of the electrode **204** of the electric field generator was able to be detected. Then, the coordinate at which the peak exists was the x-coordinate value of the position in which the electrode **204** of the electric field generator **207** is located. Then, in a manner similar to the above, the y-coordinate value of the position in which the electrode **204** is located can be detected on the common electrode **201** side similarly to the experiment performed on the segment electrode **202** side. Therefore, the coordinates (x,y) of the electrode **204** can be specified.

As shown in the above-mentioned experiment, a potential difference signal depending on the position of the electrode **204** of the electric field generator **207** can be detected without specifically forming a loop by connecting the ends of the segment electrodes **202** or the common electrodes **201** of the LCD panel **200**. Therefore, it was discovered that the position of the electrode **204** of the electric field generator **207** on the LCD panel **200** can be specified taking advantage of the above-mentioned arrangement without forming any loop by connecting the ends of the common electrodes **201** or the segment electrodes **202** of the LCD panel **200**. In other words, it can be said that the result of the above-mentioned experiment can be applied to a coordinate detection device.

Based on the above-mentioned experiment, the inventor and others further performed an experiment as shown in FIG. **5**. In the experiment, the common electrodes **201** are all connected to the ground, while adjoining two segment electrodes **202***a* and **202***b* of the segment electrodes **202** are paired to be connected to a positive input terminal and a negative input terminal of the differential amplifier **205** similarly to the experiment shown in FIG. **3**. The same LCD panel as the LCD panel **200** used in the experiment of FIG. **3** was used (for simplicity, only eight electrodes are shown).

In the above place, an electric field generator **607** as shown in FIG. **6**A was prepared, and when a tip end of the electric field generator **607** is put close to the segment electrodes **202***a* and **202***b* connected to the differential amplifier **205**, it was measured what sort of voltage was obtained. The electric field generator **607** differs from the electric field generator **207** shown in FIG. **3** in that it is not connected to the ground.

FIGS. **6**A and **6**B show structures of the electric field generator **607** used for the experiment. The electric field

generator **607** has therein an AC power source **603**, and both output terminals **603***a* and **603***b* of the AC power source **603** are connected to a rod-shaped inner electrode **604***b* and a megaphone-shaped outer electrode **604***a* arranged coaxially with the inner electrode **604***b*. An AC frequency generated by the AC power source **603** is 100 kHz, and an AC voltage outputted across the electrode **604***a* and the electrode **604***b* is 100 Vp-p.

A structure of the electric field generator **607** will be described in detail below. As shown in FIG. **6**A, the electric field generator **607** has a structure in which both the output terminals of the AC power source **603** are connected to the outer electrode **604***a* and the inner electrode **604***b* of the coaxial electrode.

The structure of the outer electrode **604***a* of the coaxial electrode is allowed to have a tapered configuration as shown in FIG. **6**A or a complete coaxial structure in which only a portion of the outer electrode **604***a* inside a tip end portion B of the body of the electric field generator **607** surrounds the inner electrode **604***b* as shown in FIG. **6**B. Although FIGS. **6**A and **6**B show no support member for supporting the electrodes, the outer electrode **604***a* and the inner electrode **604***b* are fixed to the body of the electric field generator **607**. Though not shown in FIGS. **6**A and **6**B, the AC power source **603** also includes a switch and so forth other than a power source such as a battery. The reason why the outer electrode **604***a* and the inner electrode **604***b* constitute the specific configuration of the coaxial electrode will be described below. The embodiment of the present invention is to operate so as to specify the position of the electric field generator by detecting on the LCD panel side an electrical change given from the electric field generator to the electrodes of the LCD panel through an electrostatic capacitive coupling between the electric field generator and the electrodes of the LCD panel. The electric field generator is generally stored in a cylindrical pen-shaped casing as shown in FIG. **2**. The electric field generator having such a cylindrical pen-shaped exterior configuration tends to roll. The above-mentioned fact conversely produces an advantageous effect of allowing the electric field generator to be easily handled from the standpoint of the operator because it can be handled similarly to an ordinary writing pen. In another aspect, from a standpoint that an electrostatic capacitive coupling between the electric field generator and the electrodes of the LCD panel is used as the principle of operation of the embodiment of the present invention, it is indispensable to make the pen have a structure in which the electrostatic capacitive coupling does not change regardless of the rolling of the pen. That is because the electric field generator has the specific configuration of the coaxial electrode. In other words, so long as the coaxial electrode configuration is assured, not depending on the direction and angle of the pen-shaped object in which the electric field generator is incorporated, the electric field generator is consistently coupled with the electrodes of the LCD panel through an electrostatic capacitive coupling, and the electrical change to be applied can be made constant.

Dimensions of a tip end portion A constituted by the coaxial electrodes **604***a* and **604***b* shown in FIGS. **6**A and **6**B are determined depending on the electrode dimensions of the LCD panel used, depending on how many electrodes, for determining an electrode pitch, of the LCD panel are connected to the differential amplifier, and depending on other factors. For instance, when the electrode pitch of a generic LCD panel is 100 μm to 300 μm and adjoining two electrodes are connected to two input terminals of the differential amplifier, a distance between the tip end of the inner electrode **604***b* and the outer electrode **604***a* is set to 100 μm approximately equal to the electrode pitch. When two or three electrodes are existing between the two electrodes of the LCD panels connected to the differential amplifier, the distance between the inner electrode **604***b* and the outer electrode **604***a* is preferably set to about 1 mm.

It is required to properly determine a radius of a tip end portion C of the outer electrode **604***a* and properly process the configuration of the tip end portion A of the inner electrode **604***b*. For instance, the tip end portion A is preferably processed to have a sharp tip end configuration.

In the case of the electric field generator **607** having the above-mentioned structure, in a manner as shown in FIG. **26**, when electrodes **2601***a* and **2601***b* provided in an LCD panel **2600** are connected to a differential amplifier **2602**, the coaxial electrode comprised of the electrodes **604***a* and **604***b* of the electric field generator **607** can be placed in a position just above the electrodes **2601***a* and **2601***b* of the LCD panel **2600**. In the above case, as shown in FIG. **26**, the outer electrode **604***a* and the inner electrode **604***b* are coupled most intensely with the electrodes **2601***a* and **2601***b* via capacitors **2610***a* and **2610***b*.

In the above place, electric fields applied to the outer electrodes **604***a* and **604***b* are opposite in phase to each other, and the electrodes **2601***a* and **2601***b* are also connected to the input terminals, which are opposite in phase to each other, of a differential amplifier **2602**. Therefore, an output can be taken out most efficiently from the differential amplifier **2602** via the capacitors **2610***a* and **2610***b*.

An electric equivalent circuit corresponding to the arrangement of FIG. **26** is shown in FIG. **27**. As shown in FIG. **27**, the AC power source **603** included in the electric field generator **607** is connected to the differential amplifier **2602** via the capacitors **2610***a* and **2610***b*.

The electrode structure of the electric field generator **607** may have a structure as shown in FIG. **28** instead of the coaxial structure shown in FIG. **26**. In the electrode structure, a plurality of electrodes D1 are mounted on a circumference of the tip end portion of the pen, and the electrodes D1 are connected to an AC power source A1 so that a rotational electric field is generated on the circumference. According to the above-mentioned structure, there is produced an effect that, even though the pen which serves as the electric field generator rolls, the electrostatic capacity between the electrodes of the pen and the electrodes of the panel do not change similarly to the electric field generator shown in FIG. **26**.

Then, a result of an experiment shown in FIG. **5** performed by means of the electric field generator **607** is shown in FIG. **7**. FIG. **7** shows a potential difference measured at the frequency of the AC power source **603**. FIG. **37** shows a frequency characteristic of a detection voltage obtained through normalization with a peak-to-peak value of the detection voltage set to **1** when the AC frequency is 100 kHz. According as the frequency is increased in order of 20 kHz, 60 kHz, 140 kHz, 200 kHz, 300 kHz, and 400 kHz, the detection voltage tends to decrease, however, it can be substantially ignored.

The experiment result shown in FIG. **7** differs from the experiment result shown in FIG. **4** in that the detected voltage is a double-humped output. Then, the x-coordinate value of the bottom portion of the double-humped output represents the x-coordinate value of the position in which the electrodes **604***a* and **604***b* at the tip end of the electric field generator **607** are located. Furthermore, though not shown in FIG. **7**, the detected AC potential difference

exhibited a phase difference of 180° between both sides of the minimum point (bottom portion), i.e., between bilateral peaks located on the right and left sides of the minimum point.

In the experiment shown in FIG. **7**, a potential difference across a pair of adjoining segment electrodes **202** was detected by connecting the pair of segment electrodes **202** to the differential amplifier **205** with the common electrodes **201** shown in FIG. **5** all connected to the ground. However, conversely a potential difference across a pair of adjoining common electrodes **201** can be detected by connecting the pair of common electrodes **201** to the differential amplifier **205** with the segment electrodes **202** all connected to the ground. Therefore, a y-coordinate value of the electrodes **604***a* and **604***b* of the electric field generator **607** can be obtained similarly to the experiment shown in FIG. **3**. That is, by performing two times similar detection operations from the segment electrode side and from the common electrode side so as to detect and decide the coordinates of the bottom portion of each double-humped output obtained, the coordinates of the bottom portion correspond to the coordinates of the position in which the electrodes **604***a* and **604***b* are located. Therefore, the coordinates (x,y) of the position in which the electrodes **604***a* and **604***b* of the electric field generator **607** are located can be specified.

Although the electric field generator corresponding to the electric field generator **102** shown in FIG. **1** is provided with an AC power source in the aforementioned two experiments, a combination of a Peltier device and an LC parallel circuit or a serial resonance circuit may be provided in place of the AC power source. What is essential is the structure in which the electric field generator is capable of generating an AC electric field.

Although the segment electrodes are connected to the ground in the aforementioned two experiments, the segment electrodes may be connected to nothing as opened instead of being connected to the ground. However, taking into account influence of external noises, the segment electrodes are preferably connected to something having a reference potential. Further, a specified voltage may be of course superimposed on the segment electrodes via a capacitor or the like.

Based on the results of the above-mentioned two experiments, the inventor proposes the present invention by integrating the experiment results with the conventional techniques of the LCD devices which have been provided specially for image display.

Based on the above description, the first embodiment of the present invention will be described in more detail below. Since the image display function of the present invention is quite the same as those of the LCD techniques used conventionally, a coordinate input function will be particularly described in detail.

The basic structure of the first embodiment is as shown in FIG. **1**, and is related to all the embodiments. According to the present invention, the LCD panel **100** may have an electrode structure of a generic STN LCD panel, and the present invention can be also applied to an electrode structure of an STN panel having an improved display capacity as in a second embodiment described hereinafter. Furthermore, the present invention can be also applied to an LCD panel having an electrode structure of a TFT panel as in a third embodiment described hereinafter.

FIG. **8** shows in detail a structure of the coordinate detection circuit **105** provided in the aforementioned first embodiment. It is to be noted that the image display drive circuit **101** and the function changeover control circuit **108** shown in FIG. **1** are not shown in FIG. **8**. The image display drive circuit **101** and the function changeover control circuit **108** will be described hereinafter.

Furthermore, the electric field generator **102** shown in FIG. **1** is denoted as an electric field generator **208** in FIG. **8**. The electric field generator **208** is provided with the structure shown in FIG. **6** as described hereinbefore.

As shown in FIG. **8**, a reference numeral **100** denotes an LCD panel, and the LCD panel **100** has common electrodes **106** and segment electrodes **107**. In particular, segment electrodes **107***a* and **107***b* constitute a segment electrode pair comprised of two adjoining electrodes of which one end is opened and the other end is electrically connected to a differential amplifier **242** via a first switch circuit group **249-1** and a second switch circuit group **250**. The above-mentioned structure is the basic structure of the first embodiment.

As shown in FIG. **8**, the coordinate detection circuit **105** includes the first switch circuit group **249-1**, the second switch circuit group **250**, a third switch circuit **249-2**, a coordinate transformation circuit **175** and a timing control circuit **174**. The first switch circuit group **249-1** includes switch circuits **249***a*, **249***b*, **249***c*, **249***d*, **249***e*, **249***f*, **249***g* and **249***h*. The second switch circuit group **250** includes switch circuits **250***a*, **250***b*, **250***c* and **250***d*. The third switch circuit **249-2** includes switch circuits **249***i* and **249***j*.

The first, second and third switch circuit groups **249-1**, **250**, and **249-2** transmit a signal detected from each of the segment electrodes **107** and the common electrodes **106** of the LCD panel **100** to the differential amplifier **242** in the first stage provided in the coordinate transformation circuit **175** by properly switching in a manner as described hereinafter. In the present case, among a plurality of segment electrodes **107** and common electrodes **106** owned by the LCD panel **100**, the electrode to which the electric field generator **208** is put close and electrodes around it yield the maximum detection signal. The principle of the signal detection operation is as described based on the aforementioned experiment result. In more detail, the experiment on which the first embodiment is based is shown in FIG. **5**, and therefore the experiment result shown in FIG. **7** can be obtained when the electric field generator **208** is put close to the electrodes. According to the experiment result shown in FIG. **7**, it was confirmed that the electric field generator **208** was located near the segment electrode placed in an x-coordinate position where a bottom of a detected double-humped output signal takes place.

Meanwhile, the first switch circuit group **249-1**, the second switch circuit group **250** and the third switch circuit group **249-2** are controlled to be switched by a timing circuit **174**. Then, the first, second and third switch circuit groups **249-1**, **250** and **249-2** are controlled by the timing circuit **174** so as to connect to the differential amplifier **242** a pair of adjoining segment electrodes **107** and a pair of adjoining common electrodes **106**, and a combination of the electrode pair to be connected to the differential amplifier **242** is shifted one by one in a direction in which the electrodes are arranged.

Therefore, according to the first embodiment, an output of the differential amplifier **242** becomes a signal in which the axis of abscissas (x-coordinate axis) of the experiment result shown in FIG. **7** is replaced by a time base. A substitution rate of the x-coordinate axis to the time base depends on the speed of switching the first, second and third switch circuit groups by means of the timing circuit **174**. Therefore, by detecting a timing (time) of the bottom portion of the

double-humped output signal as shown in FIG. **7** by means of the coordinate transformation circuit **175**, the coordinates of the position of the electric field generator **208** placed on the LCD panel **100** can be detected. What is essential in the first embodiment is to detect the coordinates of the position of the electric field generator **208**.

As described above, the coordinate transformation circuit **175** has a function of detecting the bottom portion of the double-humped output obtained in the experiment of FIG. **5** and thereby designating the position in which the electric field generator **208** is located. As described above, the signal inputted from the first, second and third switch circuits **249-1**, **250** and **249-2** controlled by the timing circuit **174** to the coordinate transformation circuit **175** is converted into a signal in which the axis of abscissas of the experiment result shown in FIG. **7** is replaced by a time base. The aforementioned signal transformation is performed by controlling the operations of the switch circuits by means of the timing circuit **174**. Again in more detail, by switching the first, second and third switch circuit groups **249-1**, **250**, and **249-2** by means of the timing circuit **174** so as to scan, for example, the segment electrodes **107**, an output similar to that of FIG. **7** can be obtained. Then, the axis of abscissas of the output can represent the scanning position of the electrodes currently scanned on the LCD panel **100** as well as a time at which the electrodes are sequentially scanned. Operations of the aforementioned switch circuit groups will be described in detail hereinafter.

Next, an operation of the first embodiment will be described with reference to FIG. **8**. Meanwhile, signal waveforms inside the coordinate transformation circuit **175** shown in FIG. **8** are shown in order according to a signal flow in FIGS. **9**A, **9**B, **9**C, **9**D, **9**E and **9**F.

A signal transmitted from the common electrodes **106** and the segment electrodes **107** of the LCD panel **100** to the coordinate transformation circuit **175** via the first switch circuit group **249-1**, the second switch circuit group **250** and the third switch circuit group **249-2** is firstly inputted to the differential amplifier **242**. In the differential amplifier **242**, the transmitted signal is properly amplified to a level at which the signal can be easily handled. In the aforementioned experiment, the signal to be detected has a voltage of several millivolts. Therefore, by amplifying the transmitted signal by several hundred times to thousand times, the amplified signal has a voltage on the order of several volts to be easily handled.

As a result, an output obtained by amplifying a signal similar to that shown in FIG. **7** can be obtained from the differential amplifier **242** according to the position of the electric field generator **208**. Since the signal detection is thus performed by means of the differential amplifier **242**, there is an advantage that external noises which have entered evenly into two inputs of the differential amplifier can be effectively removed.

In the present case, the first, second and third switch circuits groups **249-1**, **250** and **249-2** are controlled by the timing circuit **174** in a manner as described above so as to scanningly select between the plural number of common electrodes **106** and the plural number of segment electrodes **107** and connect each selected electrode to the differential amplifier **242**. In other words, the signal to be inputted to the differential amplifier **242** is a signal in which the axis of abscissas of the experiment result of FIG. **7** is replaced by a time base.

Then, the signal amplified in the differential amplifier **242** is inputted to an envelope detector **186**. A waveform of the signal inputted to the envelope detector **186** is shown in FIG. **9**A. Then, the envelope detector **186** outputs an envelope of an amplified signal. Then, the signal of which envelope is detected is inputted to a comparator **180** so as to be compared with a reference voltage (reference voltage for comparison) in the comparator **180** to be binarized. FIG. **9**B shows a waveform of the signal inputted to the comparator **180** and the reference voltage (one-dot chain line), while FIG. **9**C shows a waveform of the signal binarized by the comparator **180**.

Then, an output binarized by the comparator **180** is inputted to a T-flip-flop **181**. The T-flip-flop **181** is a type which operates using a trailing edge of a T-input as a clock and includes a set terminal S, and a Q output terminal thereof is set upon receiving a signal from the timing circuit **174** at the set terminal S. The T-flip-flop **181** forms a pulse having a leading edge at a bottom portion of the double-humped signal indicated by a dashed line in FIG. **9**C at an inverted Q output terminal thereof. The pulse waveform is shown in FIG. **9**D.

Then, a Q output pulse of the T-flip-flop **181** is processed in a delay circuit **182** to be delayed as indicated by a solid line in FIG. **9**E, and further inputted to a NAND gate **183**. With the above-mentioned operation, a pulse as shown in FIG. **9**F which has a negative polarity and a duration corresponding to a delay time of the delay circuit **182** can be obtained as an output of the NAND gate **183**. The pulse shown in FIG. **9**F exists at the bottom portion of the double-humped output voltage of the output signal of the differential amplifier **242** shown in FIG. **9**A.

Meanwhile, a set signal which is outputted from the timing circuit **174** and then inputted to the set terminal S of the T-flip-flop **181** is simultaneously transmitted to a load terminal of a counter **184**. Then, the counter **184** starts counting according to a specified clock using the set signal as a time reference. A count value of the counter **184** is inputted to a D terminal of a D-flip-flop **185**. At the same time, the negative pulse from the NAND gate **183** is inputted to a clock terminal of the D-flip-flop **185**. The D-flip-flop **185** holds data supplied from the counter **184** at a time when it receives the negative pulse from the NAND gate **183**.

In the present case, operation timings of the switch circuit groups **249-1**, **250** and **249-2** are controlled by the timing circuit **174** in a manner as described above, and the electrodes **106** and **107** of the LCD panel **100** are scanned sequentially one by one in the y-axis and x-axis directions with two adjoining ones of the electrodes set as a pair. Therefore, the data held in the D-flip-flop **185** represents the coordinates of the position in which the electric field generator **208** is located on the LCD panel **100**.

Next, operations of the first switch circuit group **249-1**, the second switch circuit group **250**, the third switch circuit group **249-2** and the timing circuit **174** will be described in greater detail below. First, an operation of the timing circuit **174** will be described. The timing circuit **174** controls the operations of the first, second and third switch circuit groups. The timing circuit **174** outputs a clock signal to the counter **184**.

As described hereinbefore with regard to each experiment, it is acceptable to connect all the common electrodes **106** to the ground and detect a signal from the segment electrodes **107**. Conversely, it is acceptable to connect all the segment electrodes **107** to the ground and detect a signal from the common electrodes **106**. In the aforementioned experiment, a voltage having a double-humped waveform was able to be detected at and around the

coordinates of the position in which the electric field generator **208** was located. The coordinates at which the bottom of the double-humped voltage waveform was located were the coordinates of the position in which the electric field generator **208** was located. Then, the x-coordinate value of the electric field generator **208** can be specified by scanning the segment electrodes, while the y-coordinate value of the electric field generator **208** can be specified by scanning the common electrodes. Therefore, by performing the scanning operation time-sharingly two times, the xy-coordinates of the electric field generator **208** can be specified.

FIG. **12** shows a sequence that the first switch circuit group **249-1**, the second switch circuit group **250** and the third switch circuit group **249-2** are controlled by the timing circuit **174** so as to scan the segment electrodes **107** sequentially from a first one to an "n"th one and thereafter scan the common electrodes **106** sequentially from a first one to an "m"th one. It is to be noted that "n" and "m" represent the numbers of the segment electrodes and the common electrodes.

According to the experiment shown in FIG. **5** described hereinbefore, it is required to connect all the common electrodes **106** to the ground when the detection is performed from the segment electrodes **107**. The converse can also hold. Taking the above-mentioned matter into account, when the segment electrode **107** are scanned to detect coordinates from the segment electrode **107**, the timing circuit **174** controls switch circuits **249***a*, **249***b*, **249***c* and **249***d* connected to the segment electrodes so as to connect the switch circuits **249***a* through **249***d* to switch circuits **250***a* and **250***b* constituting the second switch circuit group **250** in the next stage. Meanwhile, the timing circuit **174** controls switch circuits **249***e*, **249***f*, **249***g* and **249***h* connected to the common electrodes **106** so as to connect the switch circuits **249***e* through **249***h* to the ground. Then, the timing circuit **174** controls switch circuits **249***i* and **249***j* of the third switch circuit group **249-2** so as to switch the switch circuits **249***i* and **249***j* to the segment electrode side S. With the above-mentioned operation, a signal from the segment electrodes **107** is transmitted to the differential amplifier **242**. Meanwhile, the common electrodes **106** are connected to the ground.

Conversely, when coordinates are detected from the common electrodes **106** side, the timing circuit **174** connects the switch circuits **249***e*, **249***f*, **249***g* and **249***h* connected to the common electrodes **106** to switch circuits **250***c* and **250***d* in the next stage. Then, the timing circuit **174** connects to the ground the switch circuits **249***a* through **249***d* connected to the segment electrodes **107**. Then, the timing circuit **174** connects the third switch circuits **249***f* and **249***g* to the common electrode side C. With the above-mentioned operation, a signal from the common electrodes **106** is transmitted to the differential amplifier **242**, while the segment electrodes **107** are connected to the ground.

It is to be noted that the second switch circuits **250***a*, **250***b*, **250***c* and **250***d* are controlled by the timing circuit **174** to be properly switched so as to sequentially scan the segment electrodes and the common electrodes. Therefore, the differential amplifier **242** can sequentially detect a voltage outputted from the segment electrodes **107** or the common electrodes **106**.

The switch circuits **250***a* through **250***d* of the second switch circuit group **250** are switched so as to sequentially scan from the electrode on the origin side of the x- and y-coordinate axes shown in FIG. **8**. In the contact point connection state of the switch circuits **250***a* through **250***d* shown in FIG. **8**, a first segment electrode **107** from the origin is connected to the positive input terminal of the differential amplifier **242**, while a second segment electrode **107** from the origin is connected to the negative input terminal of the differential amplifier **242**.

Subsequently, when scanning proceeds by one step, the contact point connection state shown in FIG. **8** changes to connect the second segment electrode **107** in the shown x-coordinate axis to the positive input terminal of the differential amplifier **242** and connect the third segment electrode **107** to the negative input terminal of the differential amplifier **242**. Thus the two electrodes to be connected to the differential amplifier **242** are shifted one by one in the direction in which the electrodes are arranged.

In accordance with proceeding of the electrode scanning operation (elapse of time), there is inputted to the input terminals of the differential amplifier **242** a double-humped waveform which is similar to a voltage waveform shown in FIG. **7**, i.e., the experiment result of FIG. **5** and has its axis of abscissas replaced by a time base.

Although the adjoining two electrodes are paired in scanning in order to reproduce the experiment of FIG. **5** in the first embodiment, it is also acceptable to pair adjoining two electrode groups so as to connect the electrode groups to the differential amplifier **242**.

In the first embodiment, a timing at which the second switch circuits **250***a* through **250***d* shown in FIG. **8** are switched to sequentially scan the electrodes of the LCD panel **100** and a timing at which the counter **184** increments its count value one count by one count are made to coincide with each other. Therefore, the electrode connected to the differential amplifier **242** in the electrode scanning time can be known by means of the count value of the counter **184**.

Then the NAND gate **183** outputs a pulse to the D-flip-flop **185**, and when the D-flip-flop **185** receives the pulse, the D-flip-flop **185** holds the count value inputted from the counter **184**. In other words, the count value thus held represents each of the ordinal numbers of electrodes assigned in order from the origin of the xy-coordinate axes in which the electric field generator **208** is located.

It is to be noted that the timing control circuit **174** is required to switch the second switch circuit group **250** according to a switching control signal synchronized with the clock signal outputted to the counter **184**.

In FIG. **12**, numerals **1**, **2**, **3**, . . . , n and numerals **1**, **2**, **3**, . . . , m each enclosed in a mark ◇ illustrated respectively in the segment electrode detection period and the common electrode detection period of the coordinate detection period represent count values of the counter **184**, and concurrently represent the ordinal numbers of contact points to which the second switch circuit group **250** is connected as well as the ordinal numbers of electrodes assigned in order from the origin of the xy-axes.

The above-mentioned coordinate detection operation is achieved by controlling switching of the switch circuit groups **249-1**, **250** and **249-2** by the switching control signal outputted from the timing control circuit **174** on the control lines extending from the timing control circuit **174**. FIG. **12** shows a switching operation performed by the switch circuit groups.

The switch circuits for performing the above-mentioned switching operation according to the signal obtained from the control lines extending from the timing control circuit **174** can be easily implemented by, for example, an appropriate multiplexer device. Furthermore, the timing circuit **174** for outputting the switching control signal on the control

lines can be also easily implemented by combining a counter device, a gate device, and so forth availed on the market.

Furthermore, as described above, the timing control circuit **174** outputs a set signal to the set terminal S of the T-flip-flop **181** and the load terminal of the counter **184**. The above-mentioned time is the set timing of the T-flip-flop **181**, the load timing of the counter **184**, and the time (timing) at which the electrode scanning is started from the segment electrode side or the common electrode side.

As described hereinbefore, the timing at which the second switch circuit group **250** sequentially switches to scan the electrodes **106** and **107** and the timing at which the counter **184** is incremented one count by one count are made to coincide with each other. Therefore, the ordinal number from the origin of the coordinate axes of the electrode that is connected to the differential amplifier **242** in the electrode scanning time is represented by the count value of the counter **184**. The above is because, as described hereinbefore, the timing control circuit **174** outputs a switching control signal to the second switch circuit group **250** in synchronization with the clock inputted from the timing control circuit **174** to the counter **184**.

Since the first, second and third switch circuit groups **249-1**, **250** and **249-2** are thus controlled by the timing control circuit **174**, the D-flip-flop **185** holds its count value obtained by sequentially counting each of the segment electrodes and common electrodes, i.e., data representing the ordinal number from the origin of the electrode connected to the differential amplifier **242**. That is, the held data can be interpreted as a value counted by the counter **184** in synchronization with the electrode scanning from the time when the counter **184** is reset on starting scanning of electrodes to the time when the negative pulse is generated from the NAND gate **183**. It is a matter of course that the counter **184** starts counting at the reset time and counts one count by one count only when the electrode scanning position is shifted by one electrode.

In other words, the above-mentioned count value can be interpreted as a value which is obtained, as a result of searching a bottom portion of the double-humped output voltage corresponding to the position of the coordinates of the electric field generator **208** by shifting one by one the electrodes of the LCD panel **100** which are connected to the differential amplifier **242** by means of the switch circuit groups, by representing the bottom position by the amount of electrodes counted by the coordinate transformation circuit **175**, and then held in the D-flip-flop **185**. That is, the result of detecting the x-coordinate value or the y-coordinate value of the position of the electric field generator **208** is detected as represented by the amount of electrodes counted.

The above-mentioned operation will be described again with reference to timing charts shown in FIGS. **38**A through **38**J. The timing charts show an enlargement of the coordinate detection period of the timing chart shown in FIG. **12**.

Among signals transmitted from the timing circuit **174** to the counter **184** shown in FIG. **8**, a clock signal is continuously supplied in a manner as shown in FIG. **38**B.

The timing circuit **174** generates a switching control signal to be supplied to the first switch circuit group **249-1** based on a timing signal as shown in FIG. **38**A supplied from the function changeover control circuit **108**. A switching control signal supplied to the switch circuits **249***a* through *d* is shown in FIG. **38**C, while a switching control signal supplied to the switch circuits **249***e* through *j* is shown in FIG. **38**D. The control signals are used for switching the switch circuits according to FIG. **12**. There are two signals shown in FIGS. **38**C and **38**D supplied from the timing circuit **174** to the switch circuits **249**. In the coordinate detection period, both the signals switch the contact points of the switch circuits to the segment electrode side S and to the common electrode side C. In the image display period, the switching control signal shown in FIG. **38**C connects the switch circuits **249***a* through *d* to the segment electrode side, while the switching control signal shown in FIG. **38**D connects the switch circuits **249***e* through *j* to the common electrode side. Further, a switching control signal as shown in FIG. **38**E connects the switch circuit **250** always to the contact point **6** in the image display period, and sequentially scans the contact points **1** through **5** in the coordinate input period.

Furthermore, the timing circuit **174** generates a load signal as shown in FIG. **38**F based on a timing signal supplied from the function changeover control circuit **108**. The load signal is outputted once at a detection start time on the segment electrode side and a detection start time on the common electrode side. Subsequently, the counter **184** starts counting, and increments it count value in accordance with a clock.

When the electric field generator **208** is located around the third segment electrode and the fourth common electrode, i.e., around the coordinates (x,y)=(3,4), a waveform as shown in FIG. **38**H is outputted from the T-flip-flop **181** as explained with reference to the waveform shown in FIG. **9**. When the second switch circuit group **250** scans a position around the third segment electrode and the fourth common electrode, a pulse having a negative polarity is outputted from the NAND circuit **183** as shown in FIG. **38**I. With the above-mentioned operation, an instantaneous count value (3,4) of the counter **184** is latched in the D-flip-flop **185** as shown in FIG. **38**J. The count value represents the coordinates at which the electric field generator **208** is located. Thus the coordinate detection is achieved.

As described above, the x-coordinate value and the y-coordinate value of the position in which the electric field generator **208** is located are held in the D-flip-flop **185** in accordance with the timing at which the negative pulse is outputted from the NAND circuit **183** in each of the detection periods shown in FIG. **12**. Data representing the coordinates of the position of the electric field generator **208** can be separately utilized as detected coordinate data. There is no specific limitation on application methods of the data. For instance, by repetitively lighting previously detected coordinates in a period in which the function changeover control circuit **108** shown in FIG. **1** orders an image display operation, an image can be written on the LCD panel **100** by means of the electric field generator **208** with a touch of writing an image on a paper sheet by means of a writing pen. Furthermore, by taking the simultaneously detected coordinate data in a CPU, a desired processing operation such as character recognition can be performed.

Although the coordinate transformation circuit **175** shown in FIG. **8** is used in the first embodiment, a coordinate transformation circuit **175T** as shown in FIG. **10** may be used in place of the coordinate transformation circuit **175** shown in FIG. **8**. The coordinate transformation circuit **175T** includes a parallel connection composed of an envelope detector **191** having a great time constant and an envelope detector **192** having a small time constant. The envelope detectors **191** and **192** connected in parallel with each other are connected between an output of the differential amplifier **242** and a differential circuit **193**. An output of the differential circuit **193** is binarized in a binarizing circuit **194** and further connected to a clock terminal of the D-flip-flop **185**.

The D-flip-flop **185** is connected to the counter **184**, and the counter **184** is connected to the timing circuit **174** in the same manner as in the coordinate transformation circuit **175** shown in FIG. **8**.

In the coordinate transformation circuit **175T**, a signal which has passed through the switch circuits **249***i* and **249***j* shown in FIG. **8** is inputted to the differential amplifier **242** and amplified to a specified level. Then, the amplified signal is inputted to the envelope detector **191** having a great time constant and the envelope detector **192** having a small time constant. A signal waveform inputted to the envelope detectors **191** and **192** is shown in FIG. **11**A. Further, the envelope detector **191** having a great time constant outputs a signal wherein the bottom of the double-humped output is shallowed as shown in FIG. **11**C. On the other hand, as shown in FIG. **11**B, the envelope detector **192** having a small time constant outputs a signal having the envelope waveform of the signal shown in FIG. **11**A.

Then, the differential circuit **193** takes a difference between the outputs of the two detectors **191** and **192**. An output waveform of the differential circuit **193** is shown in FIG. **11**D. The output signal shown in FIG. **11**D is inputted to the binarizing circuit **194**, and compared with a specified reference voltage in the binarizing circuit so as to be binarized. An output waveform of the binarizing circuit **194** is shown in FIG **11**E. An output signal of the binarizing circuit **194** is a pulse signal. By shaping the pulse signal by means of the T-flip-flop **181**, the delay circuit **182**, and the NAND gate **183** in the same manner as described hereinbefore, a pulse signal which is synchronized with the position of the bottom of the signal waveform of the experiment result shown in FIG. **7** can be obtained. Therefore, the coordinates of the position of the electric field generator **208** can be obtained by means of the counter **184** and the D-flip-flop **185** in the same manner as described hereinbefore. Although the difference between the outputs of the envelope detectors **191** and **192** is calculated, the bottom portion where a great difference takes place between the outputs can be also detected by subjecting the outputs of the detectors **191** and **192** to a product calculation process.

Although the envelope of the signal is extracted by subjecting the output of the differential amplifier **242** to an envelope detection process by means of an envelope detector in the first embodiment, a means for detecting an effective value may be used.

The two structural examples **175** and **175T** of the aforementioned coordinate transformation circuit are to detect the bottom portion of the signal waveform by paying attention to a change in amplitude. However, there is a variety of structural examples for implementing such a coordinate transformation circuit other than the aforementioned two structural examples.

There can be considered another structure for each of the switch circuits of the first embodiment. Since each switch circuit can be easily constructed in a variety of ways, no description is provided therefor herein. What is essential is the provision of a structure which can assure the timing shown in FIG. **12**. Furthermore, there is no special reason for using a switch circuit, and therefore a circuit having a function similar to that of each switch circuit can be constructed by combining a three-state buffer circuit and other devices in an effective combinatorial style.

Although the above description has been based on an LCD panel having 16 pixels for simplicity in the first embodiment, the LCD panel **100** of course includes a greater amount of pixels in a practical case as described hereinbefore. Furthermore, in a case of an LCD panel having more pixels, utterly the same basic structure and basic operation as those of the first embodiment can be also achieved.

As described hereinbefore, the function changeover control circuit **108** shown in FIG. **1** controls the image display drive circuit **101** and the coordinate detection circuit **105** so as to time-sharingly alternately perform image display and coordinate detection operations on the LCD panel **100**. The function changeover control circuit **108** shown in FIG. **1** outputs a control signal to the timing circuit **174** shown in FIG. **8**. Then, the coordinate detection circuit **105** performs the aforementioned coordinate detection operation only in the coordinate detection period, and operates to disconnect the first switch circuit group **249** and so forth from the LCD panel **100** so that they do not hinder the image display operation in the image display period. In more detail, in the image display period, the switch circuits **249***a* through *h* constituting the first switch circuit group **249-1** are connected to the contact points for connecting all the electrodes to the second switch circuit group **250**. That is, the switch circuits **249***a* through *d* are connected to the contact points on the side S in FIG. **8**, while the switch circuits **249***e* through *h* are connected to the contact points on the side C. On the other hand, switch circuits **250***a* through *d* constituting the second switch circuit group **250** are connected to the sixth contact point connected to nothing. Further, the switch circuits **249***i* and **249***j* constituting the third switch circuit group **249-2** in the next stage are connected to no contact point. With the above-mentioned arrangement, the image display operation on the LCD panel **100** is not influenced by the coordinate detection circuit **105**, and therefore the image display operation is performed utterly in the same manner as in the prior arts. Meanwhile, an output circuit (not shown) of the image display drive circuit **101** shown in FIG. **1** normally has a three-state buffer, and therefore an output terminal thereof is allowed to have a high impedance by external control. Therefore, it is proper to make the function changeover control circuit **108** control the image display drive circuit **101** so as to operate the output circuit of the image display drive circuit **101** only in the image display period and make the output terminal of the image display drive circuit **101** have a high impedance in the coordinate input period. With the above-mentioned arrangement, the image display drive circuit **101** exerts no influence on the coordinate detection circuit **105**. Thus the coordinate input circuit and the image display drive circuit can be easily separated from each other.

In the first embodiment, as shown in FIG. **8**, one segment electrode **107** or one common electrode **106** is connected to each of the two input terminals of the differential amplifier **242**. However, as shown in FIG. **33**A, two electrodes of the LCD panel may be connected to each of the input terminals of the differential amplifier **242**. Furthermore, as shown in FIG. **33**B, three electrodes of the LCD panel may be connected to each of the input terminals of the differential amplifier **242**. Thus, by connecting several electrodes to each of the input terminals of the differential amplifier, a signal-to-noise ratio of the detection signal can be improved. It is to be noted that the switch circuits and the timing circuit shown in FIG. **8** are not illustrated in FIG. **33** for simplification.

In the first embodiment, a pair of electrodes **107** connected to the input terminals of the differential amplifier **242** are adjoining to each other. However, as shown in FIG. **34**A, a pair of electrodes **107** arranged with interposition of one electrode **107** may be connected to the input terminals of the differential amplifier **242**. Furthermore, as shown in FIG.

Petitioner Shenzhen Qianfenyi Intelligent Technology Co., Ltd.
Exhibit 1005 Page 60

34B. a pair of segment electrodes **107** arranged with interposition of two electrodes **107** may be connected to the input terminals of the differential amplifier **242**. Furthermore. as shown in FIG. **35**A. a pair of electrode groups **107**G2 arranged with interposition of one electrode **107** may be connected to the differential amplifier **242**. The electrode groups **107**G2 are each comprised of two electrodes **107**. Furthermore. as shown in FIG. **35**B. a pair of electrode groups **107**G3 arranged with interposition of two electrodes **107** may be connected to the differential amplifier **242**. The electrode groups **107**G3 are each comprised of three electrodes.

As shown in FIGS. **33**A through **35**B. there are numbers of methods for connecting the electrodes to the differential amplifier **242**. What is essential is to connect the electrodes so as to achieve a most improved signal-to-noise ratio. For instance. when a pair of electrode groups arranged with interposition of three electrodes are connected to the differential amplifier. the electrode groups are each required to include four electrodes. Furthermore. in any of the connections shown in FIGS. **33**A through **35**B. the point that the scanning of the electrodes is performed one electrode by one electrode is the same as in the first embodiment. and therefore a resolution in position detection does not deteriorate.

Second embodiment

Next. a second embodiment of the present invention will be described. The second embodiment includes an LCD panel of which display capacity is increased. The LCD panel of which display capacity is increased is shown in FIG. **13**. The LCD panel **260** shown in FIG. **13** includes a common electrode **261***a* in an upper row in FIG. **13** and a common electrode **261***b* in a lower row in FIG. **13**. The common electrodes **261***a* and **261***b* are connected to common electrode connectors **264***a* and **264***b*, respectively.

The LCD panel **260** further includes a segment electrode **262***a* in an upper row in FIG. **13** and a segment electrode **262***b* in a lower row in FIG. **13**. The segment electrodes **262***a* and **262***b* are connected to segment electrode connectors **263***a* and **263***b*, respectively.

As shown in FIG. **13**. a pair of segment electrode **262***a* and segment electrode **262***b* has a configuration where an approximately center portion of one segment electrode is removed.

The LCD panel **260** shown in FIG. **13** is referred to as a "multiple electrode simultaneous scanning type panel". The LCD panel **260** adopts a duty ratio drive system. and has a configuration where each segment electrode comprised of a pair of segment electrode **262***a* and segment electrode **262***b* is separated into two parts at its center portion. In other words. the segment electrode comprised of a pair of segment electrodes **262***a* and **262***b* has a structural feature that it does not continuously extend from one end to the other end of the LCD panel **260**. Therefore. the LCD panel **260** has. so to speak. a structure in which two upper and lower LCD panels are connected with each other at the center position in FIG. **13**. In regard to structure. the multiple electrode simultaneous scanning type LCD panel **260** has a pair of terminals led from the common electrodes **261***a* and **261***b* and two pairs of terminals wired from the segment electrodes **262***a* and **262***b*. The terminals of the common electrodes **261***a* and **261***b* are often led rightward or leftward. while the terminals of the segment electrodes **262***a* and **262***b* are often led both upward and downward.

The present invention is capable of completely separating the coordinate input function from the image display function as described hereinbefore. Therefore. whatever display panel is used. a coordinate input function can be incorporated into the panel by means of the technique of the present invention. Therefore. the present invention can be also applied to the multiple electrode simultaneous scanning type LCD panel **260**. The second embodiment is an embodiment wherein the present invention is applied to the LCD panel **260**.

FIG. **36** shows a module structure of the second embodiment. As shown in FIG. **36**. the second embodiment includes a printed circuit board **701** which is provided in a bracket-like form alongside the LCD panel **260**. The printed circuit board **701** is provided with an x-axis IC device **702**. an x-axis IC device **703**. a y-axis IC device **704**. a timing control IC **705**. and a signal I/O terminal **706**. The x-axis IC device **702** is connected to the segment electrode **262***a*, and the x-axis IC device **703** is connected to the segment electrode **262***b*, and the y-axis IC device **704** is connected to the common electrodes **261***a* and **261***b*.

The x-axis IC devices **702** and **703** and the y-axis IC device **704** are designed to have the function of the coordinate detection circuit **105** concurrently with the function of the image display drive circuit **101** shown in FIG. **1**. The timing control IC **705** corresponds to the function changeover control circuit **108** shown in FIG. **1**.

The module structure of the second embodiment differs from the conventional LCD module provided specially for image display in that the timing control IC **705** and the signal I/O terminal are incorporated.

As shown in FIG. **36**. the module of the second embodiment is the same as the conventional display module provided specially for image display in terms of the point that the bracket-shaped printed circuit board **701** is attached to the LCD panel **260** as arranged opposite to only three sides of the panel. Therefore. the printed circuit board **701** of the second embodiment can be mounted in a space having an area identical to that of the space in which the conventional module provided specially for image display has been provided. The above-mentioned arrangement not only satisfies a requirement for compacting the product but also prevents the possible complication of the manufacturing process. thereby producing an effect of remarkably reducing the manufacturing cost.

In contrast to the above. in the conventional coordinate input function-integrated display device as described hereinbefore. it is required to connect a printed circuit board to all the four sides of the LCD panel. which has been resulted in a drawback that a device in which a module (printed circuit board) is mounted dimensionally increases.

As shown in FIG. **14**. the second embodiment has at least two sets of the basic structure of the first embodiment of the present invention described hereinbefore. In regard to the segment electrodes **262***a* and **262***b*, signals are taken out both from the upper side and lower side by means of differential amplifiers **205***a* and **205***b*. In FIG. **14**. the common electrodes **261***a* and **261***b* are connected to the ground. Conversely. it is required to provide a switch circuit (not shown) for changing the connections so as to connect the segment electrodes **262***a* and **262***b* to the ground and take out signals from the common electrodes **261***a* and **261***b*. It is to be noted that a reference numeral **208** denotes an electric field generator.

Since the LCD panel **260** is widely used in a word processor or the like. numbers of reference documents can be obtained. For instance. it is appropriate to refer to page 99 of "Liquid crystals=Applications. compiled by Okano and

kobayashi, published by Tofuukan, 7th issue, 1992" as a reference document. Needless to say, the LCD panel **260** has been conventionally used specially for image display, and therefore peripheral circuits and so forth for an image display operation are well known.

Next, a structure and an operation of the second embodiment will be described with reference to FIG. **15**. FIG. **15** for explaining the second embodiment corresponds to FIG. **8** for explaining the first embodiment. An LCD panel **280** as shown in FIG. **15** is an LCD panel substantially similar to that of the multiple electrode simultaneous scanning type LCD panel **260** shown in FIG. **13**. The LCD panel **280** includes a segment electrode **284** of which approximate center portion is removed similarly to the LCD panel **260** shown in FIG. **14**. Therefore, the segment electrode **284** has a segment electrode **284***a* in an upper row in FIG. **15** and a segment electrode **284***b* in a lower row in FIG. **15**. The LCD panel **280** further includes a common electrode **285** similarly to the LCD panel **260**.

As shown in FIG. **15**, a pair of two segment electrodes **284***a* and **284***b* have their one end opened and the other end connected to a differential amplifier **281** and a differential amplifier **282**. Then, outputs of the differential amplifier **281** and the differential amplifier **282** are connected to an adder **283**. A reference numeral **208** denotes an electric field generator.

A coordinate transformation circuit **175** as shown in FIG. **15** has a structure substantially similar to that of the coordinate transformation circuit **175** shown in FIG. **8**. The coordinate transformation circuit **175** has an envelope detection circuit **286***b*, a binarizing circuit **286**, a counter **288**, a D-flip-flop **288**, a timing circuit **290**, a T-flip-flop **181**, a delay circuit **182**, and a NAND circuit **183**. As described hereinafter, there are required several switch circuits similar to those shown in FIG. **8** other than the structure shown in FIG. **15**.

In the state shown in FIG. **15**, the common electrodes **285** are connected to the ground, while the segment electrodes **284** are connected to two differential amplifiers **281** and **282**. Some of the above-mentioned switch circuits have a role of changing the connections of the segment electrodes **284** and the common electrodes **285** and a role of scanning the electrodes.

As described hereinbefore, an experiment on which the present embodiment is based is shown in FIG. **5**. An output as shown in FIG. **7** was able to be obtained from the electrodes to which the electric field generator **208** was put close. According to the experiment result shown in FIG. **7**, it was confirmed that the electric field generator **208** was located at or around the coordinates indicated by the bottom of the detected double-humped output signal. Therefore, also in the second embodiment, it can be considered that the differential amplifier **281** or **282** outputs a signal in which the axis of abscissas of the experiment result of FIG. **7** is replaced by a time base similarly to the first embodiment. Then, by detecting a timing (time) at which the bottom of the output signal takes place, the coordinates of the position in which the electric field generator **208** is located can be detected.

In the second embodiment, the LCD panel **280** can be regarded as a panel separated into two upper and lower parts in FIG. **15**. Therefore, when the electric field generator **208** is located at the upper half part of the LCD panel **280**, a signal from the electrodes **284** and **285** of the LCD panel **280** can be detected only by the differential amplifier **281**. When the electric field generator **208** is located at the lower half part of the LCD panel **280**, the signal from the electrodes **284** and **285** can be detected only by the differential amplifier **282**. Therefore, by adding together the outputs from the two differential amplifiers **281** and **282** in the adder **283**, the position of the electric field generator **208** can be detected on the entire surface of the LCD panel **280**. The above-mentioned arrangement is the main feature of the second embodiment.

Next, an operation of the second embodiment will be described according to a signal flow with reference to FIG. **15**.

First, when the electric field generator **208** is located at the upper half part of the LCD panel **280**, a signal from the LCD panel **280** is detected only by the differential amplifier **281**. When the electric field generator **208** is located at the lower half part of the LCD panel **280**, the signal from the LCD panel **280** is detected only by the differential amplifier **282**. Therefore, the differential amplifiers **281** and **282** output signals similar to the signal shown in FIG. **7** according to the position of the electric field generator **208**. Therefore, by adding together the outputs of the differential amplifiers **281** and **282** in the adder **283**, an output similar to the output shown in FIG. **7** can be obtained when the electric field generator **208** is located in whichever position of the entire surface of the LCD panel **280**.

A signal flow subsequent to the adder **283** is approximately equal to that of the first embodiment. That is, the signal is detected by the envelope detection circuit **286***b* to detect an envelope, and then the envelope output is binarized by the binarizing circuit **286** to obtain a pulse signal. Then the pulse signal is subjected to a waveform shaping process in the T-flip-flop **181**, the delay circuit **182** and the NAND circuit **183** to obtain an output pulse. The output pulse is generated in correspondence with the position of the bottom of the double-humped signal shown in FIG. **7** similarly to the first embodiment. Therefore, by detecting the output pulse, the position of the electric field generator **208** can be detected.

The timing circuit **290** inputs a set signal representing a specified timing to a load terminal of the counter **289**. The counter **289** starts counting according to a specified clock with the set signal used as a time reference. Then, by inputting a count value of the counter **289** to a D terminal of the D-flip-flop **288** and inputting the output pulse from the NAND gate **183** to a clock terminal of the D-flip-flop **288**, the D-flip-flop **288** holds data supplied from the counter **289** to the D-flip-flop **288** in accordance with a timing at which the output pulse from the binarizing circuit **286** is outputted.

When the timing circuit **290** performs an operation timing control as described below, the data held in the D-flip-flop **288** can represent the coordinates of the electric field generator **208**.

The operation of detecting the coordinates of the position of the electric field generator **208** is performed similarly to the first embodiment, just as explained with reference to FIG. **8**. That is, though not shown in FIG. **15**, by providing a specific switch circuit and controlling the switch circuit similarly to the first embodiment so as to scan the segment electrodes and the common electrodes, a signal can be detected to allow the coordinates of the electric field generator **208** to be specified.

Next, necessary switch circuits which are not illustrated in FIG. **15** will be described with reference to FIG. **16**. FIG. **16** shows a first switch circuit **291**, a second switch circuit **292** and a third switch circuit **293** which are necessary. The first switch circuit **291** is comprised of first switch circuits **291***a*

Petitioner Shenzhen Qianfenyi Intelligent Technology Co., Ltd.
Exhibit 1005 Page 62

through *d*, **291***e* through *h* and **291***i* through *l*. The second switch circuit **292** is comprised of switch circuits **292***a* and *b*, switch circuits **292***c* and *d* and switch circuits **292***e* and *f*. Operations of the first, second and third switch circuits **291**, **292** and **293** and the timing circuit **290** will be described.

As shown in FIG. **16**, in the second embodiment, the first switch circuits **291***a*, *b*, *c* and *d* are provided for the segment electrode **284***a*, while the first switch circuits **291***e*, *f*, *g* and *h* are provided for the segment electrode **284***b*. In other words, in the second embodiment, the first switch circuits **291***a* through *d* and **291***e* through *h* are provided along two sides of the LCD panel **280**. Since the second embodiment has the switch circuits for detecting a signal from the segment electrodes along the two sides of the LCD panel **280**, the switch circuit structure is more complicated than that of the first embodiment.

Though no detailed structure is shown in FIG. **16**, the first and second switch circuits **291** and **292** have the same structures as those of the first switch circuit group **249-1** and the second switch circuit group **250** shown in FIG. **8**. For instance, the switch circuits **291***a*, *b*, *c* and *d* and **291***e*, *f*, *g* and *h* shown in FIG. **16** have the same structures as those of the switch circuits **249***a*, *b*, *c* and *d* shown in FIG. **8**. Similarly, the switch circuits **291***i*, *j*, *k* and *l* shown in FIG. **16** have the same structures as those of the switch circuits **249***e*, *f*, *g* and *h* shown in FIG. **8**.

The switch circuits **292***a* and *b* and switch circuits **292***c* and *d* shown in FIG. **16** have the same structures as those of the switch circuits **250***a* and *b* shown in FIG. **8**, while the switch circuits **292***e* and *f* shown in FIG. **16** have the same structures as those of the switch circuits **250***c* and *d* shown in FIG. **8**.

Thus, since the first and second switch circuits **291** and **292** of the second embodiment correspond to the first and second switch circuits of the first embodiment, it is easy to understand the structure shown in FIG. **16** with reference to FIG. **8**.

Next, an operation of the timing circuit **290** will be described. The timing circuit **290** mainly controls the operations of the first, second and third switch circuits **291**, **292** and **293**, and further generates a clock signal to be inputted to the counter **289**. The timing circuit **290** controls the switch circuits **291**, **292** and **293**, and makes the data held in the D-flip-flop **288** designate the coordinates of the electric field generator **208** by inputting the clock signal to the counter **289**. The control is performed by the timing circuit **290** in the same manner as in the first embodiment shown in FIG. **12**.

In the second embodiment, a signal can be detected from the segment electrodes **284** by means of the differential amplifiers **281** and **282** with the common electrodes **285** all connected to the ground in the same manner as described in the aforementioned experiment. Also, a signal can be detected from the common electrodes **285** by means of a differential amplifier **294** with the segment electrodes **284** all connected to the ground. In the aforementioned experiment, a voltage waveform having a double-humped form was able to be detected in correspondence with the position of the electric field generator. Then, the bottom portion of the double-humped voltage waveform represented the coordinates of the position in which the electric field generator **208** was located. Therefore, by performing two times coordinate detection from the segment electrode side and coordinate detection from the common electrode side, the xy-coordinates of the electric field generator **208** was able to be specified. Therefore, also in the second embodiment, it is proper to time-sharingly perform two times coordinate detection of the position of the electric field generator **208** from the segment electrode **284** side and from the common electrode **285** side. In a manner similar to that confirmed in the experiment of FIG. **5**, when the segment electrodes **284** are scanned to detect the coordinates of the position, it is required to connect all the common electrodes **285** to the ground. The converse can also hold. Therefore, the timing circuit **290** switchingly controls the switch circuits **291** and **292** so as to satisfy the aforementioned requirements. In detail, when the segment electrodes **284** are scanned to detect the x-coordinate value of the electric field generator **208**, the first switch circuits **291***a* through *d* and **291***e* through *h* connected to the segment electrodes **284** are connected to the second switch circuits **292***a* and *b* and **292***c* and *d* in the next stage so as to transmit signals. Then, the first switch circuits **291***i* through *l* connected to the common electrodes **285** are connected to the ground. Consequently, signals from the segment electrodes **284** are transmitted to the differential amplifiers **281** and **282** via the second switch circuits **292***a* and *b* and **292***c* and *d*, respectively. Then, signals amplified in the differential amplifiers **281** and **282** are further added together in the adder **283**. Then, a signal outputted from the adder **283** is inputted to the coordinate transformation circuit **175** via the third switch circuit **293** switched to the segment electrode side s, and then transmitted to the binarizing circuit **286**. A subsequent signal flow and an operation of the coordinate transformation circuit **175** are the same as explained in the first embodiment.

Conversely, when the coordinate detection is performed from the common electrodes **285** side, the first switch circuits **291***i* through *l* connected to the common electrodes **285** are connected to the second switch circuits **292***e* and *f* in the next stage to transmit a signal. Meanwhile, the switch circuits **291***a* through *d* and **291***e* through *h* connected to the segment electrodes **284** are connected to the ground. A signal outputted from the second switch circuits **292***e* and **292***f* is transmitted via the differential amplifier **294** to the third switch circuit **293** which is switched to the common electrode side c. Since the third switch circuit **293** is switched to the common electrode side c, the signal is transmitted to the binarizing circuit **286** of the coordinate transformation circuit **175**. A subsequent signal flow and an operation of the coordinate transformation circuit **175** are the same as those of the first embodiment described hereinbefore.

The second switch circuits **292***a* and *b*, *c* and *d* and *e* and *f* are switched so as to sequentially scan the segment electrodes **284** and the common electrodes **285**, with which it can be detected how great value of voltage is outputted from each of the segment electrodes **284** and the common electrodes **285** by means of the differential amplifiers **281**, **282** and **294**. The second switch circuit **292** sequentially scans each of the electrodes from the electrode adjacent to the origin of xy-coordinate axes shown in FIG. **16**. In FIG. **16**, there are set xy-coordinate axes of which origin is located at a lower right position of the LCD panel **280** similarly to FIG. **8**. Then, the electrodes are sequentially scanned from the one adjacent to the origin of the xy-coordinate axes.

When the states of the contact points of the switch circuits **291** and **292** shown in FIG. **16** are in the same contact point connection states as those of the first and second switch circuits shown in FIG. **8**, the first segment electrode **284** from the origin of the x-axis is connected to a negative input terminal of the differential amplifier **281**, and the second segment electrode from the origin of the x-axis is connected

to a positive input terminal of the differential amplifier **281**. When the scanning proceeds by one step, the second segment electrode from the origin of the x-axis and the third segment electrode from the origin of the x-axis are connected to the negative input terminal and the positive input terminal of the differential amplifier **281**, respectively.

Meanwhile, the first segment electrode from the origin of the x-axis is connected to a positive input terminal of the differential amplifier **282**, and the second segment electrode from the origin of the x-axis is connected to a negative input terminal of the differential amplifier **282**. When the scanning proceeds by one step, the second segment electrode from the origin of the x-axis and the third segment electrode from the origin of the x-axis are connected to the negative input terminal and the positive input terminal of the differential amplifier **282**, respectively.

Thus a combination of the pair composed of four segment electrodes **284***a* and **284***b* which are arranged in the upper and lower rows and connected to the two differential amplifiers **281** and **282** is shifted sequentially one electrode by one electrode in a direction in which x-axis position coordinates are arranged in the x-axis. Thus, each combination of the segment electrodes to be connected to the differential amplifiers **281** and **282** is sequentially scanned. Therefore, a waveform obtained by replacing the axis of abscissas of the double-humped waveform shown in FIG. **7** with a time base is outputted from the output terminal of the adder **283**. In other words, the condition of the experiment shown in FIG. **7** is reproduced.

In the second embodiment, the scanning is performed by pairing adjoining two electrodes in order to faithfully reproduce the experiment shown in FIG. **5**. However, the above-mentioned scanning may be performed by grouping adjoining or adjacent two or more electrodes as an electrode group and pairing adjoining two electrode groups.

The scanning operation is performed by outputting a switching control signal from the timing circuit **290** to control lines which are wired from the timing circuit **290** to the switch circuits **291** through **293**. A switching operation of the switch circuits is shown in FIG. **12**.

The switch circuit for performing the switching operation by a signal inputted via the control lines from the timing circuit **290** can be easily implemented by, for example, an appropriate multiplexer device. Furthermore, the timing circuit **290** for outputting a control signal as described above to the control lines can be easily implemented by combining a counter device, a gate device, and so forth availed on the market.

A timing at which the second switch circuits **292** are sequentially switched under the control of the timing circuit **290** to scan the electrodes **284** and **285** and a timing at which the counter **289** counts one count by one count are made to coincide with each other. Therefore, the count value of the counter **289** represents the ordinal number from the origin of each of the electrodes **284** and **285** connected to the differential amplifiers **281**, **282** and **294** in the scanning time. The timing circuit **290** of course generates a switching control signal to be inputted to the second switch circuits **292** in synchronization with the clock signal inputted from the timing circuit **290** to the counter **289**. It is easy to make the timing circuit **290** have a structure for generating such a control signal.

If the switch circuits **291** are thus controlled, consequently a value representing the ordinal number from the origin of the electrodes connected to the differential amplifiers in the electrode scanning time, i.e., the count value of the counter **289** is held in the D-flip-flop **288**. The value held in the D-flip-flop **288** is a count value that the counter **289** has counted sequentially one count by one count in synchronization with the electrode scanning from a time when the counter **289** is reset to a time when a negative pulse is generated from the NAND gate **183**.

In other words, the count value is a value which is obtained, as a result of searching by means of the switch circuits the bottom portion of a double-humped output voltage corresponding to the coordinates of the position of the electric field generator **208** by shifting one by one the electrodes of the LCD panel **280** connected to the differential amplifiers in the scanning direction, by representing the position of the bottom with the amount of electrodes counted by the coordinate transformation circuit **175**, and then held in the D-flip-flop **288**. In other words, the x-coordinate value or the y-coordinate value of the position in which the electric field generator **208** is located is detected as represented by the counted amount of electrodes.

As described above, the x-coordinate value and the y-coordinate value of the position in which the electric field generator **208** is located are each held in the D-flip-flop **288** when the negative pulse is outputted from the NAND gate **183** in each detection period shown in FIG. **12**. The data representing the coordinates of the position of the electric field generator **208** can be separately utilized as detected coordinate data. Though there is no specific limitation on application methods of the data, for example, an application similar to that described in the first embodiment can be achieved.

It is to be noted that each switch circuit may have a structure other than that of the second embodiment. Since each switch circuit can be easily constructed in a variety of ways, no particular description is provided therefor herein. What is essential is the assurance of the timing shown in FIG. **12** by means of the switch circuits. Furthermore, there is no special reason for using a switch circuit, and therefore a circuit obtained by effectively combining a three-state buffer circuit and other devices may be utilized.

Although the second embodiment has been described based on only 16 pixels shown concretely for simplicity, the LCD panel **280** of course practically includes a greater number of pixels. Furthermore, the same basic structure and basic operation as those of the second embodiment can be also achieved in an LCD panel having more pixels.

The second embodiment includes the function changeover control circuit **108** shown in FIG. **1**. The function changeover control circuit **108** controls the image display drive circuit **101** and the coordinate detection circuit **105** to make the LCD panel **280** perform time-sharingly alternately image display and coordinate detection operations. The function changeover control circuit **108** shown in FIG. **1** outputs a control signal to the timing circuit **290** shown in FIG. **16**. Then, the coordinate detection circuit **105** performs the aforementioned coordinate detection operation only in the coordinate detection period, and operates to disconnect the first switch circuits **291** and so forth from the LCD panel **280** so that they do not hinder the image display operation in the image display period. In more detail, in the image display period, the first switch circuits **291***a* through *l* connect their contact points so as to electrically connect all the electrodes of the LCD panel **280** to the second switch circuits **292***a* through *f*. Then, the second switch circuits **292** are connected to contact points connected to nothing. Therefore, the differential amplifiers **281**, **282** and **294** subsequent to the second switch circuits **292** are discon-

nected from the LCD panel **280**. Consequently, the image display operation is not influenced by the coordinate detection circuit **105** shown in FIG. **1** including the coordinate transformation circuit **175**. In other words, an operation similar to that of the conventional LCD device provided specially for image display can be performed in the image display period. The second embodiment includes the function changeover control circuit **108** and the image display drive circuit **101** shown in FIG. **1**, and the operations of the circuits are the same as those of the first embodiment.

Third embodiment

Next, a third embodiment of the present invention will be described. The third embodiment is an embodiment in which a coordinate detection device of the present invention is applied to a TFT (Thin Film Transistor) LCD panel. As described hereinbefore in the first and second embodiments, the coordinate input function and the image display function can be completely separated from each other when the present invention is applied to an LCD panel provided for image display. Then, as is apparent from the following description of the third embodiment, a coordinate input function can be incorporated into a TFT LCD panel by means of the technique of the present invention.

FIG. **17** shows a structure of a TFT LCD panel **310**. As shown in FIG. **17**, the TFT LCD panel **310** normally has a structural feature that segment electrodes **314***a* and **314***b* are extending in a comb-like form alternately from the upper and lower ends of the LCD panel **310**.

As shown in FIG. **18**, the third embodiment includes two pairs of the basic structure of the first embodiment shown in FIG. **8**. That is, a signal can be taken out of the segment electrodes **314***a* and **314***b* owned by the LCD panel **310** alternately from the upper and lower ends in a direction in which the electrodes are arranged. FIG. **18** shows a state in which common electrodes **315** of the LCD panel **310** are connected to the ground. The third embodiment includes switch circuits similarly to the second embodiment shown in FIG. **16**. The switch circuits switch an electrode connection state as shown in FIG. **18** so that they can connect the segment electrodes **314** to the ground and take out a signal from the common electrodes **315** and transmit the signal to a differential amplifier (not shown).

Since the above-mentioned TFT LCD panel is already used widely, numbers of reference documents can be easily obtained. For instance, it is appropriate to refer to page 104 of "Liquid crystals=Applications, compiled by Okano and kobayashi, published by Tofuukan, 7th issue, 1992" as a reference document. Since the TFT LCD panel has been conventionally used specially for image display, peripheral circuits and so forth for image display are well known.

In the TFT LCD panel **310**, a display section has a dimension of 17 cm (laterally)×14.3 cm (longitudinally), a pixel structure of 640 (for each of R, G and B colors) pixels (laterally)×480 pixels (longitudinally) and a pixel dimension of 255 μm (laterally)×300 μm (longitudinally). Further, the TFT LCD panel has two glass plates each having a thickness of **1** mm, a gap of about 7 μm between the two glass plates, an electrode width of about 35 μm, and an electrode thickness of about 1 μm.

FIG. **19** shows in detail the structure of the third embodiment. FIG. **19** corresponds to FIG. **15** used for the description of the second embodiment. In FIG. **19**, a reference numeral **310** denotes a TFT LCD panel, and the TFT LCD panel **310** includes segment electrodes **314** and common electrodes **315**. A pair of two segment electrodes **314***a* and **314***a* are arranged with interposition of one segment electrode **314***b*, and one end of the segment electrodes **314***a* is electrically opened in a position before a peripheral edge of the LCD panel **310**. Then the other end of the pair of the segment electrodes **314***a* is connected to an input terminal of a differential amplifier **311**. On the other hand, a pair of two segment electrodes **314***b* and **314***b* are arranged with interposition of one segment electrode **314***a*, and one end of the segment electrodes **314***b* is electrically opened in a position before a peripheral edge of the LCD panel **310**. Then the other end of the pair of the segment electrodes **314***b* is connected to an input terminal of a differential amplifier **312**.

An output terminal of the differential amplifier **311** and an output terminal of the differential amplifier **312** are connected to input terminals of an adder **313**. A reference numeral **208** denotes an electric field generator.

The third embodiment has a coordinate transformation circuit **175** connected to an output terminal of the adder **313**. The coordinate transformation circuit **175** has the same structure as that of the coordinate transformation circuit of the second embodiment shown in FIG. **15**, and includes an envelope detection circuit **316***b*, a binarizing circuit **316**, a counter **319**, a D-flip-flop **318**, a T-flip-flop **181**, a delay circuit **182**, and a NAND gate **183**. The third embodiment further includes a timing circuit **320** similar to that of the second embodiment.

As described hereinafter, the third embodiment requires several switch circuits similarly to the second embodiment. The switch circuits have a function of switching a connection state of the common electrodes **315** and the segment electrodes **314** and a function of shifting the connection state of the electrodes one by one in a direction in which the electrodes are arranged as explained in the second embodiment.

The third embodiment is based on the experiment shown in FIG. **5** similarly to the first and second embodiments. By putting the electric field generator **208** close to the electrodes shown in FIG. **5**, the experiment result shown in FIG. **7** was able to be obtained. It was confirmed that the electric field generator **208** was located near the electrodes of the LCD panel at which the bottom of the detected output signal waveform took place.

Therefore, the differential amplifier **311** or **312** outputs a signal in which the axis of abscissas of the experiment result shown in FIG. **7** is replaced by a time base similarly to the first embodiment. Therefore, similarly to the first embodiment, a timing (time) at which the bottom of the signal waveform exists can be used as a signal representing the coordinates of the position in which the electric field generator **208** is located.

When the electric field generator **208** is located near the segment electrodes **314***a*, signals are outputted from both the differential amplifier **311** and the differential amplifier **312**. Therefore, by adding together the output signals from the differential amplifiers **311** and **312**, the position of the electric field generator **208** can be detected when the electric field generator **208** is located in whichever position of the entire surface of the LCD panel **310**.

FIG. **20** shows a result obtained by performing an experiment similar to that shown in FIG. **5** on the TFT LCD panel. The experiment result shown in FIG. **20** shows a tendency similar to that of the experiment result shown in FIG. **7**. That is, as shown in FIG. **20**, an AC output voltage of which envelope has a double-humped shape can be obtained from the differential amplifiers. Then, a minimum (bottom) output voltage can be obtained from the segment electrodes **314***a* to which the electric field generator **208** is put close. In other

words, the output voltage shown in FIG. **20** is related to the position of the electric field generator **208**.

Next, an operation of the third embodiment will be described with reference to FIG. **19**.

First, the differential amplifiers **311** and **312** output a detection voltage shown in FIG. **20** in correspondence with the position of the electric field generator **208**. Then, the adder **313** adds together the outputs of the differential amplifiers **311** and **312**, and outputs a double-humped output voltage waveform similar to that shown in FIG. **9**A. Then, the envelope detection circuit **316***b* detects and extracts the envelope of the double-humped output voltage waveform. Then, the binarizing circuit **316** compares the detected envelope waveform with a specified reference voltage to binarize the same, and outputs a pulse signal similar to that shown in FIG. **9**C. The position of the pulse signal corresponds to the bottom of the signal of the experiment result shown in FIG. **20**. That is, the position of the pulse signal represents the position of the electric field generator **208**. An output signal of the binarizing circuit **316** is inputted to the T-flip-flop **181** similarly to the first embodiment, and an output from an inverted Q terminal of the T-flip-flop **181** is directly inputted to the NAND gate **183**, and an output from a Q terminal of the T-flip-flop **181** is inputted to the NAND gate **183** via the delay circuit **182**. Then, an output of the NAND gate **183** is inputted to a clock terminal of the D-flip-flop **318**.

On the other hand, the timing circuit **320** outputs a signal representing a specified timing as a set signal to a load terminal of the counter **319**, and the counter **319** starts counting according to a specified clock with the load signal used as a time reference. A count value of the counter **319** is inputted to a D terminal of the D-flip-flop **318**.

An output of the NAND gate **183** is inputted to a clock terminal of the D-flip-flop **318**. Therefore, data supplied from the D-flip-flop **318** is held in accordance with the timing at which a pulse is outputted from the D-flip-flop **318**.

Therefore, by making the timing circuit **320** perform a proper timing control as follows, the data held in the D-flip-flop **318** can represent the coordinates of the position of the electric field generator **208**.

As to an operation of the timing circuit **320**, there is required an operation of scanning the segment electrodes and the common electrodes by controlling the switch circuits similarly to the timing circuit **290** shown in FIGS. **15** and **16** of the second embodiment. The above-mentioned operation will be described below.

As shown in FIG. **21**, in the third embodiment, first switch circuits **341***a*, **341***b* and **341***c* and second switch circuits **342***a* and **342***b* are provided for the segment electrodes **314***a*, while first switch circuits **341***d*, **341***e* and **341***f* and second switch circuits **342***c* and **342***d* are provided for the segment electrodes **314***b*. Further, first switch circuits **341***g*, **341***h* and **341***i* and second switch circuits **342***e* and **342***f* are provided for the common electrodes **315**.

Though FIG. **21** does not show a detailed structure of the switch circuits provided in the third embodiment, the switch circuits have utterly the same structures as those of the switch circuits shown in FIG. **8** of the first embodiment except for a difference in amount of circuits.

In detail, the first switch circuits **341***a*, *b* and *c* and **341***d*, *e* and *f* shown in FIG. **21** have the same structures as those of the switch circuits **249***a*, *b* and *c* shown in FIG. **8**. The first switch circuits **341***g*, *h* and *i* shown in FIG. **21** have the same structures as those of the switch circuits **249***e*, *f* and *g* shown in FIG. **8**. The second switch circuits **342***a* and *b* and the second switch circuits **342***c* and *d* shown in FIG. **21** have the same structures as those of the switch circuits **250***a* and *b* shown in FIG. **8** except for a difference in amount of circuits. Further, the second switch circuits **342***e* and *f* shown in FIG. **21** have the same structures as those of the switch circuits **250***c* and *d* shown in FIG. **8** except for a difference in amount of circuits. Therefore, the operation of the switch circuits of the third embodiment can be easily understood with reference to FIG. **8** together with FIG. **21** while taking the above-mentioned correspondence into account.

Then, an operation of the timing circuit **320** will be described. The timing circuit **320** mainly controls the operations of the first, second and third switch circuits **341**, **342** and **343**. Further, the timing circuit **320** generates a clock signal to be inputted to the counter **319**. The timing circuit **320** controls the switch circuits **341**, **342** and **343**, and inputs the clock signal to the counter **319** so as to make the data held in the D-flip-flop **318** represent the coordinates of the electric field generator **208**. The above-mentioned control operation is performed by the timing circuit **320** in a manner as shown in FIG. **12** of the first embodiment.

In the third embodiment, with the common electrodes **315** all connected to the ground, a signal from the segment electrodes **314** can be detected by the differential amplifiers **311** and **312** in a manner as described in the aforementioned experiment. Also, with the segment electrodes **314** all connected to the ground, a signal can be detected from the common electrodes **315** by a differential amplifier **344**. In the aforementioned experiment, a double-humped voltage waveform was able to be obtained in correspondence with the position of the electric field generator. The bottom portion of the double-humped voltage waveform represented the coordinates of the position in which the electric field generator **208** was located. Therefore, by performing two times the operations of position coordinate detection from the segment electrode side and position coordinate detection from the common electrode side, the xy-coordinates of the electric field generator was able to be specified. Therefore, also in the third embodiment, it is proper to time-sharingly perform two times the operations of the coordinate detection of the position of the electric field generator **208** from the segment electrode **314** side and from the common electrode **315** side. Similarly to the experiment shown in FIG. **5**, it is required to connect all the common electrodes **315** to the ground when the coordinates of the position are detected by scanning the segment electrodes **314**. The converse can also hold. Therefore, the timing circuit **320** switchingly controls the switch circuits **341** and **342** so as to satisfy the aforementioned requirements. In detail, when the segment electrodes **314** are scanned to detect the x-coordinate value of the electric field generator **208**, the first switch circuits **341***a*, *b* and *c* and **341***d*, *e* and *f* connected to the segment electrodes **314** are connected to the second switch circuits **342***a* and *b* and **342***c* and *d* in the next stage to transmit signals. Then, the first switch circuits **341***g* through *i* connected to the common electrodes **315** are connected to the ground. Consequently, the signals from the segment electrodes **314***a* and *b* are transmitted to the differential amplifiers **311** and **312** via the second switch circuits **342***a* and *b* and *c* and *d*. Then, signals amplified in the differential amplifiers **311** and **312** are further added together in the adder **313**. Then, an output signal from the adder **313** is inputted to the coordinate transformation circuit **175** via the third switch circuit **343** switched to the segment electrode side s, and then transmitted to the binarizing circuit **316** via the envelope detection circuit **316***b*. A subsequent signal flow and an operation of the coordinate transformation circuit **175** are the same as explained in the first embodiment.

Conversely, when the coordinate detection operation is performed from the common electrode **315** side, the first switch circuits **341***g* through **341***i* connected to the common electrodes **315** are connected to the second switch circuits **342***e* and *f* in the next stage to transmit the signal. Meanwhile, the switch circuits **341***a* through *f* connected to the segment electrodes **314** are connected to the ground. The signal outputted from the second switch circuits **342***e* and **342***f* is transmitted via the differential amplifier **344** to the third switch circuit **343** which is switched to the common electrode side c. Then, the above-mentioned signal is transmitted to the envelope detection circuit **316***b* and the binarizing circuit **316** of the coordinate transformation circuit **175**. A subsequent signal flow and an operation of the coordinate transformation circuit **175** are the same as those of the first embodiment described hereinbefore.

The second switch circuits **342***a* through **342***f* are switched so as to scan the segment electrodes **314** and the common electrodes **315**, with which it can be detected how great value of voltage is outputted from each of the segment electrodes **314** and the common electrodes **315** by means of the differential amplifiers **311**, **312** and **344**. The second switch circuit **342** sequentially scans the electrodes from the one adjacent to the origin of the xy-coordinate axes shown in FIG. **21**. In FIG. **21**, the origin is located in a lower right position of the LCD panel **310** similarly to FIG. **8**.

When the connection states of the contact points of the switch circuits **341** and **342** shown in FIG. **21** are in the same connection states as those of the contact points of the first and second switch circuits shown in FIG. **8**, a negative input terminal of the differential amplifier **311** is connected to the first segment electrode **314***a* as counted from the origin, and a positive input terminal thereof is connected to the second segment electrode **314***a* as counted from the origin. When the scanning proceeds by one step, the negative input terminal of the differential amplifier **311** is connected to the second segment electrode **314***a* as counted from the origin, and the positive input terminal thereof is connected to the third segment electrode **314***a* as counted from the origin.

Meanwhile, a positive input terminal of the differential amplifier **312** is connected to the first segment electrode **314***b* as counted from the origin, and a negative input terminal thereof is connected to the second segment electrode **314***b* as counted from the origin. When the scanning proceeds by one step, the positive input terminal of the differential amplifier **312** is connected to the second segment electrode **314***b* as counted from the origin, and the negative input terminal thereof is connected to the third segment electrode **314***b* as counted from the origin.

Thus a total of four electrodes comprised of a pair of two electrodes connected to the two differential amplifiers **311** and **312** constitute a pair, and a combination of the pair is shifted sequentially one electrode by one electrode in a direction in which the x-axis extends. Thus, combinations of the segment electrodes to be connected to the differential amplifiers **311** and **312** are sequentially scanned. Therefore, a waveform obtained by replacing the axis of abscissas of the double-humped waveform shown in FIG. **20** with a time base is outputted from the output terminal of the adder **313**. In other words, the state of the experiment shown in FIG. **20** is reproduced.

In the third embodiment, the scanning operation is performed by pairing adjoining two segment electrodes **314** of the upper side and those of the lower side of the LCD panel **310** in order to faithfully reproduce the experiment shown in FIG. **5**. However, the aforementioned scanning may be performed by grouping, for example, adjoining or adjacent two or more electrodes as an electrode group and pairing adjoining two electrode groups.

The scanning operation is performed by outputting a switching control signal from the timing circuit **320** to control lines which are wired from the timing circuit **320** to the switch circuits **341** through **343**. The switching operation of the switch circuits is performed according to FIG. **12**.

The switch circuits for performing the switching operation by a signal inputted from the control lines wired from the timing circuit **320** can be easily implemented by, for example, an appropriate multiplexer device. Furthermore, the timing circuit **320** for outputting a control signal as described above to the control lines can be easily implemented by combining a counter device, a gate device, and so forth availed on the market.

A timing at which the second switch circuits **342** are sequentially switched under the control of the timing circuit **320** to scan the electrodes **314** and **315** and a timing at which the counter **319** counts one count by one count are made to coincide with each other. Therefore, the count value of the counter **319** represents the ordinal number from the origin of each of the electrodes **314** and **315** connected to the differential amplifiers **311**, **312** and **344** in the scanning time. Also, the timing circuit **320** generates a switching control signal to be inputted to the second switch circuits **342** in synchronization with the clock signal inputted from the timing circuit **320** to the counter **319**. It is easy to make the timing circuit **320** have a structure for generating such a control signal.

If the switch circuits **341**, **342** and **343** are thus controlled, consequently a value representing the ordinal number from the origin of the electrode connected to the differential amplifiers in the electrode scanning time, i.e., the count value of the counter **319** is held in the D-flip-flop **318**. The value held in the D-flip-flop **318** is a count value that the counter **319** has counted sequentially one count by one count in synchronization with the electrode scanning from a time when the counter **319** is reset to a time when a negative pulse is generated from the NAND gate **183**.

In other words, the count value is a value which is obtained, as a result of searching by means of the switch circuits the bottom of the double-humped output voltage corresponding to the coordinates of the position of the electric field generator **208** by shifting in a scanning direction one by one the electrodes of the LCD panel **310** connected to the differential amplifiers, by representing the position of the bottom with the amount of electrodes counted by the coordinate transformation circuit **175**, and then held in the D-flip-flop **318**. The x-coordinate value or the y-coordinate value at the position in which the electric field generator **208** is located is represented by the counted amount of electrodes.

As described above, the x-coordinate value and the y-coordinate value of the position in which the electric field generator **208** is located are held in the D-flip-flop **318** when the negative pulse is outputted from the NAND gate **183** in each detection period shown in FIG. **12**. Data representing the coordinates of the position of the electric field generator **208** can be separately utilized as detected coordinate data. Though there is no specific limitation on application methods of the data, for example, an application similar to that described in the first embodiment can be achieved.

It is to be noted that each switch circuit may have a structure other than that of the third embodiment. Since each switch circuit can be easily constructed in a variety of ways.

no description is provided therefor herein. What is essential is the assurance of the timing shown in FIG. **12** by means of the switch circuits. Furthermore, there is no special reason for using a switch circuit, and therefore a circuit provided by effectively combining a three-state buffer circuit and other devices may be utilized.

Although the third embodiment has been described based on an LCD panel having 30 pixels shown concretely for simplicity, utterly the same basic structure and basic operation as those of the third embodiment can be also achieved in an LCD panel having more pixels.

Furthermore, when the TFT LCD panel **310** is used as in the third embodiment, connections of the segment electrodes and the common electrodes to the switch circuits are not limited to the connections shown in FIGS. **19** and **21**. That is, the electrodes may be connected in a manner as shown in FIG. **8** where a duty ratio drive LCD panel is used. In the above-mentioned case, either one of the two differential amplifiers provided at the upper and lower sides shown in FIG. **19** is required to be provided. That is, in the present case, there is no need to provide two differential amplifiers at the upper and lower sides, and either one of the differential amplifiers is required to be provided. Then, the segment electrodes are to be used every other one for coordinate detection.

The third embodiment includes the function changeover control circuit **108** shown in FIG. **1**. The function changeover control circuit **108** controls the image display drive circuit **101** and the coordinate detection circuit **105** to make the LCD panel **310** perform time-sharingly alternately image display and coordinate detection operations. The function changeover control circuit **108** shown in FIG. **1** outputs a control signal to the timing circuit **320** shown in FIG. **21**. Then, the coordinate detection circuit **105** performs the aforementioned coordinate detection operation only in the coordinate detection period, and operates to disconnect the first switch circuits **341** and so forth from the LCD panel **310** so that they do not hinder the image display operation in the image display period. In more detail, in the image display period, the first switch circuits **341***a* through *i* connect contact points thereof so that all the electrodes of the LCD panel **310** are connected to the second switch circuits **342**. The second switch circuits **342** are connected to contact points connected to nothing. Therefore, the differential amplifiers **311**, **312** and **344** subsequent to the second switch circuits **342** are electrically disconnected from the LCD panel **310**. As a result, the image display operation is not influenced by the coordinate detection circuit **105** shown in FIG. **1** including the coordinate transformation circuit **175**. In other words, an operation similar to that of the conventional LCD device provided specially for image display can be performed in the image display period. The operations of the function changeover control circuit **108** and the image display drive circuit **101** provided in the third embodiment are the same as those of the first embodiment.

As described hereinbefore, the aforementioned first through third embodiments are designed to make respective LCD panels have a coordinate detection function by applying the present invention to the LCD panels which operate according to different principles of image display operations.

Furthermore, in the descriptions of the first through third embodiments, the position of the electric field detector is determined by means of a binarized pulse as shown in FIGS. **9**A through **9**F. However, instead of using the binarized pulse signal, it is acceptable to detect three points which represent x-coordinate values of x**1**, x**2** and x**3** and voltages corresponding to the coordinate values in a manner as shown in FIG. **22**, perform regression analysis or the like based on the three points to apply a polynomial, and detect the coordinates of an objective point x corresponding to the position in which the electric field generator is located. There can be considered a variety of other ways to derive the coordinates of the position of the electric field generator by detecting a voltage induced at the electrodes of the LCD panel by means of an electric field exerted from the electric field generator.

One of the segment electrode and the common electrode, being not used for coordinate detection, is connected to the ground in the first through third embodiments, however, the electrode may be opened as connected to nothing. In the above-mentioned case, the electrode tends to be influenced by external noises, and therefore it is required to separately take some countermeasure such as shield. Therefore, when the electrode is not connected to the ground, the electrode is preferably connected to a specified reference potential. It is of course acceptable to superimpose a sort of AC voltage or DC voltage via, for example, a capacitor on the electrode which is not used for coordinate detection.

Although the second and third embodiments are provided with the coordinate transformation circuit **175** of the first embodiment, each of the embodiments may be provided with a coordinate transformation circuit **175**T of the modification of the first embodiment.

Fourth embodiment

Next, a fourth embodiment of the present invention will be described. The fourth embodiment has a feature that it includes a coordinate transformation circuit **275** as shown in FIG. **23** having a principle of operation of coordinate transformation fundamentally different from that of the coordinate transformation circuit **175** owned by the first embodiment shown in FIG. **8** in place of the coordinate transformation circuit **175**. The other components except for the coordinate transformation circuit **275** have the same structure as those of the first embodiment. Therefore, the fourth embodiment includes a function changeover control circuit **108** and an image display drive circuit **101** having the same structures as those of the first embodiment.

The fourth embodiment is common to the first through third embodiments in a point as follows. That is, a double-humped signal waveform in which the axis of abscissas of the experiment result shown in FIG. **7** is replaced by a time base is inputted to the coordinate transformation circuit **175**, and the coordinate transformation circuit **175** detects a timing at the bottom of the double-humped output signal so as to detect the coordinates of the position of the electric field generator **208**.

Furthermore, the fourth embodiment differs from the first through third embodiments in a point as follows. That is, the coordinate transformation circuit having a structure different from those of the first through third embodiments is provided, and the coordinate transformation circuit detects the bottom portion of the double-humped output signal not by the amplitude of the signal but by the phase of the signal. In other words, the coordinate transformation circuit provided in the fourth embodiment detects the bottom portion of the double-humped output signal by taking advantage of a phase inversion characteristic that is characterized by a phase difference of 180° between a portion of the signal before the bottom portion of the double-humped output and a portion of the signal behind the bottom portion. As described above, the point of the fourth embodiment is to

detect the timing of the bottom portion by phase paying attention to the fact that the phase of the signal is inverted between the portions before and behind the bottom portion.

FIG. **23** shows the structure of the coordinate transformation circuit **275** provided in the fourth embodiment. The coordinate transformation circuit **275** includes a differential amplifier **179** of which input terminals are connected to switch circuits similar to the switch circuits of the first embodiment, a delay circuit **220** connected to an output terminal of the differential amplifier **179**, and a subtracter **221** of which positive input terminal + is connected to the output terminal of the delay circuit **220**. A negative input terminal – of the subtracter **221** is connected to the output terminal of the differential amplifier **179**. An output terminal of the subtracter **221** is connected to an envelope detector **222**. An output terminal of the envelope detector **222** is connected to a binarizing circuit **223**. An output terminal of the binarizing circuit **223** is connected to a clock terminal of the D-flip-flop **185**. To an input terminal of the D-flip-flop **185** is connected an output terminal of the counter **184**. Though not shown, the counter **184** is connected to a timing circuit having the same structure as that of the timing circuit of the first embodiment.

In the fourth embodiment having the above-mentioned structure, a signal which is obtained by scanning the segment electrodes or the common electrodes of the display panel and transmitted to the differential amplifier **179** similarly to the first embodiment is amplified in the differential amplifier **179** and then inputted to the delay circuit **220**. An output signal waveform of the differential amplifier **179** is shown in FIG. **24**A. In FIGS. **24**A through **24**E, the axis of abscissas represents time, while the axis of ordinates represents amplitude. As shown in FIG. **24**A, the output signal of the differential amplifier **179** has a double-humped signal waveform similarly to the first embodiment. Further, as shown in FIG. **24**B, the output waveform of the delay circuit **220** is a waveform obtained by delaying the waveform shown in FIG. **24**A by a specified time. The delay time is related to the switching speed of the switch circuits. The delay time is preferably equal to or shorter than a time interval between the two peaks shown in FIG. **24**A. Therefore, the slower the switching speed of the switch circuits is, the longer the delay time is to be set. Therefore, the switching speed must be determined taking the practicability of the delay circuit **220** into account. FIGS. **24**A through **24**E show an example wherein the delay time of the delay circuit **220** is equal to the time interval between the two peaks.

Then, the output signal of the differential amplifier **179** having the double-humped waveform shown in FIG. **24**A and the output signal of the delay circuit **220** having the double-humped waveform shown in FIG. **24**B are inputted to the subtracter **221** to be subjected to a subtraction process therein. The phase of the signal is inverted by 180° between the portions before and behind the bottom of the double-humped input signal. Therefore, when signals are simultaneously inputted to the two input terminals of the subtracter **221**, the signals themselves are indeed subjected to the subtraction process, however, the signal waveform, i.e., the amplitudes of the signals are added together in a manner as shown in FIG. **24**C. Therefore, an output waveform of the subtracter **221** becomes a waveform having a highest peak and two low peaks arranged with interposition of the highest peak as shown in FIG. **24**C.

Then, the output signal of the subtracter **221** is inputted to the envelope detector **222** in which the envelope of the signal is extracted. The envelope waveform is shown in FIG. **24**D. Further, the signal having the above-mentioned envelope is inputted to the binarizing circuit **223** which compares the signal with a reference voltage for comparison to make the portion having an amplitude greater than that of the reference voltage have an amplitude of zero and make the portion having an amplitude smaller than that of the reference voltage have a specified amplitude, thereby binarizing the signal in a manner as shown in FIG. **24**E. The binarized signal is a pulse signal having a negative polarity, or a pulse signal having a negative polarity which substantially falls at the time when the bottom of the double-humped signal takes place.

When there is a delay time longer than the delay time shown in FIGS. **24**A and **24**B and the output waveform of the differential amplifier **179** and the output waveform of the delay circuit **220** do not timely overlap each other, the signal inputted to the subtracter **221** is outputted from the subtracter **221** while satisfying the aforementioned phase relationship. Exchange of inputs of the subtracter **221** can be of course properly performed based on a logic.

It is to be noted that, as shown in FIG. **24**E, the output pulse of the binarizing circuit **223** has a time delay approximately corresponding to the delay time of the delay circuit **220** relative to the bottom portion of the output signal of the differential amplifier **179**. The above-mentioned phenomenon possibly causes an error in coordinate detection. However, the delay time of the delay circuit **220** is always constant. Therefore, by preparatorily measuring a value of deviation of the aforementioned delay time in coordinates and subtracting the value of deviation from the coordinate data held in the D-flip-flop (latch circuit) **185**, the possible occurrence of an error in coordinate detection can be prevented.

The fourth embodiment, which performs a coordinate detection operation with regard to the change in phase of the signal, has an inherent feature that it is less influenced by noises which enter into the detected signal and cause a change in amplitude of the signal.

Operations of the fourth embodiment other than that described above are utterly the same as those of the first embodiment of the present invention, and therefore no description is provided therefor.

Fifth embodiment

Next, a fifth embodiment of the present invention will be described. The fifth embodiment differs from the first through third embodiments only in that a band-pass filter BF as shown in FIG. **25** is connected to the input terminal of the coordinate detection circuit **105** shown in FIG. **1**.

The band-pass filter BF is practically required to be connected to the input terminal of the differential amplifier **242** and the input side of the switch circuits **249***a* through **249***h* in the circuit of the first embodiment shown in FIG. **8**. In the circuit of the second embodiment shown in FIG. **16**, the band-pass filter BF is required to be connected to the input terminals of the differential amplifiers **281**, **282** and **294** and the input side of the switch circuits **291***a* through **291***l*. In the circuit of the third embodiment shown in FIG. **21**, the band-pass filter BF is required to be connected to the input terminals of the differential amplifiers **311**, **312** and **344** and the input side of the switch circuits **341***a* through **341***l*.

The band-pass filter BF includes a capacitor C and a resistor R connected across an output side terminal of the capacitor C and the ground. The band-pass filter BF selects only a frequency component at and around the frequency of the AC electric field generated by the electric field generator

208 and allows it to pass. Therefore, by virtue of the existence of the band-pass filter BF, only a signal frequency effective for coordinate detection is allowed to satisfactorily pass and unnecessary noises such as hum noises belonging to a cut-off frequency range of the filter BF can be effectively reduced.

In the first through fifth embodiments, the frequency characteristic can be optimized by connecting a feedback circuit F1 as shown in FIG. 39 across the output terminal and the inverted input terminal of each differential amplifier. The feedback circuit F1 is constituted by a parallel circuit comprised of an inductance L, a capacitor C and a resistor R. The feedback device includes an LC resonance circuit which resonates at the frequency of the AC electric field. In the parallel resonance circuit, the impedance is maximized at and around the resonance point, and therefore the feedback ratio is minimized. Consequently, a great gain can be obtained only at and around the resonance frequency. In other words, such a device operates as a band-pass filter. It is to be noted that the resistor R is used for adjusting the maximum gain. In the circuit shown in FIG. 39, a parallel resonance circuit F2 comprised of a resistor R, a capacitor C and an inductance L is connected across the non-inverted input terminal of each differential amplifier and the ground. The circuit F2 also resonates at the frequency of the AC electric field, and consequently the impedance is maximized at and around the resonance frequency.

Although envelope detectors (such as 186 shown in FIG. 8, 191 shown in FIG. 10, 286*b* shown in FIG. 15, 286*b* shown in FIG. 16, 316*b* shown in FIG. 19, 316*b* shown in FIG. 21 and 222 shown in FIG. 23) are used in the embodiments described hereinbefore, the envelope detectors may be each replaced by a synchronous detector. If the above-mentioned arrangement is adopted, though a slightly complicated circuit configuration results, the envelope of the signal can be extracted without distortion more correctly than the envelope detector, which produces an effect of improving the pen coordinate detection accuracy.

A synchronous detector shown in FIG. 40 can directly substitute for each of the envelope detectors provided in the aforementioned embodiments. A PLL forms a continuous signal synchronized in phase with a carrier component of the input signal, and obtains a product of the input signal and the formed continuous signal in a multiplier circuit. Furthermore, a low-pass filter LPF allows only a low-frequency component to pass so as to extract an envelope of the signal. The operation of such a synchronous detector is well known, and the detector can be easily implemented by combining devices availed on the market.

As is apparent from the above description, in the coordinate detection device of the present invention, the AC generator of the coordinate pointing device outputs an AC electric field from the tip end of the electrode. When the outputted AC electric field effects on the first and second electrodes of the panel, a voltage corresponding to the amplitude of the AC electric field is generated at the first and second electrodes.

Meanwhile, the switching means sequentially switches the connections of the first and second electrodes of the panel so as to connect the selected electrodes to the differential amplifier. Therefore, when the first and second electrodes at which the voltage is induced are each connected to the differential amplifier, the differential amplifier amplifies the induction voltage and outputs the resulting voltage.

The voltage outputted from the differential amplifier is inputted to the coordinate detection means. Then, the coordinate detection means detects the coordinates of the coordinate pointing device on the panel based on the timing at which the first and second electrodes are each selected and the output of the differential amplifier.

Therefore, according to the present invention, the coordinates of the coordinate pointing device can be detected without necessitating a signal line between the coordinate pointing device and the panel. Furthermore, the coordinates of the coordinate pointing device can be detected according to the voltage induced at the first and second electrodes by an electric field generated from the coordinate pointing device. Therefore, the first and second electrodes are not required to form a closed loop. Therefore, an LCD panel provided specially for image display can be used as the above-mentioned panel without making alterations. Furthermore, according to the present invention, the first and second electrodes are not required to form a closed loop, and therefore a coordinate detection function can be incorporated into the LCD panel provided specially for image display without providing an electric circuit opposite to the four sides of the LCD panel provided specially for image display. The above-mentioned fact means that the coordinate detection function can be incorporated into the image display device without increasing the size of the image display device having the LCD panel provided specially for image display, and also means that an image display device having a coordinate detection function can be manufactured without making great alterations in the existing manufacturing equipment for the image display device.

Therefore, according to the present invention, there can be provided a coordinate detection device capable of preventing the increase of development cost and the reduction of yield, and dispensing with investment for equipment which may cause cost increase, thereby totally contributing to development of the industry.

Furthermore, according to the present invention, a signal from the electrodes of the panel is amplified in the differential amplifier. The above-mentioned arrangement has an advantage that external noises which have entered evenly into two inputs of the differential amplifier can be effectively removed.

Furthermore, according to an embodiment, a material having an electro-optical effect is sealedly filled in a space between two substrates, and the first and second electrodes are arranged on the substrates while making the first and second electrodes concurrently serve as electrodes for image display. Therefore, a display panel which has concurrently the coordinate detection function and the image display function can be provided.

Furthermore, according to an embodiment, the coordinate pointing device outputs electric fields which are opposite in phase to each other from its first and second electrodes to which electric fields being opposite in phase to each other are applied from the oscillator.

Therefore, the electrode of the panel receiving the electric field from the first electrode outputs an electric field opposite in phase to the electric field outputted from the electrodes of the panel receiving the electric field from the second electrode. Therefore, electric fields which are opposite in phase to each other are applied to the differential amplifier. Therefore, the coordinate detection means can detect a state in which the electrodes of the coordinate pointing device are located in the position of the panel electrodes selected by the switching means upon detecting a discontinuity of the signal outputted from the differential amplifier occurring when the electric fields which are opposite in phase to each other are applied to the differential amplifier.

Furthermore, according to an embodiment, the first electrode of the coordinate pointing device is a cylinder-shaped electrode, while the second electrode of the coordinate pointing device is a rod-shaped electrode arranged inside the cylinder-shaped electrode. Therefore, even when the coordinate pointing device is rotated around the center axis of the rod-shaped electrode, unchanged electric fields are applied from the coordinate pointing device to the electrodes of the panel. Therefore, the electric fields applied to the electrodes of the panel are not changed by the above-mentioned rotation irrelevant to the coordinates to be detected, thereby allowing an improved coordinate detection accuracy to be achieved.

Furthermore, according to an embodiment, the first electrode of the coordinate pointing device is arranged as separated apart at approximately regular intervals around the circumference of the second electrode. Therefore, the rotation of the coordinate pointing device around the center axis does not change the electric fields applied to the electrodes of the panel, thereby allowing an improved coordinate detection accuracy to be achieved.

Furthermore, according to an embodiment, the coordinate pointing device has a battery storing section for storing therein a battery which serves as a power source for the AC oscillator. Therefore, by storing the battery in the battery storing section, there is no need to supply an electric power to the coordinate pointing device from outside the coordinate pointing device. Therefore, the coordinate pointing device is permitted to be connected to nothing. The above-mentioned arrangement allows a complete codeless coordinate pointing device to be achieved.

Furthermore, according to an embodiment, when the coordinate pointing device is stored in the storing portion provided at the casing to which the panel is mounted, the charging terminal owned by the coordinate pointing device and the power supply terminal of the casing are electrically connected to each other. Therefore, in the above-mentioned time, the secondary battery stored in the battery storing section of the coordinate pointing device is charged. Therefore, the operating life of the battery which is the power source of the coordinate pointing device can be remarkably increased.

Furthermore, according to an embodiment, a resonance circuit which resonates with the AC electric field generated by the AC oscillator is connected across the output terminal and the inverted input terminal of the differential amplifier. Therefore, the differential amplifier can selectively amplify the AC electric field with a great gain. Therefore, an improved coordinate detection sensitivity can be achieved.

According to an embodiment, the switching means selects at least one pair of adjoining electrodes so as to connect the selected electrodes to the differential amplifier, and shifts the selected electrodes one by one in the direction in which the electrodes are arranged. Therefore, by shifting the selected electrodes, the coordinate pointing device is, so to speak, searched to allow the position coordinates of the coordinate pointing device located in the area where the electrodes are arranged to be securely detected.

Furthermore, according to an embodiment, the switching means selects a pair of adjoining electrodes of the panel, and shifts the selected pair of electrodes one by one in the direction in which the electrodes are arranged. Therefore, the selection can be achieved in a manner simpler than that of the above-mentioned embodiment, thereby allowing the structure of the switching means to be simplified.

Furthermore, according to an embodiment, the switching means has the first terminal connected in parallel with two or more adjoining electrodes and the second terminal connected in parallel with two or more electrodes adjacent to the electrodes connected to the first terminal. Therefore, by electrically connecting the first terminal and the second terminal to the differential amplifier, four or more electrodes which are receiving the AC electric field outputted from the electrodes of the coordinate pointing device can be connected to the differential amplifier. Therefore, an improved detection sensitivity can be achieved in comparison with the case where only two electrodes of the panel are connected to the differential amplifier.

Furthermore, according to an embodiment, the envelope of the output from the differential amplifier is extracted by the envelope extraction means, and a bottom portion of the double-humped output from the envelope extraction means is detected. Then, based on the time at which the bottom portion is detected and the timing at which the switching means selects the electrodes of the panel, the coordinates representing the position of the coordinate pointing device are specified. Thus, according to the present embodiment, a characteristic double-humped signal is outputted from the envelope extraction means, and by detecting the bottom portion of the double-humped envelope waveform, coordinate detection can be achieved. Furthermore, in order to specify the coordinates, a signal obtained by removing unnecessary signal components therefrom and being subjected to an envelope detection process is used, and therefore the detection of the bottom portion can be easily achieved.

Furthermore, according to an embodiment, a synchronous detector is provided as the envelope extraction means. The synchronous detector can extract the envelope of the signal without distortion more correctly than the envelope detector, and therefore an improved coordinate detection accuracy can be achieved.

Furthermore, according to an embodiment, the coordinate detection means includes a first envelope detector which has a relatively great time constant and operates to receive the output from the differential amplifier and detect the envelope of the output as well as a second envelope detector which has a relatively small time constant and operates to receive the output from the differential amplifier and detect the envelope of the output. By subjecting the double-humped output from the first envelope detector and the double-humped output from the second envelope detector to a subtraction process, the bottom portion of the double-humped output outputted from the second envelope detector is detected.

The output of the first envelope detector having a great time constant becomes a double-humped signal where the bottom portion is shallowed, while the output of the second envelope detector having a small time constant becomes a double-humped signal where the bottom portion is not shallowed. Therefore, by subjecting the output of the first envelope detector and the output of the second envelope detector to a subtraction process, a signal having a peak at the bottom portion can be obtained. With the above-mentioned signal, the bottom portion can be detected.

Furthermore, according to an embodiment, the bottom detection means detects the bottom portion of the double-humped output according to the output obtained by binarizing the double-humped output from the envelope detector. By the above-mentioned binarizing operation, an output in which a difference between the bottom portion and the peak portion of the double-humped output is ascertained can be obtained. Therefore, the bottom portion can be easily detected by means of the output, and through detection of the bottom portion, a coordinate detection operation can be performed.

Furthermore, according to an embodiment, the coordinate detection means includes the delay circuit which receives the output from the differential amplifier and delays the output by a specified time, the subtracter which subjects the output of the differential amplifier and the delayed output to a subtraction process, and the bottom detection means which binarizes the signal outputted from the subtracter and detects the bottom portion of the double-humped output according to the binarized signal. According to the present embodiment, a preceding peak of the double-humped signal outputted from the differential amplifier and a subsequent peak of the delayed double-humped signal are added together. With the above-mentioned operation, a signal which has three peaks comprised of a highest peak and two low peaks located besides the highest peak obtained through the addition is outputted from the subtracter. Then, by binarizing the signal having the three peaks, a difference between the highest peak portion and the low peak portions is ascertained. The highest peak portion is delayed by the above-mentioned delay time from the bottom portion of the double-humped output which is not delayed. Therefore, the bottom portion can be easily detected according to the binarized signal of which highest peak portion is ascertained, and a coordinate detection operation can be performed through the detection of the bottom portion.

Furthermore, according to an embodiment, the flat display panel wherein the material having an electro-optical effect characteristic is sealedly filled in the space between the two substrates, and the plural number of x-axis electrodes and the plural number of y-axis electrodes which are intersecting each other are provided on the substrates can be time-sharingly changed over so as to be used for either image display or coordinate detection by means of the image display-coordinate detection changeover circuit. When the flat display panel is used for image display, the x-axis electrodes and the y-axis electrodes are driven by the drive circuit to electrically drive the panel so as to display an image. When coordinate detection is performed, a voltage induced at the x-axis electrodes and the y-axis electrodes by an electric field generated from the coordinate pointing device which is provided separately with a function of generating an AC electric field is detected by the coordinate detection circuit which utilizes a change in voltage of the signal, thereby allowing the coordinates of the coordinate pointing device to be detected.

In particular, according to the above-mentioned embodiment, one LCD panel can be used concurrently for image display and coordinate input through an electrostatic capacitive coupling.

Furthermore, in the above-mentioned embodiment, a flat display panel such as an LCD panel which has been conventionally developed specially for image display can be used as it is without making alterations. The above-mentioned arrangement has an economical advantage that a coordinate input function can be incorporated into a flat display panel without requiring any change of the manufacturing process accompanied by huge amount of investment.

In particular, the above-mentioned embodiment has a feature that the structure thereof is very simple. Furthermore, a signal detection operation is performed by means of a differential amplifier. The above-mentioned arrangement has an advantage that external noises which have entered evenly into two inputs of the differential amplifier can be effectively removed. In addition, since substantially an addition process is performed in the differential amplifier, there can be expected an improved signal-to-noise ratio in the signal detection operation.

Furthermore, according to an embodiment, the flat display panel wherein the material having an electro-optical effect characteristic is sealedly filled in the space between the two substrates, and the plural number of x-axis electrodes and the plural number of y-axis electrodes which are intersecting each other are provided on the substrates can be time-sharingly changed over so as to be used for either image display or coordinate detection by means of the image display-coordinate detection changeover circuit. When the flat display panel is used for image display, the x-axis electrodes and the y-axis electrodes are driven by the drive circuit to electrically drive the panel so as to display an image. When coordinate detection is performed, a voltage induced at the x-axis electrodes and the y-axis electrodes by an electric field generated from the coordinate pointing device which is provided separately with a function of generating an AC electric field is detected by the coordinate detection circuit which utilizes a change in phase of the signal, thereby allowing the coordinates of the coordinate pointing device to be detected.

Furthermore, the above-mentioned embodiment performs coordinate detection paying attention to the change in phase of the signal, and therefore it has an inherent feature that it is less influenced by noises which enter into the detected signal and cause a change in amplitude of the signal.

Furthermore, according to a coordinate detection device of an embodiment, a band-pass filter or a high-pass filter for selectively allowing only a signal at and around the frequency of the AC electric field to pass is connected to an input terminal of the coordinate detection circuit. Therefore, the coordinate detection circuit can consistently detect a stabilized voltage from the x-axis electrodes and the y-axis electrodes without being influenced by noises.

Furthermore, the above-mentioned embodiment has an advantage that hum noises and the like which may be induced from a hand of the operator who touches the panel screen can be effectively removed, thereby allowing an improved coordinate detection accuracy to be achieved. Conversely, the circuit structure and the like can be simplified so as to satisfy the required detection accuracy.

Furthermore, according to a coordinate detection device of an embodiment, an electrode which is provided at the tip end of the coordinate pointing device provided with a function of generating an AC electric field is a coaxial electrode comprised of a center electrode and a peripheral electrode. Therefore, not depending on which circumferential direction the coordinate pointing device is directed in use, a stabilized voltage can be consistently induced at the x-axis electrodes and the y-axis electrodes.

Furthermore, in the above-mentioned embodiment, the coordinate pointing device has an electrode having a specific coaxial configuration. Therefore, not depending on the direction and angle of the pen-shaped coordinate pointing device in which the AC generator is incorporated, the coordinate pointing device is consistently coupled with the electrodes of the LCD panel consistently through a constant electrostatic capacity, and an electrical change to be applied can be made constant. Therefore, the AC generator can be stored in a pen-shaped casing. As a result, a coordinate pointing device which can be handled very easily in utterly the same manner as the generic writing pen.

Furthermore, according to an embodiment, the x-axis drive circuit and the y-axis drive circuit for image display use, the coordinate detection circuit, and the image display-coordinate detection changeover circuit are arranged along two or three sides of the peripheries of the display panel.

According to the above-mentioned embodiment, a coordinate detection function can be incorporated into the image display device without increasing the size of the display device having an LCD panel provided specially for image display, and a display device having a coordinate detection function can be manufactured without making great alterations in the existing manufacturing equipment for the display device. Therefore, according to the above-mentioned embodiment, there can be provided a coordinate detection device capable of preventing the increase of development cost and the reduction of yield, and dispensing with investment for equipment which may cause cost increase, thereby totally contributing to development of the industry.

The present invention can provide a coordinate input function-integrated display device capable of solving the aforementioned problems of the prior arts. That is, in achieving a coordinate input function-integrated display device, the present invention can obviate the need of a connection cable which has been conventionally necessitated. Furthermore, since there is no need to form a closed loop on which an electric field is effected, there is no need to newly incorporate into an LCD panel any specific bi-directional switching element for short-circuiting adjoining electrodes of the LCD panel at the tip end of the electrodes. Therefore, it is not required to provide a tab connection terminal at the four sides of the LCD panel. Therefore, the increase of development cost and the reduction of yield can be prevented. Furthermore, unnecessary investment can be avoided, and a compact light-weight coordinate input function-integrated display device can be provided. That is, according to the present invention, the conventionally used panel provided specially for image display use can be applied as it is to the panel of an image display/coordinate input function integrated device without making alterations in the LCD panel. Therefore, the above-mentioned arrangement can totally contribute to development of the industry.

The coordinate input function of the present invention can be operated in a panel of any type with same circuit according to same principle of operation not depending on the type of the panel. Therefore, whichever one of LCD panels such as the duty ratio drive LCD panel and the active matrix type LCD panel in which a TFT is incorporated is selected as a panel, the coordinate detection function of the present invention is not influenced by the type of the panel. The above is because the present invention allows a coordinate input function to be incorporated into an LCD panel which has been conventionally used specially for image display, and furthermore, as a result of time-sharingly changing over between the image display function and the coordinate input function, the image display function and the coordinate input function can be utterly made independent both in terms of function and in terms of circuit.

The present invention can be applied to a type of a panel in which a signal I/O connector is attached to at most three sides among the conventionally used panels provided specially for image display. Therefore, so-called a peripheral edge portion can be dimensionally decreased to allow a compact application product to be developed. In contrast to the above, even when a new panel is manufactured by changing the manufacturing process, it has been conventionally required to provide a signal I/O connector and so forth at all the four sides of the panel.

Furthermore, according to the present invention, the AC oscillator can be driven by a battery. The above-mentioned arrangement has an advantage that no lead wire for connecting the coordinate pointing device to the coordinate detection circuit is necessitated. Furthermore, there is no need to incorporate a built-in wireless transmitter, which is advantageous in terms of the operating life of the battery. Furthermore, the coordinate pointing device can be totally compacted, which produces an advantageous effect that a light-weight coordinate pointing device allowing easy use thereof can be constructed. Furthermore, since there is no need to compulsorily mount a wireless transmitter or the like in the compact coordinate pointing device, which is advantageous in terms of cost.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

What is claimed is:

1. A panel which is provided for coordinate detection and includes a first plurality of electrodes and a second plurality of electrodes extending in a direction crossing a direction in which the first plurality of electrodes extends;

a coordinate pointing device which includes an alternating current oscillator and an electrode and outputs from a tip end portion of the electrode an alternating current electric field generated by the alternating current oscillator;

a differential amplifier;

switching means for sequentially changing connection of the first and second plurality of electrodes of the panel so as to sequentially select the electrodes and electrically connect each selected electrode to the differential amplifier;

coordinate detection means for detecting a signal supplied from the coordinate pointing device to the first and second plurality of electrodes by shifting selected electrodes in accordance with a signal from said differential amplifier and detecting coordinates based on a timing at which the first and second plurality of electrodes are selected and a timing of a portion of said signal output from the differential amplifier;

the coordinate pointing device comprises:

a battery storing section for storing therein a secondary battery which as a power source for the alternating current oscillator and a charging terminal to be electrically connected to the secondary battery when the secondary battery is stored in the battery storing section; and,

a casing to which the panel is mounted is provided with a storing portion for storing the coordinate pointing device and the battery storing section, and a power supply terminal which can supply an electric power to the charging terminal while being electrically connected to a charging terminal of the coordinate pointing device when the coordinate pointing device is stored in the storing portion.

2. A panel which is provided for coordinate detection and includes a first plurality of electrodes and a second plurality of electrodes extending in a direction crossing a direction in which the first plurality of electrodes extends;

a coordinate pointing device which includes an alternating current oscillator and an electrode and outputs from a tip end portion of the electrode an alternating current electric field generated by the alternating current oscillator;

a differential amplifier;

switching means for sequentially changing connection of the first and second plurality of electrodes of the panel

so as to sequentially select the electrodes and electrically connect each selected electrode to the differential amplifier;

coordinate detection means for detecting a signal supplied from the coordinate pointing device to the first and second plurality of electrodes by shifting selected electrodes in accordance with a signal from said differential amplifier and detecting coordinates based on a timing at which the first and second plurality of electrodes are selected and a timing of a portion of said signal output from the differential amplifier; and

a resonance circuit which resonates with the alternating current electric field generated by the alternating current oscillator is connected across an output terminal of said panel and an inverted terminal of the differential amplifier.

3. A panel which is provided for coordinate detection and includes a first plurality of electrodes and a second plurality of electrodes extending in a direction crossing a direction in which the first plurality of electrodes extends;

a coordinate pointing device which includes an alternating current oscillator and an electrode and outputs from a tip end portion of the electrode an alternating current electric field generated by the alternating current oscillator;

a differential amplifier;

switching means for sequentially changing connection of the first and second plurality of electrodes of the panel so as to sequentially select the electrodes and electrically connect each selected electrode to the differential amplifier;

coordinate detection means for detecting a signal supplied from the coordinate pointing device to the first and second plurality of electrodes by shifting selected electrodes in accordance with a signal from said differential amplifier and detecting coordinates based on a timing at which the first and second plurality of electrodes are selected and a timing of a portion of said signal output from the differential amplifier; wherein the switching means selects at least one pair of adjoining electrodes of said panel so as to connect the electrodes to a differential amplifier and shifts the selected electrodes one by one in a direction in which the electrodes are arranged;

the coordinate detection means comprises:

envelope extraction means for receiving an output from the differential amplifier and extracting an envelope of the output;

bottom detection means for receiving a double-humped output from the envelope extraction means and detecting a bottom portion of the output;

time counting means for specifying a bottom portion detection time at which the bottom detection means detects the bottom portion; and

position coordinate specifying means for specifying coordinates representing a position of the coordinate pointing device on the panel based on the bottom portion detection time specified by the time counting means and a timing at which the electrodes are selected.

4. A panel which is provided for coordinate detection and includes a first plurality of electrodes and a second plurality of electrodes extending in a direction crossing a direction in which the first plurality of electrodes extends;

a coordinate pointing device which includes an alternating current oscillator and an electrode and outputs from a tip end portion of the electrode an alternating current electric field generated by the alternating current oscillator;

a differential amplifier;

switching means for sequentially changing connection of the first and second plurality of electrodes of the panel so as to sequentially select the electrodes and electrically connect each selected electrode to the differential amplifier;

coordinate detection means for detecting a signal supplied from the coordinate pointing device to the first and second plurality of electrodes by shifting selected electrodes in accordance with a signal from said differential amplifier and detecting coordinates based on a timing at which the first and second plurality of electrodes are selected and a timing of a portion of said signal output from the differential amplifier; wherein the switching means selects at least one pair of adjoining electrodes of said panel so as to connect the electrodes to a differential amplifier and shifts the selected electrodes one by one in a direction in which the electrodes are arranged;

the coordinate detection means comprises:

envelope extraction means for receiving an output from the differential amplifier and extracting an envelope of the output;

bottom detection means for receiving a double-humped output from the envelope extraction means and detecting a bottom portion of the output;

time counting means for specifying a bottom portion detection time at which the bottom detection means detects the bottom portion; and

position coordinate specifying means for specifying coordinates representing a position of the coordinate representing a position of the coordinate pointing device on the panel based on the bottom portion detection time specified by the time counting means and a timing at which the electrodes are selected; and

a synchronous detector is provided as the envelope extraction means.

5. A panel which is provided for coordinate detection and includes a first plurality of electrodes and a second plurality of electrodes extending in a direction crossing a direction in which the first plurality of electrodes extends;

a coordinate pointing device which includes an alternating current oscillator and an electrode and outputs from a tip end portion of the electrode an alternating current electric field generated by the alternating current oscillator;

a differential amplifier;

switching means for sequentially changing connection of the first and second plurality of electrodes of the panel so as to sequentially select the electrodes and electrically connect each selected electrode to the differential amplifier;

coordinate detection means for detecting a signal supplied from the coordinate pointing device to the first and second plurality of electrodes by shifting selected electrodes in accordance with a signal from said differential amplifier and detecting coordinates based on a timing at which the first and second plurality of electrodes are selected and a timing of a portion of said signal output from the differential amplifier; wherein the switching means selects at least one pair of adjoining electrodes so as to connect the electrodes to a differential amplifier

and shifts the selected electrodes one by one in a direction in which the electrodes are arranged;

the coordinate election means comprises:

a first envelope detector which has a relatively great time constant and operates to receive an output from the differential amplifier and detect an envelope of the output;

a second envelope detector which has a relatively small time constant and operates to receive an output from the differential amplifier and detect an envelope of the output;

bottom detection means for subjecting a double-humped output from the first envelope detector and a double-humped output from the second envelope detector to a subtraction process so as to detect a bottom portion of the double-humped output outputted from the second envelope detector;

time counting means for specifying a bottom portion detection time at which the bottom detection means detects the bottom portion; and

position coordinate specifying means for specifying coordinates representing a position of the coordinate pointing device on the panel based on the bottom portion detection time specified by the time counting means and a timing at which the electrodes are selected.

6. A panel which is provided for coordinate detection and includes a first plurality of electrodes and a second plurality of electrodes extending in a direction crossing a direction in which the first plurality of electrodes extends;

a coordinate pointing device which includes an alternating current oscillator and an electrode and outputs from a tip end portion of the electrode an alternating current electric field generated by the alternating current oscillator;

a differential amplifier;

switching means for sequentially changing connection of the first and second plurality of electrodes of the panel so as to sequentially select the electrodes and electrically connect each selected electrode to the differential amplifier;

coordinate detection means for detecting a signal supplied from the coordinate pointing device to the first and second plurality of electrodes by shifting selected electrodes in accordance with a signal from said differential amplifier and detecting coordinates based on a timing at which the first and second plurality of electrodes are selected and a timing of a portion of said signal output from the differential amplifier; wherein the switching means selects at least one pair of adjoining electrodes so as to connect the electrodes to a differential amplifier and shifts the selected electrodes one by one in a direction in which the electrodes are arranged;

the coordinate detection means comprises:

an envelope detector which receives an output from the differential amplifier and detects an envelope of the output;

bottom detection means for receiving a double-humped output from the envelope detector to binarize the output and detecting a bottom portion of the double-humped output according to the binarized output;

time counting means for specifying a bottom portion detection time at which the bottom detection means detects the bottom portion; and

position coordinate specifying means for specifying coordinates representing a position of the coordinate pointing device on the panel based on the bottom portion detection time specified by the time counting means and a timing at which the electrodes are selected.

7. A panel which is provided for coordinate detection and includes a first plurality of electrodes and a second plurality of electrodes extending in a direction crossing a direction in which the first plurality of electrodes extends;

a coordinate pointing device which includes an alternating current oscillator and an electrode and outputs from a tip end portion of the electrode an alternating current electric field generated by the alternating current oscillator;

a differential amplifier;

switching means for sequentially changing connection of the first and second plurality of electrodes of the panel so as to sequentially select the electrodes and electrically connect each selected electrode to the differential amplifier;

coordinate detection means for detecting a signal supplied from the coordinate pointing device to the first and second plurality of electrodes by shifting selected electrodes in accordance with a signal from said differential amplifier and detecting coordinates based on a timing at which the first and second plurality of electrodes are selected and a timing of a portion of said signal output from the differential amplifier; wherein the switching means selects at least one pair of adjoining electrodes so as to connect the electrodes to a differential amplifier and shifts the selected electrodes one by one in a direction in which the electrodes are arranged;

the coordinate detection means comprises:

a delay circuit which receives an output of the differential amplifier and delays the output by a specified time;

a subtracter which subjects the output of the differential amplifier and an obtained delayed output to a subtraction process;

bottom detection means for binarizing a signal outputted from the subtracter and detecting a bottom portion of the double-humped output according to an obtained binarized signal;

time counting means for specifying a bottom portion detection time at which the bottom detection means detects the bottom portion; and

position coordinate specifying means for specifying coordinates representing a position of the coordinate pointing device on the panel based on the bottom portion detection time specified by the time counting means and a timing at which the electrodes are selected.

8. A coordinate detection device comprising:

a flat display panel in which a material having an electro-optical effect characteristic is sealedly filled in a space between two substrates, and a plurality of x-axis electrodes and a plurality of y-axis electrodes which are intersecting each other are provided on the substrates;

x-axis drive circuit and y-axis drive circuit which are provided for image display use and electrically drive the x-axis electrodes and the y-axis electrodes of the flat display panel respectively;

a coordinate pointing device including alternating current electric field generating means having therein an alternating current power source and an electrode connected to an output terminal of the alternating current electric field generating means;

a coordinate detection circuit including a differential amplifier, a connection switching circuit which selects

two adjoining x-axis electrodes or a pair of x-axis electrodes constituted by two adjoining electrode groups of the x-axis electrodes as well as two adjoining y-axis electrodes or a pair of y-axis electrodes constituted by two adjoining electrode groups of the y-axis electrodes, connects the selected electrodes to the differential amplifier, and shifts the selected electrodes one by one in a direction in which the selected electrodes are arranged, bottom detection means for obtaining a signal which is supplied from the coordinate pointing device to the electrodes by shifting the selected electrodes as a double-humped signal from the differential amplifier and detecting a bottom portion of the double-humped signal, and position coordinate specifying means for specifying coordinates based on a time at which the bottom detection means detects the bottom portion and a timing at which the electrodes are selected; and

an image display-coordinate detection changeover circuit which time-sharingly complementarily operates the x-axis drive circuit, the y-axis drive circuit, and the coordinate detection circuit.

9. A coordinate detection device as claimed in claim **8**, wherein

a band-pass filter or a high-pass filter for allowing selectively a signal having a frequency at and around a frequency of the alternating current electric field generated by the coordinate pointing device to pass is connected to an input terminal of the coordinate detection circuit.

10. A coordinate detection device as claimed in claim **8**, wherein

the electrode of the coordinate pointing device is comprised of:

a center electrode and a peripheral electrode which are arranged coaxially.

11. A coordinate detection device as claimed in claim **8**, wherein

the x-axis drive circuit and the y-axis drive circuit for image display use, the coordinate detection circuit, and the image display-coordinate detection changeover circuit are arranged along peripheries of two or three sides of the display panel.

12. A coordinate detection device comprising:

a flat display panel in which a material having an electro-optical effect characteristic is sealedly filled in a space between two substrates, and a plurality of x-axis electrodes and a plurality of y-axis electrodes which are intersecting each other are provided on the substrates;

x-axis drive circuit and y-axis drive circuit which are provided for image display use and electrically drive the x-axis electrodes and the y-axis electrodes of the flat display panel respectively;

a coordinate pointing device including alternating current electric field generating means having therein an alternating current power source and an electrode connected to an output terminal of the alternating current electric field generating means;

a coordinate detection circuit including a differential amplifier, a connection switching circuit which selects two adjoining x-axis electrodes or a pair of x-axis electrodes constituted by two adjoining electrode groups of the x-axis electrodes as well as two adjoining y-axis electrodes or a pair of y-axis electrodes constituted by two adjoining electrode groups of the y-axis electrodes, connects the selected electrodes to the differential amplifier, and shifts the selected electrodes one by one in a direction in which the selected electrodes are arranged, bottom detection means for obtaining a signal which is supplied from the coordinate pointing device to the electrodes by shifting the selected electrodes as a double-humped signal from the differential amplifier and detecting a bottom portion of the double-humped signal by detecting a phase inversion point of the double-humped signal through calculation of an input signal and an output signal of a delay circuit, and position coordinate specifying means for specifying coordinates based on a time at which the bottom detection means detects the bottom portion and a timing at which the electrodes are selected; and

an image display-coordinate detection changeover circuit which time-sharingly complementarily operates the x-axis drive circuit, the y-axis drive circuit, and the coordinate detection circuit.

13. A coordinate detection device as claimed in claim **12**, wherein

a band-pass filter or a high-pass filter for allowing selectively a signal having a frequency at and around a frequency of the alternating current electric field generated by the coordinate pointing device to pass is connected to an input terminal of the coordinate detection circuit.

14. A coordinate detection device as claimed in claim **12**, wherein

the electrode of the coordinate pointing device is comprised of:

a center electrode and a peripheral electrode which are arranged coaxially.

15. A coordinate detection device as claimed in claim **12**, wherein

the x-axis drive circuit and the y-axis drive circuit for image display use, the coordinate detection circuit, and the image display-coordinate detection changeover circuit are arranged along peripheries of two or three sides of the display panel.

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