

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ARASHI VISION (US) LLC (D/B/A INSTA360)
Petitioner,

v.

GOPRO, INC.
Patent Owner.

Patent No. 10,529,052

Inter Partes Review No. 2025-00017

DECLARATION OF DR. AGGELOS KATSAGGELOS

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I. INTRODUCTION

1. I have been retained as an expert witness on behalf of Arashi Vision (U.S.) LLC (d/b/a Insta360) (“Petitioner” or “Insta360”) to provide expert opinions on the patentability of United States Patent No. 10,529,052 (“the ’052 patent”).

2. I am being compensated at my normal rate for my analysis, plus reimbursement for expenses. My compensation does not depend on the content of my opinions or the outcome of this proceeding.

II. EXPERIENCE AND QUALIFICATIONS

3. In formulating my opinions, I have relied upon my knowledge, training, and experience in the relevant art. My qualifications are stated more fully in my curriculum vitae, which has been provided as Exhibit 1012. Here, I provide a brief summary of my qualifications.

4. As set forth in my curriculum vitae, I have over 44 years of experience working on image processing and digital cameras, starting with my position as a Research Assistant at Georgia Institute of Technology in 1980. As shown in my curriculum vitae, I have worked on many projects relevant to the subject matter of the ’052 patent.

5. I earned a Bachelor of Science Degree in Electrical and Mechanical Engineering from Aristotle University of Thessaloniki in 1979. I earned a Master of Science Degree in Electrical Engineering from Georgia Institute of Technology

in 1981. I earned a Ph.D. in Electrical Engineering from Georgia Institute of Technology in 1985.

6. I am currently a professor at Northwestern University, holder of the Joseph Cummings chair, in the Department of Electrical and Computer Engineering and by courtesy Computer Science and Radiology. I am also the Director of the AI in Multimedia Image and Video Processing Lab (AIM-IVPL) and the Deputy Director of the Computation Center for Computational Imaging and Signal Analytics in Medicine. Over the past 44 years, I have developed and taught courses related to digital image and video processing, including image and video compression, algorithms, analysis, and enhancement techniques.

7. Over the course of my academic and professor career, I have authored numerous papers, actively participated in several organizations, received several awards, and presented at several conferences related to my work in image and video processing, which are detailed in my attached curriculum vitae (EX1012).

III. MATERIALS CONSIDERED

8. In preparing this declaration, I have reviewed, among other things, the '052 patent and its file history. I have also considered each of the documents cited in this declaration and the documents specifically identified below and in the Exhibit List. In formulating my opinions, I have further relied upon my personal

knowledge, professional judgment, education, and experience gained through my years as a professor, researcher, and practitioner in the field of the '052 patent.

IV. SUMMARY OF THE '052 PATENT

A. Summary

9. The '052 patent is directed to simulating image distortion of a virtual lens. As the '052 patent explains, it can be desirable to perform crop or zoom operations on an image to extract reduced field-of-view sub-frames. (EX1001, 1:14-16.) It is further desirable for the sub-frames to have lens characteristics that are consistent with the lens characteristics “naturally appearing” in the original image. (EX1001, 3:13-32.) The '052 patent describes applying a virtual lens model to the sub-frames in order to generate a “cohesive output video,” in which post-capture processing effects are “not apparent to the viewer.” (EX1001, 3:13-43.)

B. Effective Filing Date

10. I understand that the application that became the '052 patent is a continuation that was filed on August 8, 2019, and claims priority to a provisional application filed on May 20, 2015. (EX1001.) For purposes of this Declaration, I have assumed May 20, 2015 as the earliest effective filing date.

C. Prosecution History

11. I understand the prosecution of the '052 patent was not robust. The claims did not face any statutory prior art rejections, and were allowed as originally filed without amendment. (EX1003.) The claims were allowed following only a single Office Action, which rejected the claims for non-statutory double patenting over the parent patents, but indicated that the claims were otherwise allowable as originally filed. (EX1003, 271-287.) The applicant overcame this rejection, and obtained an allowance of the original claims, by simply filing a terminal disclaimer over the parent patents. (EX1003, 25-29, 39, 42-44, 46-55.)

V. RELEVANT LEGAL STANDARDS AND DEFINITIONS

A. Obviousness

12. I understand that a claim is unpatentable if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the claimed subject matter was made to a person of ordinary skill in the art (POSITA) to which the subject matter pertains. I understand that a patent claim may be obvious to a POSITA in view of the prior art teachings of a single reference or a combination of references.

13. To assess obviousness, I understand that I am to consider the scope and content of the prior art, the differences between the prior art and the claim, the

level of ordinary skill in the art, and any secondary considerations to the extent that they exist.

14. It is also my understanding that there are principles that may be used as further guidance in obviousness analysis (especially when considering combinations of references), which include considering whether:

- the claimed subject matter is simply a combination of prior art elements according to known methods to yield predictable results;
- the claimed subject matter is a simple substitution of one known element for another to obtain predictable results;
- the claimed subject matter uses known techniques to improve similar devices or methods in the same way;
- the claimed subject matter applies a known technique to a known device or method that is ready for improvement to yield predictable results;
- the claimed subject matter would have been “obvious to try” choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- there is known work in one field of endeavor that may prompt variations of it for use in either the same field or a different one based on design

incentives or other market forces if the various would have been predictable to a POSITA;

- there existed at the time of conception and reduction to practice a known problem for which there was an obvious solution encompassed by the patent's claims; and
- there is some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed subject matter.

15. I understand that there are secondary considerations that may tend to show that a claimed invention would not have been obvious to a POSITA. These include, for example, commercial success, long-felt but unsolved needs, failure of others, and unexpected results. I further understand that there must be a relationship, or nexus, between any secondary considerations and the novelty of the claimed invention.

B. Prior Art

16. I am informed and understand that prior art includes patents and printed publications that existed before the effective filing date of the claimed invention. The effective filing date is the earliest claimed priority date or the earliest filing date of the application that describes the subject matter. A patent or

published patent application is prior art if it was filed before the earliest filing date of the claimed invention, absent a few exceptions. I understand that a patent or published patent application is entitled to have its effective filing date as the filing date of its provisional application if the disclosure of the provisional application provides support for the claim(s) of the patent or published patent application.

VI. LEVEL OF ORDINARY SKILL IN THE ART FOR THE '052 PATENT

17. I am informed and understand that various factors can be considered in determining the level of ordinary skill in the art possessed by the POSITA. I am informed and understand that those factors include: (1) the education level of the inventors; (2) the type of problems encountered in the art; (3) prior art solutions to those problems; (4) the rapidity with which innovations are made; (5) sophistication of the technology; and (6) education level of active workers in the field.

18. Based on the disclosure of the '052 patent and a priority date of May 20, 2015, a POSITA in the field of the '052 patent would have had a bachelor's degree in Electrical Engineering, Computer Science, Physics, Optics, or an equivalent field, and one to two years of academic or industry experience working on image or video processing, or comparable academic or industry experience.

19. Based on my experience, I understand and know of the capabilities of a person of this skill level as of the effective filing date of the '052 patent. I am familiar with how a POSITA would have understood and used the terminology found in the '052 patent as the time of its filing, and with the state of the art at that time.

VII. CLAIM CONSTRUCTION

20. I have been informed that claim construction requires consideration of the words of the claims themselves, the specification, the prosecution history, and extrinsic evidence concerning relevant scientific principles, the meaning of technical terms, and the state of the art. I have also been informed that the specification is usually definitive, as it was the single best guide to the meaning of a disputed term.

21. I have been informed that, in the context of this proceeding, Petitioner does not propose any terms for construction. Instead, Petitioner's position is that each of the terms of the '052 patent carries its ordinary and customary meaning, which is the meaning that the term would have to a POSITA at the time of the alleged invention. I agree with Petitioner and apply the ordinary and customary meaning of the terms in my analysis below. For purposes of this declaration, where applicable, I have also interpreted the challenged claims based on the scope

of GoPro's infringement allegations in the related International Trade Commission (ITC) proceeding. (*See* EX1011.)

22. I understand the parties have exchanged proposed claim constructions for the '052 patent in the ITC proceeding as follows:

Term	Claim	Insta360's Proposed Construction	GoPro's Proposed Construction
the desired lens distortion and the input lens distortion exhibiting consistent lens characteristics	1	Indefinite If not indefinite: the desired lens distortion and the input lens distortion exhibiting distortion characteristics of the lens of the camera	Plain and ordinary meaning; no construction necessary
portions of the scene depicted in the subframes appear to have been captured using the reduced fields of view	1	Indefinite If not indefinite: portions of the scene depicted in the subframes appear to have been captured by the lens of the camera using the reduced fields of view	Plain and ordinary meaning; no construction necessary
wherein image stabilization is applied to the input images	2	wherein image stabilization is applied to the input images before generating output images	Plain and ordinary meaning; no construction necessary

Term	Claim	Insta360's Proposed Construction	GoPro's Proposed Construction
consistent frame-to-frame lens characteristics	7	Indefinite	Plain and ordinary meaning; no construction necessary

23. It is my view that the challenged claims are invalid under any reasonable interpretation of the claims. Moreover, it is my view that the challenged claims are invalid under any or all of the claim construction positions taken by the parties in the ITC proceeding.

VIII. PRIOR ART

24. I understand that each of the references discussed herein qualifies as prior art to the '052 patent:

25. U.S. Patent Appl. Pub. No. 2006/0017817 A1 ("Okubo," EX1004) was filed on July 18, 2005, and published on January 26, 2006.

26. U.S. Patent No. 8,994,838 B2 ("Sokeila," EX1005) was filed on April 16, 2013, published on October 16, 2014, and issued on March 31, 2015.

27. U.S. Patent No. 9,238,434 B2 ("Eder," EX1009) was filed on April 19, 2011, published on October 20, 2011, and issued on January 19, 2016.

IX. ANALYSIS AND OPINIONS

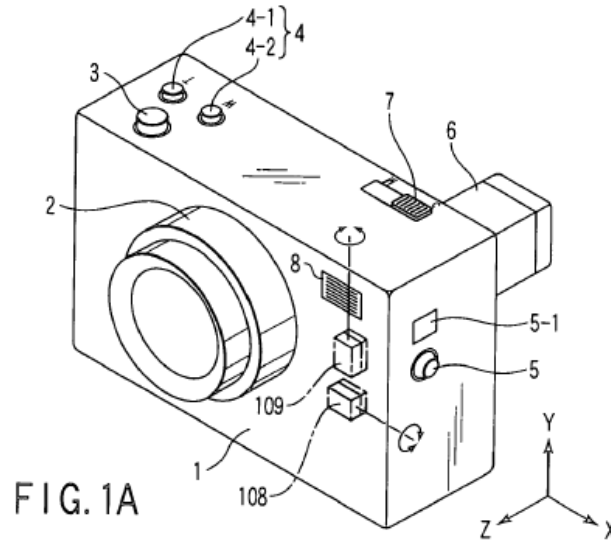
A. Ground 1: Claims 1-20 Are Obvious In View of Okubo

28. For the reasons set forth herein, it is my view that claims 1-20 of the '052 patent are rendered obvious by Okubo.

1. Summary of Okubo

29. Okubo is a U.S. Patent Application that was filed on July 18, 2005, and published on January 26, 2006. (EX1004.) I understand Okubo is thus prior art to the '052 patent under at least 35 U.S.C. §§ 102(a)(1) and (a)(2). I understand that Okubo was not cited or considered during prosecution of the '052 patent. (EX1003.)

30. Okubo discloses a “image pick-up apparatus,” which can be a digital video camera, that includes a lens unit 2 within a camera body 1. (EX1004, [0003], [0005], [0067], FIG. 1A.) FIG. 1A illustrates:



(EX1004, [0003], [0005], [0067], FIG. 1A.)

31. In the camera, as shown in FIG. 2, an image pick-up device 114, such as a charge-coupled device (CCD), is positioned behind the lenses 12, 13, 14 of the lens unit 2 such that light passing through the lenses forms an image on the CCD 114 and is photoelectrically converted:

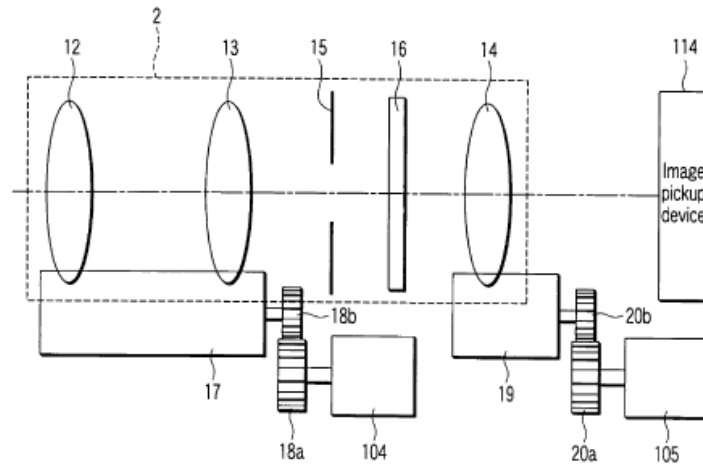
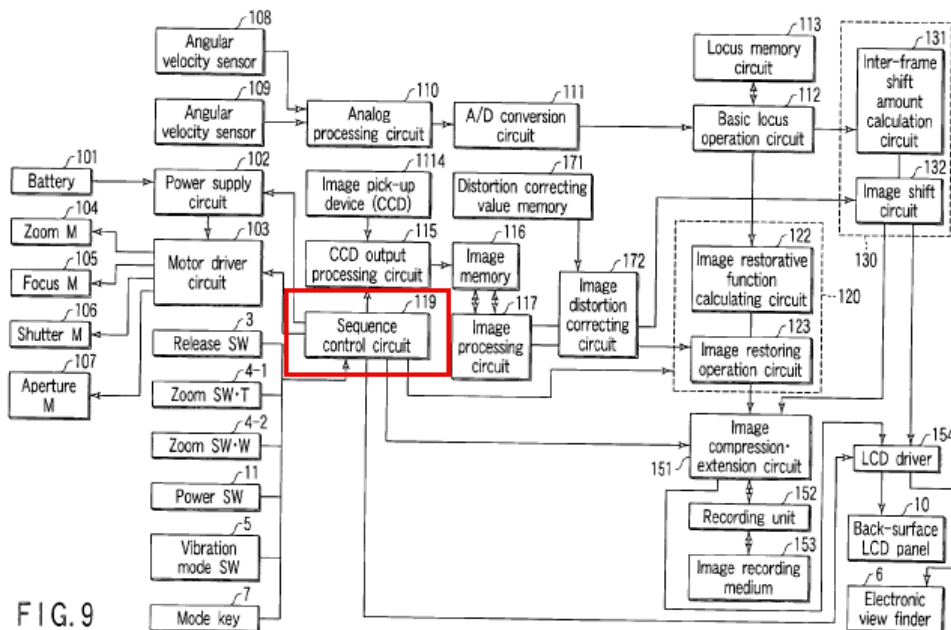


FIG. 2

(EX1004, [0069], [0072], FIG. 2.)

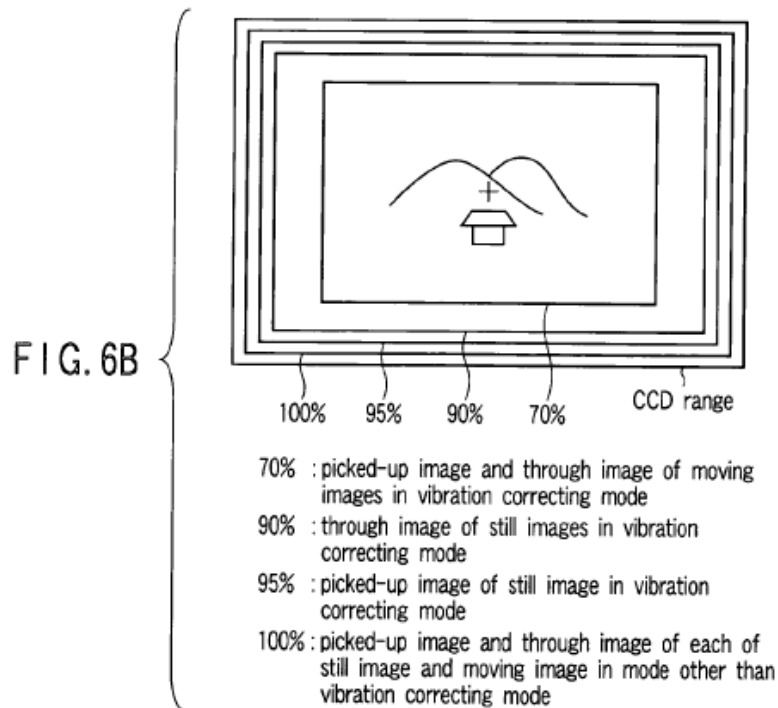
32. The CCD and other components are controlled by camera circuitry including a sequence control circuit 119:



(EX1004, [0073], [0075], [0106]-[0107], FIG. 9 (annotated).)

33. The camera circuitry performs lens distortion correction and electronic vibration correction. (EX1004, [0106].) The vibration correction is applied to picked-up images that are “image cutout ranges” of the CCD image, *e.g.*, via an image restorative function such as shown in FIGS. 7 and 8. (EX1004, [0087]-[0088], [0092], FIGS. 6A-6B, 7, 8.) These picked-up images have a smaller diagonal length than the full-range CCD image (*e.g.*, having a diagonal-length ratio of 70 percent), and thus exhibit a smaller field-of-view than the CCD

image. (EX1004, [0087]-[0088], FIG. 6B.) The picked-up images can be selected based on metadata indicating, *e.g.*, whether the image is captured in a moving image mode or a still image mode:



(EX1004, FIG. 6B.)

34. A two-stage lens distortion correction process is applied to the picked-up images, such as shown in FIG. 12:

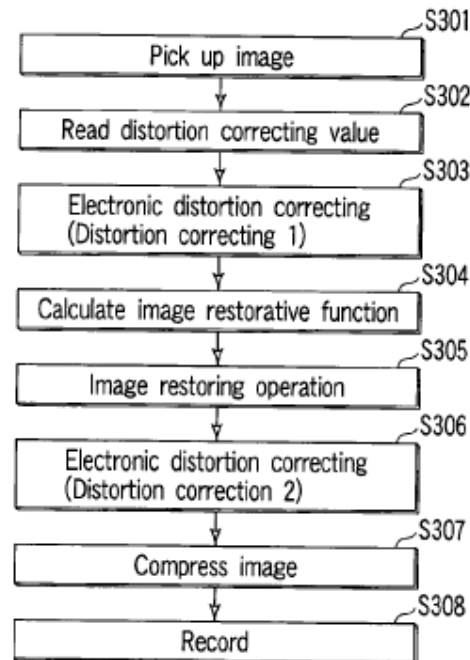


FIG. 12

(EX1004, [0113], FIG. 12.)

35. In stage S303 of the process, lens image distortion (e.g., barrel distortion or pincushion distortion) in the picked-up images is corrected to an initial target level of zero distortion (L_0), as shown in FIG. 11D. (EX1004, [0113], FIG. 11D.) This is so the image restoring operation (S305) can be applied to the picked-up images. (EX1004, [0113].) FIG. 11D illustrates:

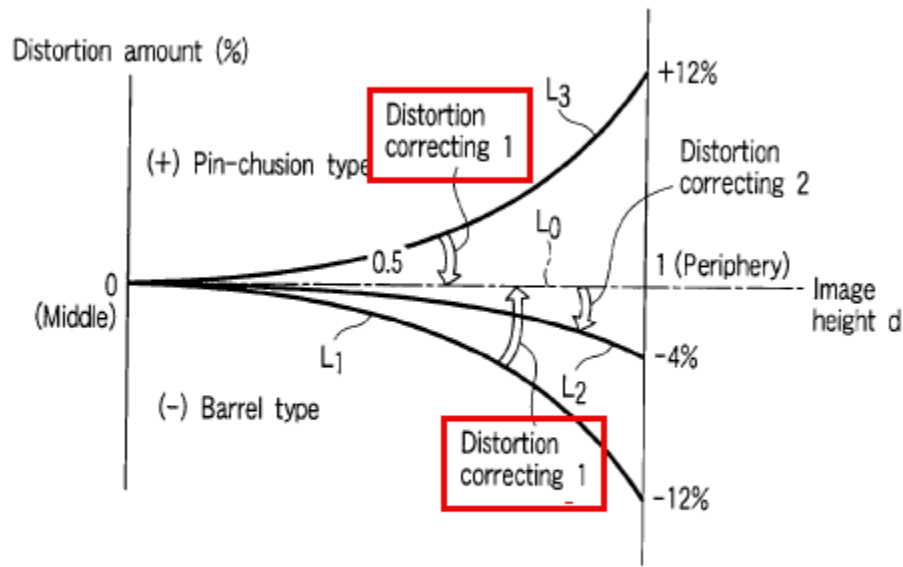
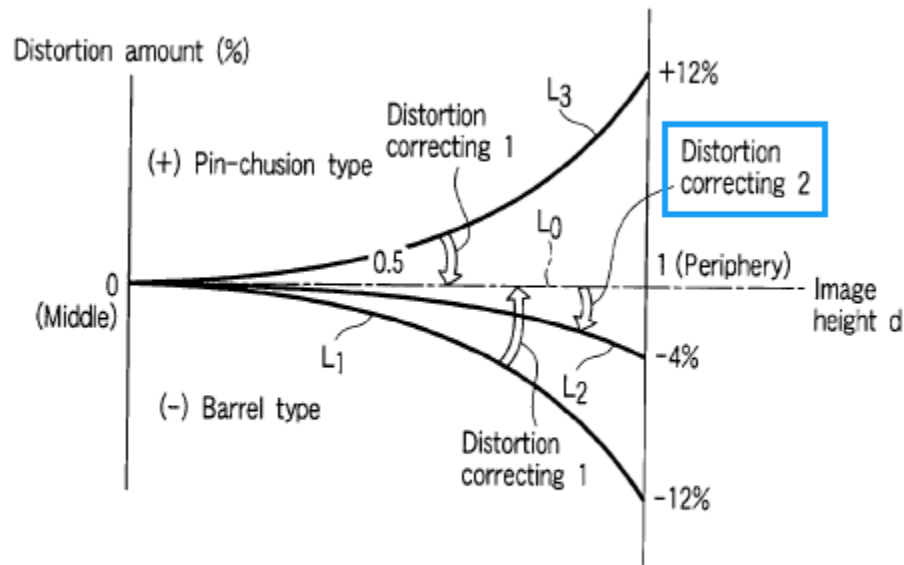


FIG. 11D

(EX1004, FIG. 11D (annotated).)

36. However, Okubo explains that “fluctuations are inevitably generated in lens properties,” causing the distortion to shift from zero after the first distortion correction is applied. (EX1004, [0110].) To account for such fluctuations, Okubo discloses applying a second distortion correction (S306), in which lens distortion (*e.g.*, barrel distortion) is intentionally introduced in order to restore the image “without any sense of incongruity.” (EX1004, [0112].) As Okubo discloses, this intentional distortion is “preferable” to fluctuations that can cause a corrected image to shift from zero distortion and appear “conspicuously unnatural.” (EX1004, [0112].) The second distortion correction can be applied as an inverse of the first distortion correction. (EX1004, [0112].) FIG. 11D illustrates:

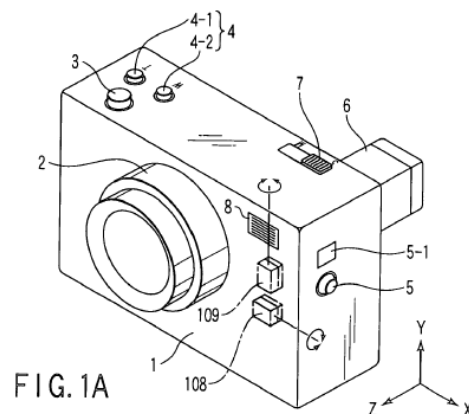


(EX1004, [0111]-[0112], FIG. 11D (annotated).)

2. Claim 1

- a. **[Preamble]** *A system that simulates image distortion of a virtual lens in a video, the system comprising:*

37. Okubo meets the preamble. For example, Okubo discloses an “image pick-up apparatus and an image restoration method,” such as for a video camera with a lens, *e.g.*, as shown in FIG. 1A:



(EX1004, [0003], [0005], [0067], FIG. 1A.)

38. Image distortion of a virtual lens is simulated at least by the process illustrated in FIG. 12, which applies a two-stage distortion correction to picked-up images, as described further below for [1F]:

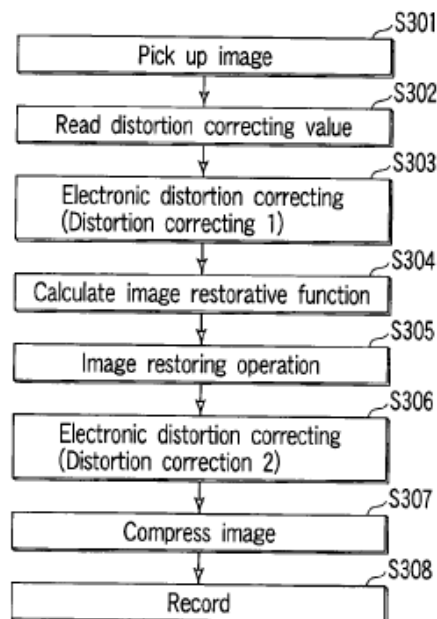


FIG. 12

(EX1004, [0113], FIG. 12.)

b. [1A] one or more processors; and

39. Okubo meets this element. For example, Okubo discloses, with respect to “a control circuit of the digital camera” shown in FIG. 3 and FIG. 9, that “sequence control circuit 119 comprises a CPU such as a microprocessor.” (EX1004, [0079], [0106].)

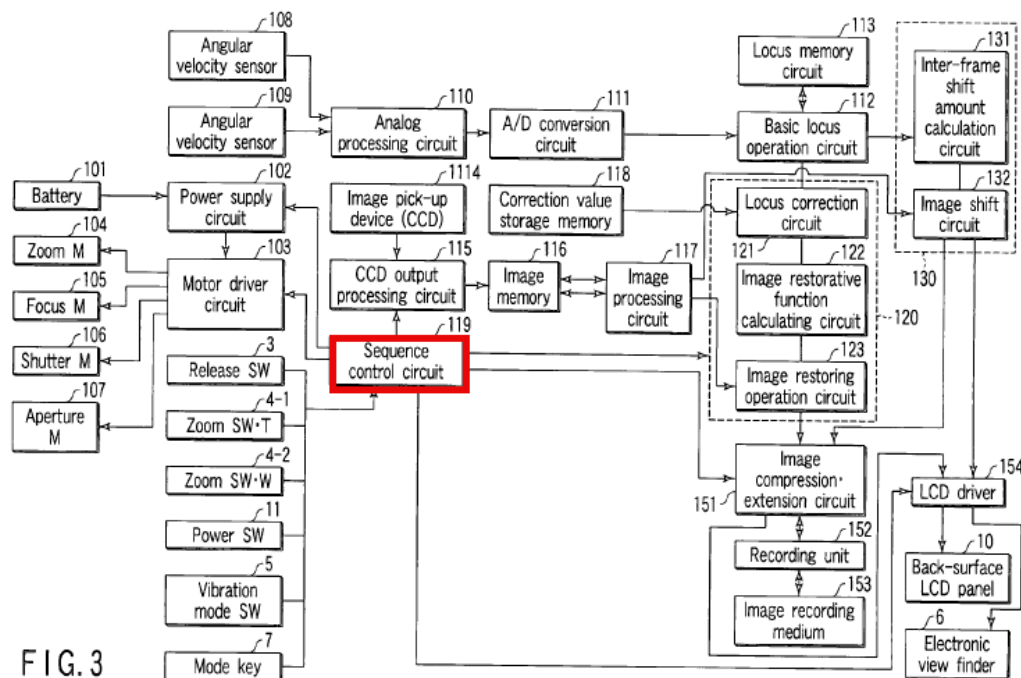


FIG. 3

(EX1004, FIG. 3 (annotated); see also EX1004, [0106], FIG. 9.)

c. [1B] a non-transitory computer-readable storage medium storing instructions that when executed cause the one or more processors to perform steps including:

40. Okubo meets this element. For example, as described above, Okubo discloses that the control circuit’s “sequence control circuit 119 comprises a CPU

such as a microprocessor,” and that sequence control circuit 119 has “instructions.” (EX1004, [0073], [0079].) Okubo further discloses that the sequence control circuit 119 “functions as a sequence controller, a continuous operation unit which continuously operates the image pick-up device, a display control unit which controls the display of the monitor (view finder 6, back-surface LCD panel 10), and controllers of first and second vibration correcting units (image restoring operation circuit 123, image shift circuit 132).” (EX1004, [0079].) Sequence control circuit 119 can be configured to perform the process shown in FIG. 12, at least via the controllers of the first and second vibration correcting units. (EX1004, [0113], FIG. 12.)

41. To the extent it is not expressly disclosed in Okubo, it would have been obvious to the POSITA that the digital camera’s control circuit includes a non-transitory computer-readable storage medium, and that sequence control circuit 119 performs the above functions by executing instructions stored on that storage medium. This is at least because the POSITA would understand a digital camera, such as in Okubo, to be an embedded computer system in which one or more processors (e.g., the CPU of sequence control circuit 119) execute instructions stored in a non-transitory memory. (EX1006, 95-97, 15, 33-34.) And as the POSITA would understand, “without a memory from which the processors

can read and write information, there would be no stored-program digital computers.” (EX1006, 34.)

- d. **[1C] *accessing input images, the input images including fields of view of a scene captured through a lens of a camera, the input images depicting the scene with an input lens distortion centered in the fields of view;***

42. Okubo meets this element. For example, Okubo discloses that an image pick-up device 114 (*e.g.*, a CCD) is positioned behind a lens such that light passing through the lens forms an image on the CCD:

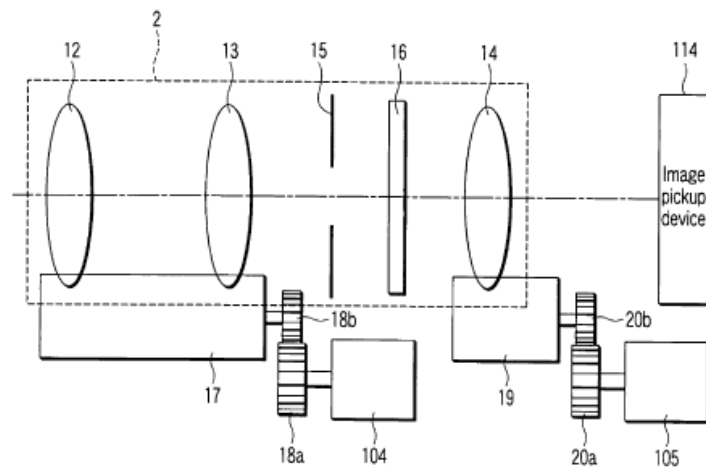
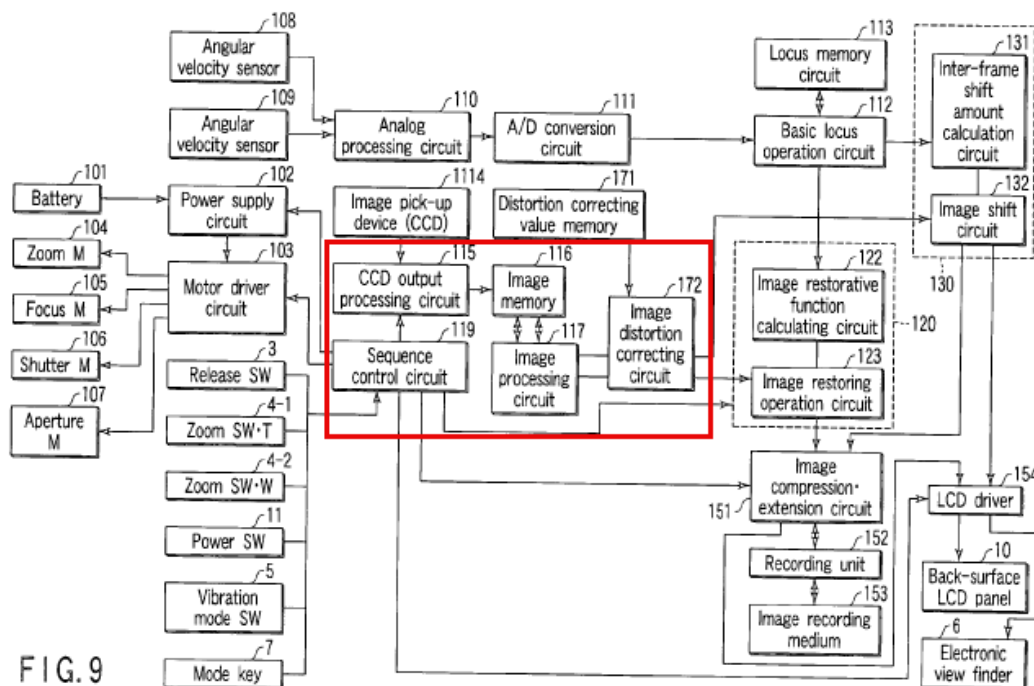


FIG. 2

(EX1004, [0069], [0072], FIG. 2.)

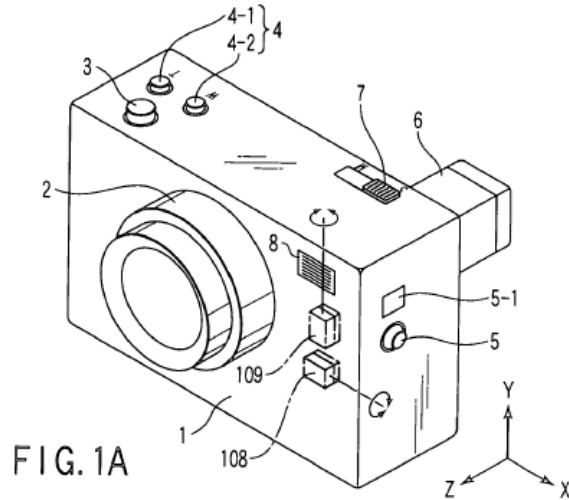
43. Input images formed on the CCD are accessed at least by CCD output processing circuit 115, which processes the output of the CCD 114; and by additional circuit elements (*e.g.*, image processing circuit 117, image distortion

correcting circuit 172), which access the input image via image memory 116, such as shown in FIG. 9:



(EX1004, [0075], [0106]-[0107], FIG. 9 (annotated).)

44. As the POSITA would recognize, the input images include fields of view of a scene captured through the lens (*e.g.*, lens 12, 13, and/or 14) of the camera. (EX1004, [0072], FIG. 2.) For example, Okubo discloses that the lenses belong to a video camera configured to capture an image of a scene, as shown in FIG. 1A; that the captured image includes a field of view, *e.g.*, as shown in FIG. 6B; and further that the image is formed from “light beam[s] passed through the lens” of the camera, thus capturing the scene in front of the lens:



(EX1004, [0003], [0005], [0067], [0072] FIGS. 1A, 6B.)

45. The POSITA would further recognize that the input images in Okubo depict the scene with an input lens distortion centered in the fields of view. This is evident to the POSITA at least from FIG. 2, which illustrates that the axes of lenses 12, 13, 14 are centered with respect to the image pick-up device 14:

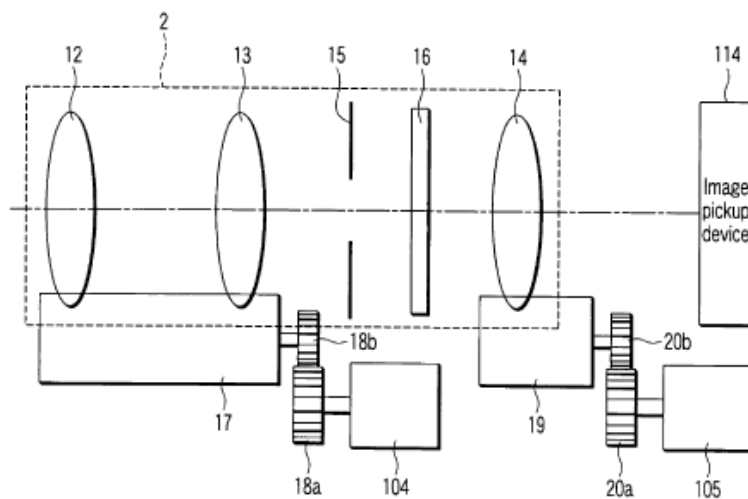


FIG. 2

(EX1004, FIG. 2.)

46. Moreover, FIGS. 11D and 11E illustrate lens distortion as a function of an image height from the center of the field of view, and indicate the lens distortion (*e.g.*, L_1 , L_3) is symmetric about the axis at which the image height d is zero (*e.g.*, the image center):

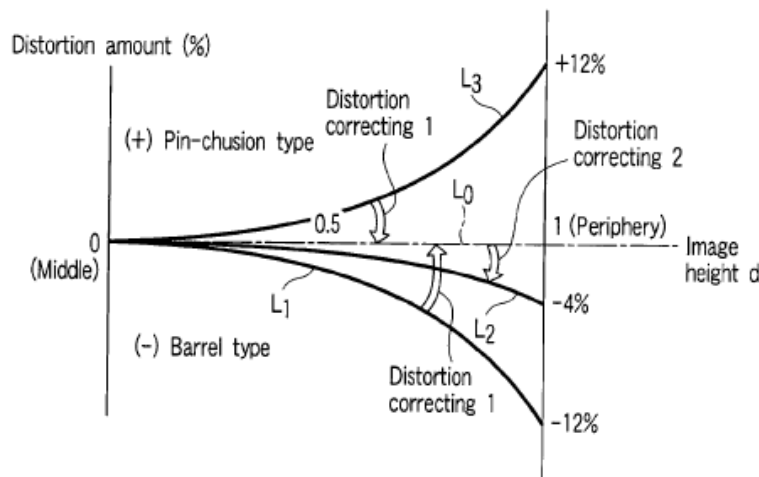
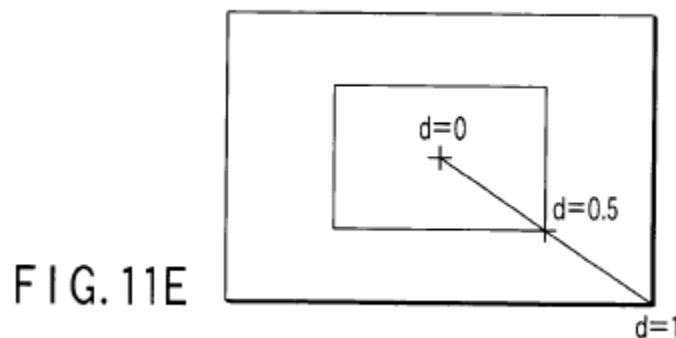


FIG. 11D

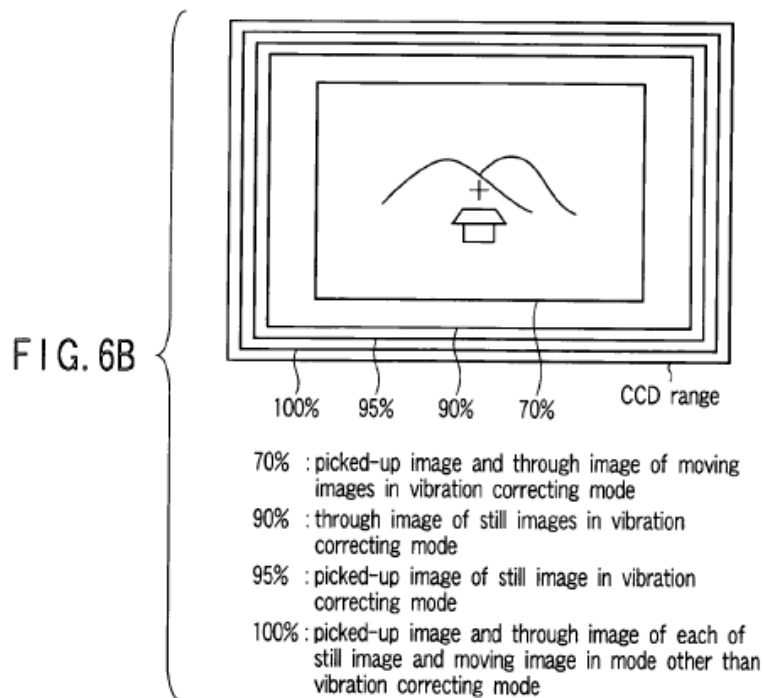


(EX1004, [0109], [0111], FIGS. 11D, 11E.)

- e. **[1D] selecting sub-frames representing portions of the input images, the sub-frames including reduced fields of view of the scene smaller than the fields of view of the input images,**

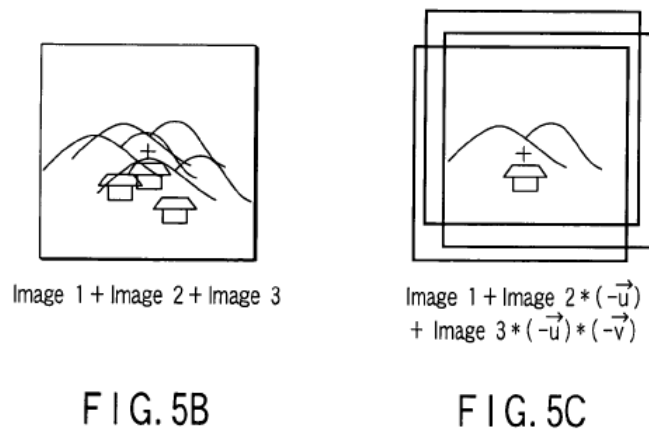
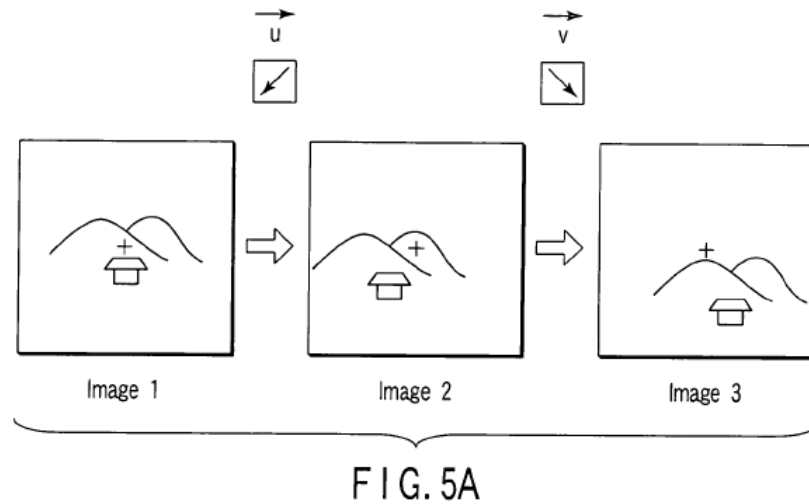
47. Okubo meets this element. For example, as part of the distortion correction process illustrated in FIG. 12, Okubo selects (S301) picked-up images that are “image cutout ranges,” or cropped sub-frames, of the CCD images.

(EX1004, [0087]-[0091], FIG. 6B.) FIG. 6B illustrates example relationships between the sub-frames and the CCD image:



(EX1004, [0087]-[0091], FIG. 6B, *see also* FIGS. 7, 8.)

48. As illustrated in the figure, the sub-frames represent portions of the input images (*e.g.*, full-range CCD images) that have a smaller diagonal length than the input images. (EX1004, [0087]-[0091], FIG. 6B.) A desired diagonal-length ratio of each sub-frame to the input image is determined based on whether a moving image mode, a still image mode, and/or a vibration correcting mode is active. (EX1004, [0087]-[0091], FIG. 6B.) For example, compared to the input images, the sub-frames can have a diagonal-length ratio of, *e.g.*, 70 percent, 90 percent, or 95 percent; and thus exhibit a smaller field-of-view of the scene than in the input images. (EX1004, [0087]-[0088], FIG. 6B.) Further, Okubo discloses selecting multiple sub-frames, at least as shown by the selection of Image 1, Image 2, and Image 3 in FIGs. 5A-5C, illustrating “three varying frames”:



(EX1004, [0085], FIGS. 5A-5C.)

49. Okubo's selection of sub-frames by cropping the input image is analogous to the '052 patent's description that "the sub-frame may be selected as ... a crop of the original input image or video frame." (EX1001, 11:47-51.) The '052 patent notes that such cropping operations are "often desirable." (EX1001, 1:14-16.) Moreover, Okubo's selection of sub-frames based on a desired diagonal-

length ratio is analogous to the '052 patent's description of obtaining a "scaling factor," defined as "a ratio of a size of the input image to the sub-frame size," and using that scaling factor to crop the input image and thus select the sub-frames.

(EX1001, 5:52-64.)

- f. ***[1E] the sub-frames including different lens distortion effects as a function of the input lens distortion present in the input images, different positions of areas of the input images included within the reduced fields of view, and a size of the areas of the input images included within the reduced fields of view; and***

50. Okubo meets this element. For example, Okubo discloses that images—and thus sub-frames of those images—can include different lens distortion effects, such as barrel distortion (shown in FIG. 11B) or pincushion distortion (FIG. 11C):

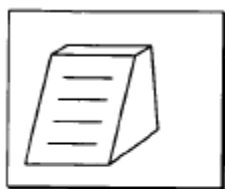


FIG. 11A



FIG. 11B

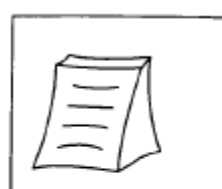


FIG. 11C

(EX1004, [0109]-[0110], FIGS. 11A-11D.) Okubo discloses that "with regard to areas other than the screen middle, the lenses 12, 13, 14 of the digital camera generate the distortions of the images which are dependent on zoom and focus

positions.” (EX1004, [0072], [0076].) This lens distortion in Okubo is analogous to the '052 patent's disclosure that lens characteristics including magnification and focal length—analogous to Okubo's zoom and focus positions—can affect the lens distortion. (EX1001, 7:40-44.)

51. The POSITA would understand the lens distortion effects in the sub-frames to be a function of the input lens distortion in the input images represented by the sub-frames. For example, FIG. 11D illustrates various distortion effects in an input image (*e.g.*, input distortion effects L_1 , L_3); Okubo explains that the distortion effects such as L_1 can represent an “image distortion ... by the lens,” such as barrel type distortion. (EX1004, [0111], FIG. 11D.) FIGs. 11D and 11E show how different lens distortion effects in an image can be expressed based on their location within the image:

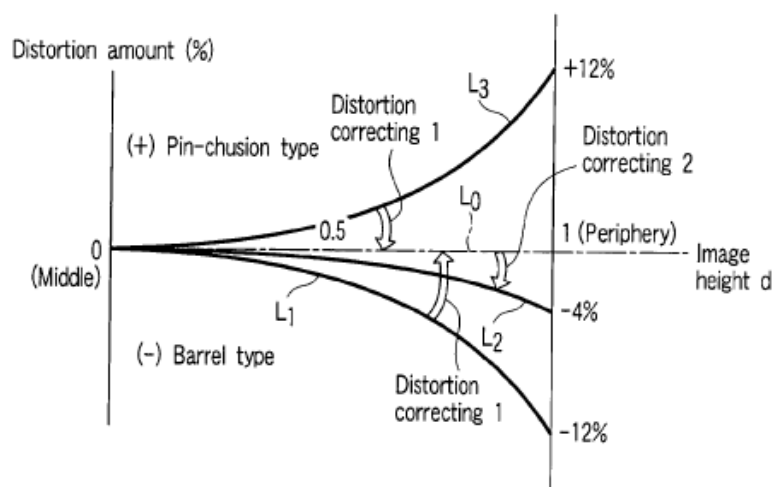
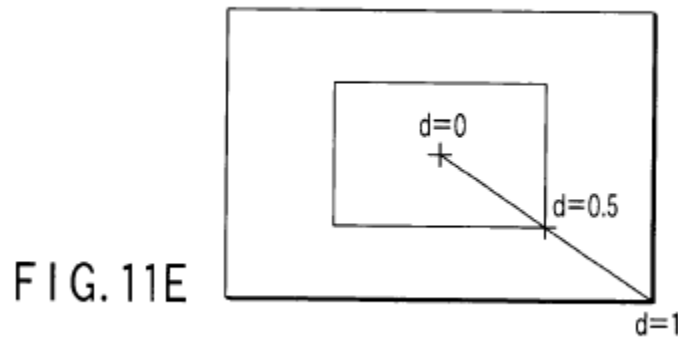


FIG. 11D



(EX1004, [0109], [0111], FIGs. 11D-11E.) The POSITA would understand FIGs. 11D and 11E to show that the amount of input lens distortion (*e.g.*, L_1 , L_3) in any area of an input image can be determined as a function of image height d , where the image height d represents a distance from the center of an image (*i.e.*, such that an image height of $d=0$ represents the center of the image, and an image height of $d=1$ represents the periphery of the image). (EX1004, FIGs. 11D-11E, [0109], [0111].) For example, an area of the image at an image height of $d=0.5$ may have a first amount of input lens distortion (corresponding to, *i.e.*, the value of L_1 or L_3 at $d=0.5$); and an area of the image at an image height of $d=0.75$ may have a second, different, amount of input lens distortion (corresponding to, *i.e.*, the value of L_1 or L_3 at $d=0.75$). (EX1004, FIG. 11D, [0109], [0111].)

52. The POSITA would further understand FIGs. 11D and 11E to describe the lens distortion effects in a sub-frame, which is simply a portion of an input image, such as described above for element [1D]. (EX1004, [0087]-[0091],

FIG. 6B.) The POSITA would understand the lens distortion effects to be a function of the input lens distortion in the input image. For example, the POSITA would understand that a lens distortion effect in an area of the sub-frame can be determined as a function of the input lens distortion, by determining the input lens distortion in the input image that corresponds to the area of sub-frame, such as described above for FIGs. 11D and 11E. The POSITA would further understand the sub-frames to include different lens distortion effects as a function of different positions of areas of the input images included within the reduced fields of view, and a size of the areas of the input images included within the reduced fields of view. This is at least because, as described above for FIGs. 11D and 11E, the lens distortion effects in an input image—and thus a sub-frame of that image—are expressed as a function of the position and/or size (*i.e.*, image height d) of an area within the input image. For example, as shown in FIG. 11D and described above, image areas having different values for image height d may exhibit different lens distortion effects as a function of that image height. (EX1004, FIGs. 11D.)

53. The POSITA would additionally understand Okubo to teach that the sub-frames include multiple different distortion effects. For example, as described above, FIG. 11D illustrates that an input image (and thus a sub-frame of that input image) can include various lens distortion effects that differ throughout the input

image, for instance as the distance from the center of the image changes. Further, as Okubo discloses, these effects may differ “dependent on zoom and focus positions.” (EX1004, [0072], [0076].) Additionally, Okubo explains that for “areas other than the screen middle,” the lens distortion is corrected by “correction data...corresponding to each area of the screen.” (EX1004, [0076], [0108].) The POSITA would thus understand that different areas of the screen (and thus an input image) may include different lens distortion effects, requiring different distortion correction data. (EX1004, [0076], [0108].) And Okubo further discloses that lens distortion may “differ[] with each area because of so-called straw hat type distortion,” which is “a mixture of the pin-cushion and barrel type distortions.” (EX1004, [0112].)

- g. ***[1F] generating output images based on a desired lens distortion and the different lens distortion effects in the sub-frames, the desired lens distortion and the input lens distortion exhibiting consistent lens characteristics,***

54. Okubo meets this element. For example, Okubo discloses a process in FIG. 12 in which output images are generated (S308) by applying two stages (S303, S306) of lens distortion correction to the sub-frames (*e.g.*, picked-up images, S301):

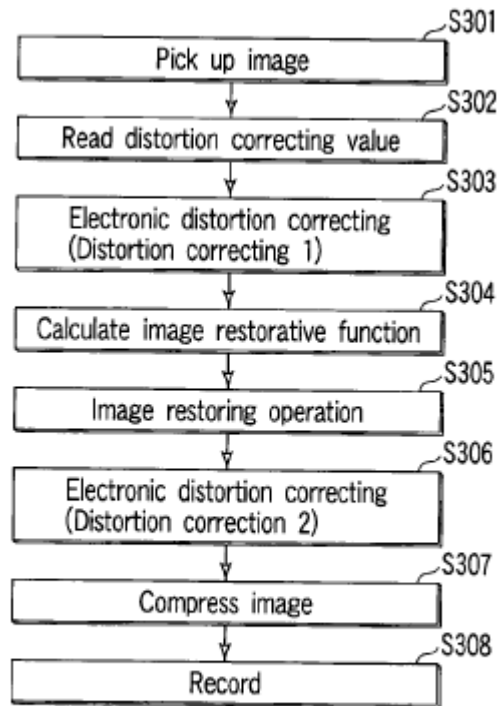


FIG. 12

(EX1004, [0106]-[0113].)

55. In stage S302 of this process, a distortion correcting value corresponding to the lens distortion is read from a distortion correcting value memory 171, based on the zoom position and the subject distance. (EX1004, [0113], FIG. 12.) At stage S303, the distortion correcting values are applied to the sub-frames to correct the lens image distortion into a first desired lens distortion level L_0 , indicating zero distortion. (EX1004, [0113], FIGS. 11D, 12.) FIG. 11D (“Distortion correcting 1”) illustrates correction of lens distortions L_1 and L_3 to L_0 according to stage S302:

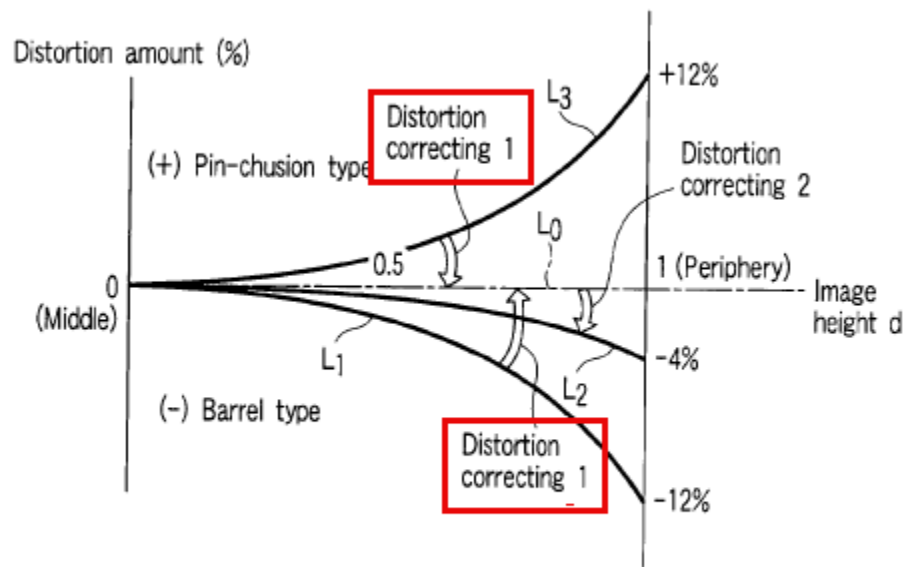


FIG. 11D

(EX1004, [0111]-[0113], FIG. 11D (annotated).)

56. Then, at stage S306, to account for fluctuations in lens properties and to generate an image “without any sense of incongruity,” lens distortion is intentionally introduced (*e.g.*, via an inverse correction of the first distortion correction) to obtain a second desired lens distortion level L_2 , *e.g.*, simulating a non-zero amount of barrel distortion. (EX1004, [0112]-[0113], FIG. 12.) FIG. 11D (“Distortion correcting 2”) illustrates a correction of lens distortion L_0 to L_2 , indicating barrel distortion, according to stage S306:

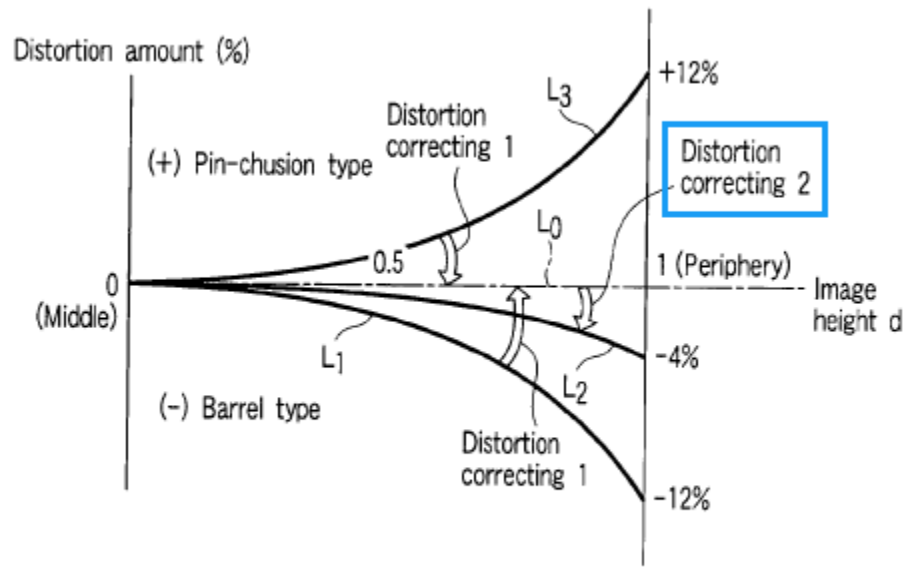


FIG. 11D

(EX1004, [0111]-[0113], FIG. 11D (annotated).)

57. Okubo's two-stage distortion process of FIG. 12 is analogous to the "two-step transformation" described in the '052 patent, in which a first step is performed to "remove the lens distortion present in the sub-frame," and a second step is then performed to "re-introduce a lens distortion effect." (EX1001, 12:25-42.)

58. The output images are based on the different lens distortion effects at least because the first distortion correction applies distortion correcting values stored in the distortion correcting value memory 171, which are associated with the different lens distortion effects as described above for [1E]. (EX1004, [0108].)

For instance, the distortion correcting values are read from the memory 171 "based

on zoom position and subject distance” and applied to correct the lens distortion.

(EX1004, [0108].)

59. The desired lens distortion and the input lens distortion exhibit consistent lens characteristics at least because, in order to obtain the desired lens distortion L_2 , the image distortion correcting circuit 172 at stage S303 first applies to the sub-frame distortion correcting values that “correspond[]” to the input lens distortion; and stage S306 then applies the “inverse correction” of stage S303 to obtain the desired lens distortion L_2 . (EX1004, [0111]-[0112].) As Okubo explains, the image distortion correcting circuit 172 operates as a “lens property correction circuit,” such that “the aberration attributed to the properties of the photographing lens or the like may be corrected.” (EX1004, [0107]-[0108].) The POSITA would recognize that by applying an inverse correction of stage S303, stage S306 inversely applies the distortion correcting values of S303 that correspond to the input lens distortion; and that the desired lens distortion L_2 and the input lens distortion thus exhibit distortion characteristics of the same lens. (EX1004, [0111]-[0112].)

60. Additionally, Okubo discloses that in obtaining the desired lens distortion L_2 , the distortion “shifts from zero” by “fluctuations in the lens properties,” thus introducing into the output image the fluctuations of the input lens

distortion during stage S303, when the distortion is first corrected to the intermediate desired level L_0 . (EX1004, [0110]-[0111].) Both the desired lens distortion and the input lens distortion thus exhibit the same fluctuation characteristics of the lens, providing another reason why the desired lens distortion and the input lens distortion exhibit consistent lens characteristics. (EX1004, [0110].)

61. Moreover, the output image is restored “without any sense of incongruity,” and as the POSITA would understand based on experience with image or video processing, a sense of incongruity could result if the desired lens distortion in the output images were not consistent with the characteristics of the lens of the camera. (EX1004, [0112]-[0113].) Okubo’s output images are thus consistent with the ’052 patent’s goal of generating images with “consistent lens characteristics” such that it is “not apparent to the viewer” that editing effects were created in post-processing instead of during capture. (EX1001, 3:39-43.)

- h. ***[1G] wherein the output images include the sub-frames remapped from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the reduced fields of view to transform the different lens distortion effects present in the sub-frames to the desired lens distortion such that portions of the scene depicted in the sub-frames appear to have been captured using the reduced fields of view.***

62. Okubo meets this element. As described above for [1F], the output images include the sub-frames remapped from the input lens distortion to the desired lens distortion. For example, the input lens distortion is centered in the fields of view as described above for [1C]; and with respect to the output images, FIGS. 11D and 11E illustrate that the desired lens distortion L_2 can be symmetric about the axis at which the image height d is zero (*i.e.*, the image center), and thus centered with respect to the field of view:

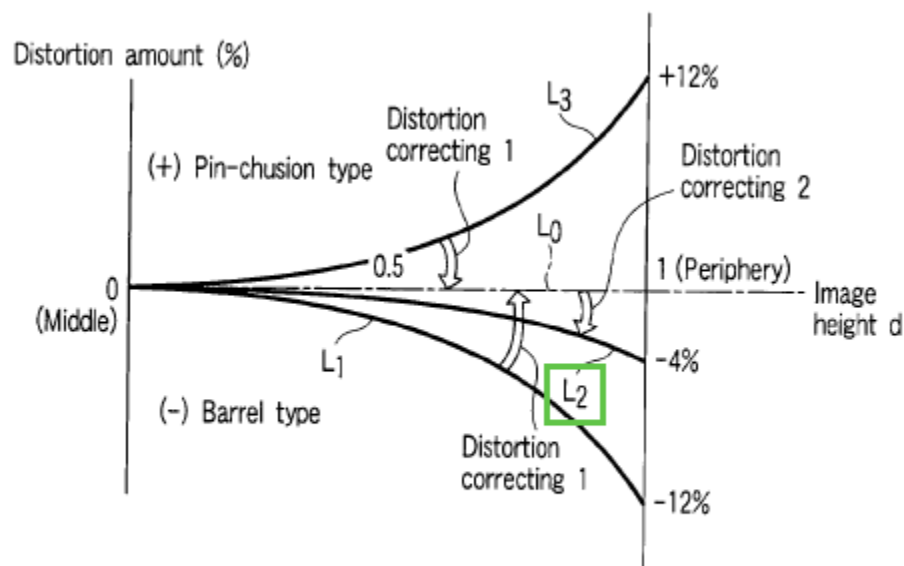
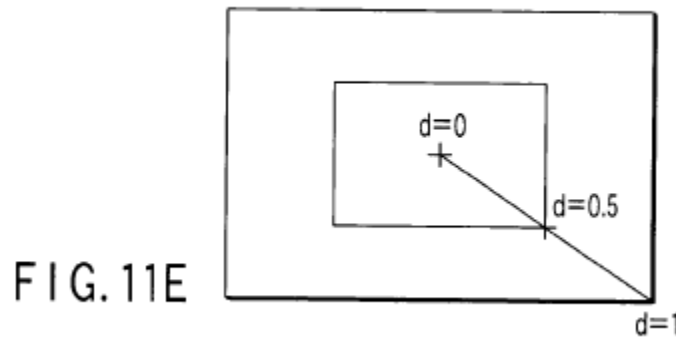


FIG. 11D



(EX1004, [0109], [0111]-[0113], FIG. 11D (annotated), 11E.)

63. In transforming the lens distortion effects of the sub-frames to the desired lens distortion L_2 , as described above for [1F], the scene depicted appears to have been captured using the reduced fields of view of the sub-frames.

(EX1004, [0106]-[0113].) This is because by applying the two-stage correction process of FIG. 12, “the image is obtained without any sense of incongruity by both of the distortion correcting into zero (distortion correcting [1]) and the inverse correction into the barrel type (distortion correcting 2),” such as described above.

(EX1004, [0112]-[0113].) For example, the image can exhibit lens distortion L_2 shown in FIG. 11D. (EX1004, [0109],[0111].) Fig. 5C illustrates an example output image in which portions of a scene depicted in the sub-frame (*e.g.*, a house and surrounding hills) appear to have been captured by the camera lens using the reduced field of view:

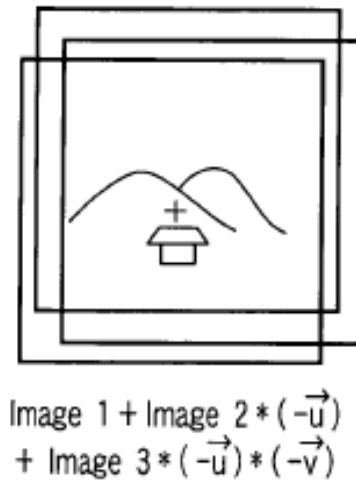


FIG. 5C

(EX1004, [0085], FIG. 5C.)

64. Moreover, the POSITA would understand based on experience with image or video processing that the image in Okubo obtained without any sense of incongruity meets an image that appears to have been captured using its reduced fields of view, as recited in the claim. This is at least because it would appear incongruous for Okubo's camera to generate an image that did not appear to have been captured by the lens of that camera using the image's own field of view (that is, the reduced field of view of the picked-up image such as illustrated in FIG. 6B). (EX1004, FIG. 6B.) That is, the observer would find such an image "conspicuously unnatural" and unfamiliar due to the mismatch between the

appearance of the image and the optical properties of the lens that captured it. (See EX1004 at [0110].)

3. Claim 2

a. [Preamble] *The system of claim 1,*

65. Okubo meets the preamble as described above for claim 1.

b. [2A] *wherein image stabilization is applied to the input images.*

66. Okubo meets this element. For example, Okubo discloses that “as correction of the vibration in a still image or the like, a locus of camera shakes is detected using an angular velocity sensor or the like at the time of the image pick-up, and a predetermined image restoring operation is performed based on the detected locus of the shake after the image pick-up.” (EX1004, [0005].) As an illustration of “the electronic vibration correcting,” Okubo discloses that “the image of FIG. 5C corresponds to an image in which the vibration has been corrected” based on input images. (EX1004, [0085], FIGs. 5B-5C.) As evident in FIG. 5C, the input images are stabilized compared to FIG. 5B, in which the vibration is not corrected:

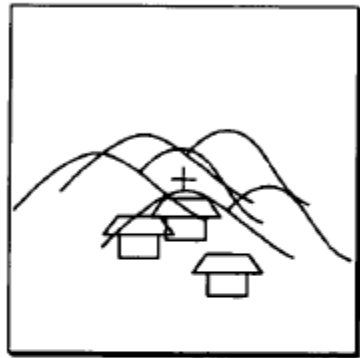


Image 1 + Image 2 + Image 3

FIG. 5B

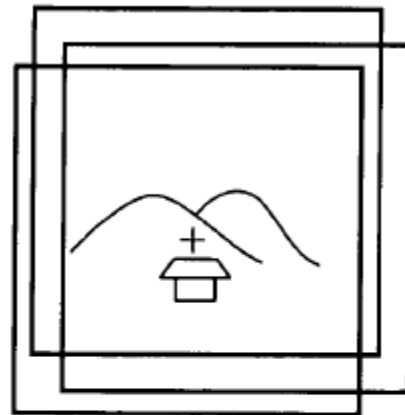


Image 1 + Image 2 * $(-\vec{u})$
+ Image 3 * $(-\vec{u}) * (-\vec{v})$

FIG. 5C

(EX1004, [0085], FIGs. 5B-5C.)

4. Claim 3

a. [Preamble] *The system of claim 1,*

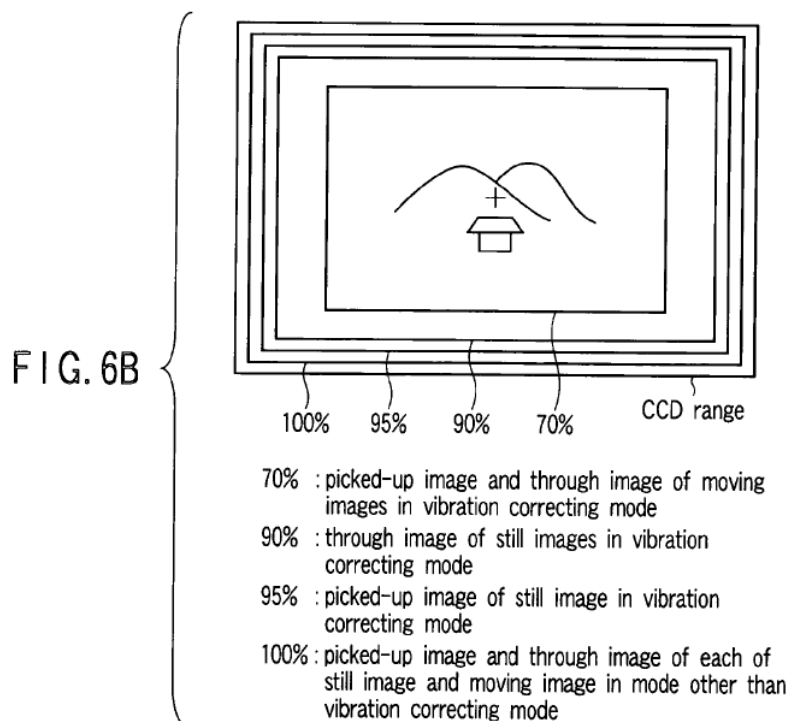
67. Okubo meets the preamble as described above for claim 1.

b. [3A] *wherein the sub-frames are selected based on metadata associated with the input images.*

68. Okubo meets this element. For example, Okubo discloses that the sub-frames are selected based on metadata indicating whether the input images were captured in a moving image mode or a still image mode, or in a vibration correcting mode. (EX1004, [0087]-[0091], FIG. 6B.) The moving image mode, still image mode, and vibration correcting mode (*i.e.*, a vibration correcting flag)

are metadata associated with the input images: for example, the camera can include a mode key that acts as a changeover key to a still image or a moving image; when the mode key 7 is set to an S-side (STILL), a still image mode is set; and when the mode key is set to an M-side (MOVIE), a moving image mode is set. (EX1004, [0069].) Similarly, the camera can include a vibration mode switch 5, and the state of the vibration mode switch determines whether a “vibration correcting flag” is set. (EX1004, [0092].)

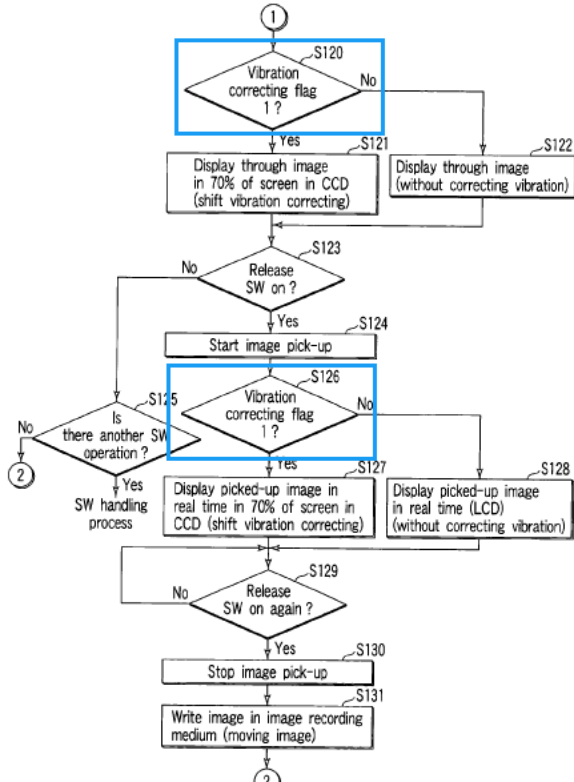
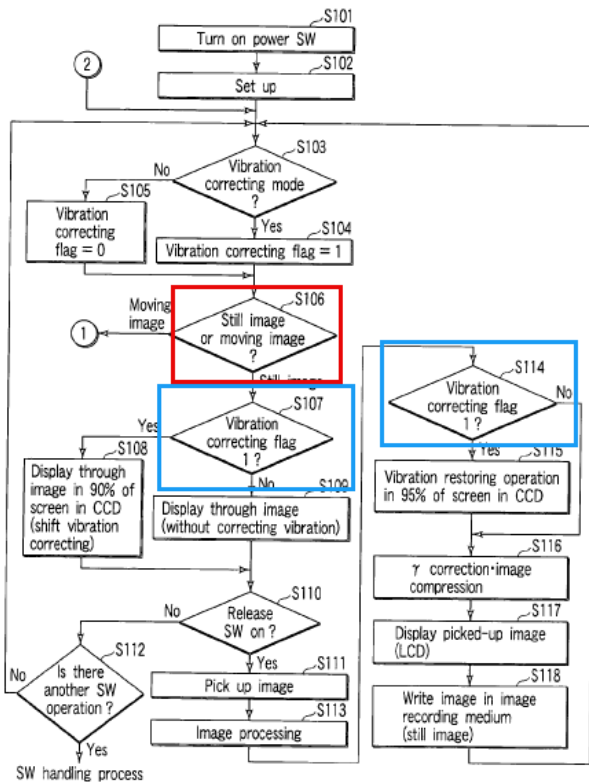
69. As shown in FIG. 6B, the size of a sub-frame (e.g., a picked-up image or through image) can depend on the above metadata:



(EX1004, [0087]-[0089], FIG. 6B.)

70. For example, as shown in FIG. 6B, if the metadata indicates the moving image mode and the vibration correcting mode, the picked-up image and through image have a range of 70 percent of the diagonal length ratio. (EX1004, [0087]-[0091], FIG. 6B.) If the metadata indicates the still image mode and the vibration correcting mode, the picked-up image has a range of 95 percent, and the through image has a range of 90 percent. (EX1004, [0087]-[0091], FIG. 6B.) And if the metadata does not indicate the vibration correcting mode, the picked-up image and the through image each have a range of 100 percent. (EX1004, [0087]-[0091], FIG. 6B.)

71. Likewise, FIGS. 7 and 8 illustrate that the selection of the images is based on the above metadata. (EX1004, [0092], FIGs. 7-8.) For example, as shown in FIG. 7, it is determined at stage S106 whether the still image mode or moving image mode is indicated; and it is determined at stages S107, S114, S120, and S126 whether the vibration correcting flag is set. (EX1004, [0092]-[0098], FIGs. 7-8.) The picked-up image and/or the through image is then selected accordingly based on this metadata. (EX1004, [0092]-[0098], FIGs. 7-8.)



72. Additionally, Okubo discloses that the metadata can include data from angular velocity sensors or angular acceleration sensors of the camera, which can indicate displacement angles in the X, Y, and Z axes. (EX1004, [0074].) This is consistent with the '052 patent, in which “sensors 440 may capture various metadata,” and can include “orientation sensors” or “accelerometers,” which the POSITA would understand to include at least Okubo’s angular acceleration sensors. (EX1001, 4:22-26, 4:54-58, 8:42-54; EX1007, 19-21, 24;.)

5. Claim 4

a. [Preamble] *The system of claim 3,*

73. Okubo meets the preamble as described above for claim 3.

b. [4A] *wherein the metadata indicates motion of the camera that captured the input images.*

74. Okubo meets this element. For example, as described above for [3A], the metadata includes indications of modes including a vibration correction mode. At least the vibration correction mode indicates motion of the camera that captured the input images. For example, in the vibration correction mode, indicated by the vibration correcting flag, “a locus of camera shakes is detected using an angular velocity sensor or the like at the time of the image pick-up, and a predetermined image restoring operation is performed based on the detected locus of the shake after the image pick-up.” (EX1004, [0005].) An angular acceleration sensor can also be used as described above for [3A]. (EX1004, [0074].) The claimed motion of the camera is met at least by the camera shakes detected in the vibration correction mode, which can be indicated by displacement angles computed from the sensor output. (EX1004, [0074].)

6. Claim 5

a. [Preamble] *The system of claim 3,*

75. Okubo meets the preamble as described above for claim 3.

b. [5A] *wherein the metadata indicates orientation of the camera that captured the input images.*

76. Okubo meets this element. For example, as described above for [3A], the metadata can include vibration rotary angles in the X, Y, and Z axes. As Okubo explains, these vibration rotary angles can be used to calculate displacement angles, or can indicate the output of angular acceleration sensors of the camera, thus indicating an orientation of the camera that captured the images. (EX1004, [0074]; EX1007, 19-21, 24.) This is consistent with the '052 patent's description of sensors, such as accelerometers, that "generate orientation metadata describing the orientation of the camera 330." (EX1001, 8:46-56.)

7. Claim 6

a. [Preamble] *The system of claim 1,*

77. Okubo meets the preamble as described above for claim 1.

b. [6A] *wherein the output images are combined as video frames of an output video.*

78. Okubo meets this element. For example, Okubo discloses that the camera can be a video camera. (EX1004, [0005].) The POSITA would understand based on experience with image or video processing that a video camera is configured to produce output video, and that output images of a video camera are combined as video frames of the output video. (EX1008, 9-10.)

8. Claim 7

a. [Preamble] *The system of claim 6,*

79. Okubo meets the preamble as described above for claim 6.

b. [7A] *wherein remapping of the sub-frames from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the reduced fields of view results in the output video having consistent frame-to-frame lens characteristics.*

80. Okubo meets this element. For example, Okubo meets the claimed remapping the sub-frames as described above for [1G]. And as Okubo explains, the remapping restores the image “without any sense of incongruity.” (EX1004, [0112].) This meets the output video having consistent frame-to-frame lens characteristics at least because, as the POSITA would understand based on experience with image or video processing, a video would include consistent frame-to-frame lens characteristics in order to avoid a sense of incongruity when viewing the video. Put differently, the POSITA would understand that inconsistent frame-to-frame lens characteristics would result in a sense of incongruity, because such inconsistent lens characteristics would result in a mismatch between frames that an observer would find visually jarring.

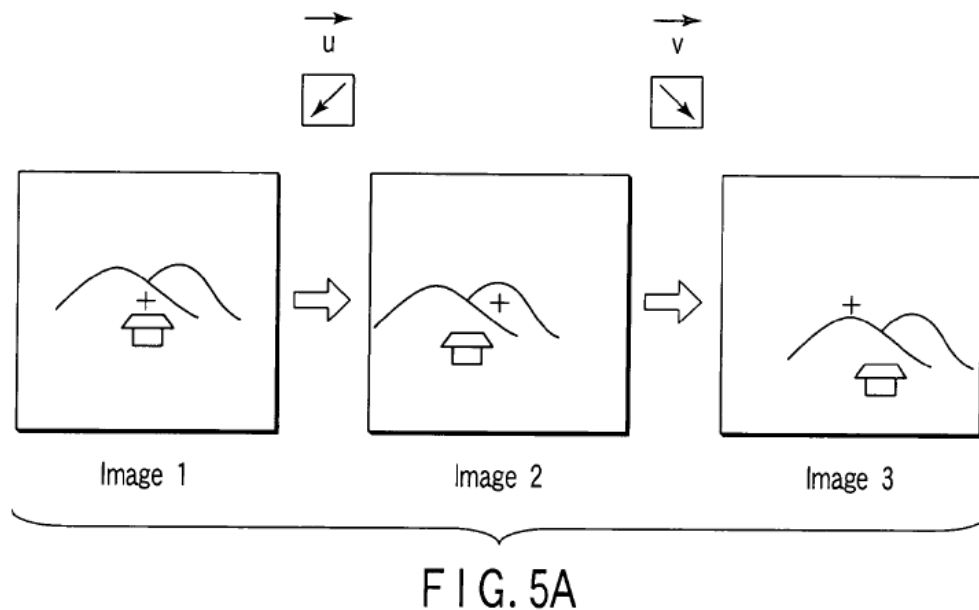
9. Claim 8

a. [Preamble] *The system of claim 7,*

81. Okubo meets the preamble as described above for claim 7.

- b. [8A] *wherein the different positions of the areas of the input images included within the reduced fields of view simulate virtual re-pointing of the camera using the reduced fields of view.*

82. Okubo meets this element. For example, in FIG. 5A, Images 1, 2, 3 illustrate areas of the input images included within the reduced fields of view:



(EX1004, [0085]-[0086], FIG. 5A.)

83. As Okubo explains, a shift between the frames is reversed by applying a vector movement in the reverse direction of the shift. (EX1004, [0085]-[0086], FIGs. 5A-5C.) This results in an output image (shown for example in FIG. 5C, with respect to FIG. 5B) in which the camera is virtually re-pointed with respect to Images 1, 2, and 3:

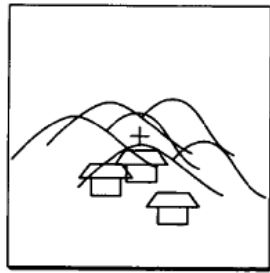


Image 1 + Image 2 + Image 3

FIG. 5B

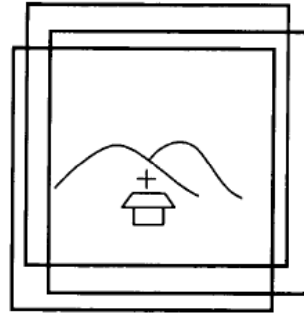


Image 1 + Image 2 * $(-\vec{u})$
+ Image 3 * $(-\vec{u}) * (-\vec{v})$

FIG. 5C

(EX1004, [0085]-[0086], FIGs. 5B-5C.)

10. Claim 9

a. [Preamble] *The system of claim 8,*

84. Okubo meets the preamble as described above for claim 8.

b. [9A] *wherein the one or more processors and the non-transitory computer-readable storage medium are included in the camera.*

85. Okubo meets this element. For example, at least sequence control circuit 119 of Okubo meets the claimed one or more processors as described above for [1A], and meets the claimed non-transitory computer-readable storage medium as described above for [1B]. FIG. 9 of Okubo illustrates that these components belong to a control circuit of the digital camera, *e.g.*, as shown in FIG. 1A:

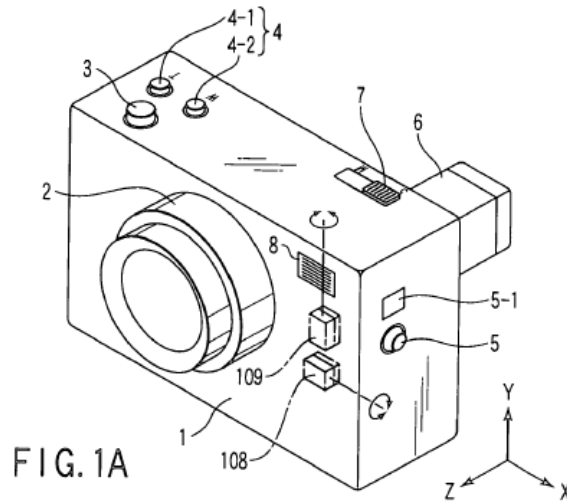


FIG. 1A

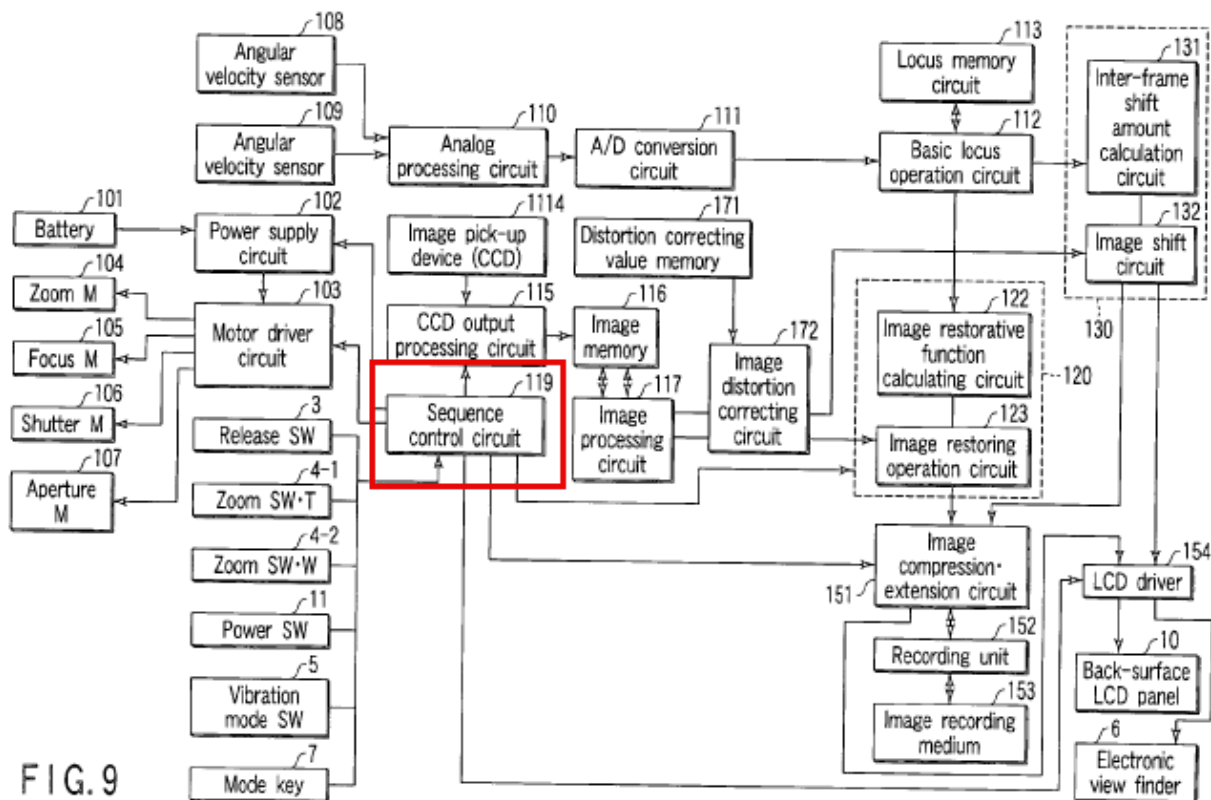


FIG. 9

(EX1004, [0073], [0106], FIGS. 1A, 9 (annotated).)

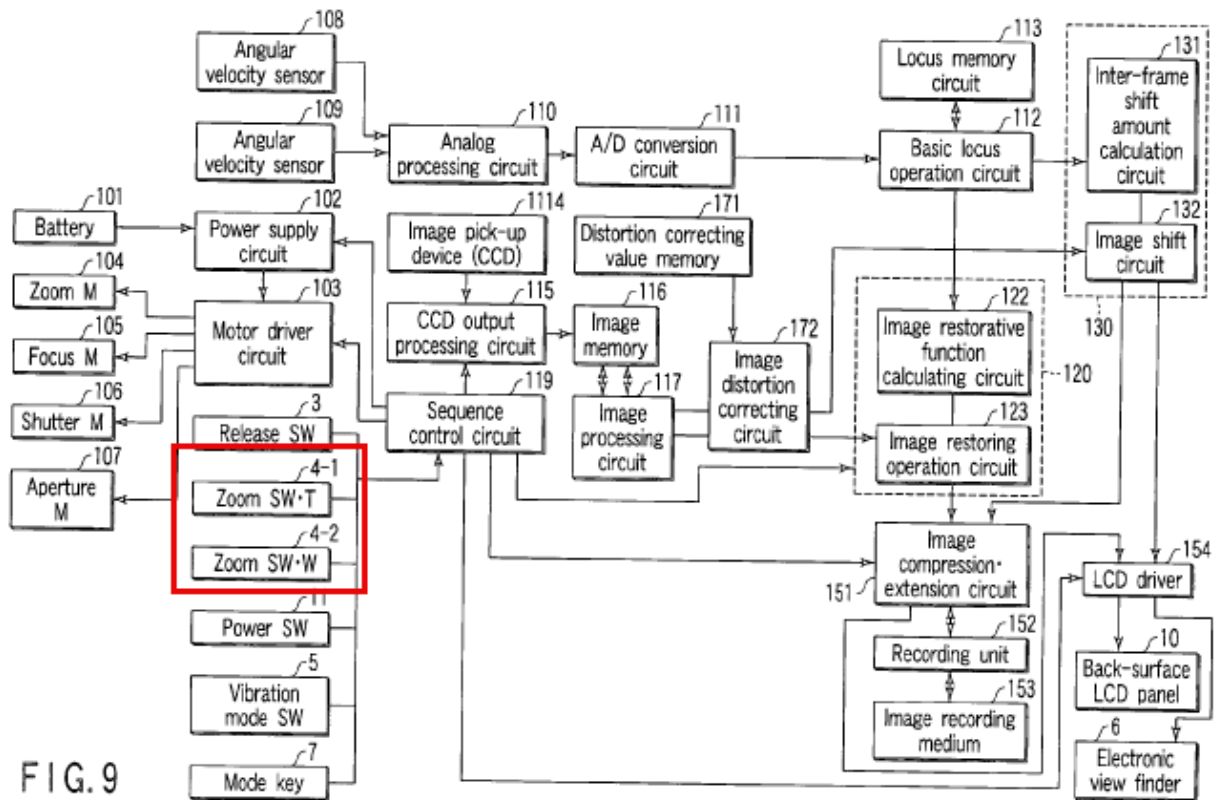
11. Claim 10

a. [Preamble] *The system of claim 9,*

86. Okubo meets the preamble as described above for claim 9.

b. [10A] *wherein the lens includes a wide angle lens, and*

87. Okubo meets this element. For example, Okubo discloses, with respect to FIG. 9, a zoom switch 4 that includes a T button 4-1 and a W button 4-2:



(EX1004, [0068], [0106], FIG. 9 (annotated).)

88. Okubo explains that “when the W button is pressed, the magnification of the lens is changed to a wide side.” (EX1004, [0068].) The POSITA would

understand based on experience with image or video processing that a lens that can be changed to a wide side to include a wide angle lens.

- c. ***[10B] lens characteristics of the wide angle lens causes straight lines in the scene to appear as curved lines near edges of the input images.***

89. Okubo meets this element. For example, FIG. 11B of Okubo illustrates barrel-type lens distortion, in which straight lines of an object (shown in FIG. 11A with zero distortion) appear as curved lines near the edges of the input images as the result of wide angle lens characteristics. (EX1004, [0109]-[0110].)

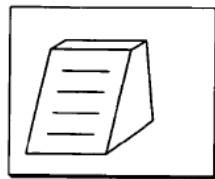


FIG. 11A

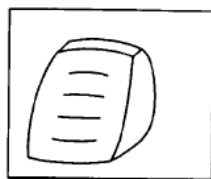


FIG. 11B

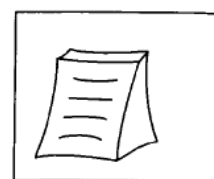


FIG. 11C

(EX1004, FIGS. 11A-11C.)

90. Additionally, FIGS. 11D and 11E illustrate that the lens distortion (*e.g.*, L_1 , L_2 , L_3) increases toward the edges of the input image (*e.g.*, as image height d increases from zero):

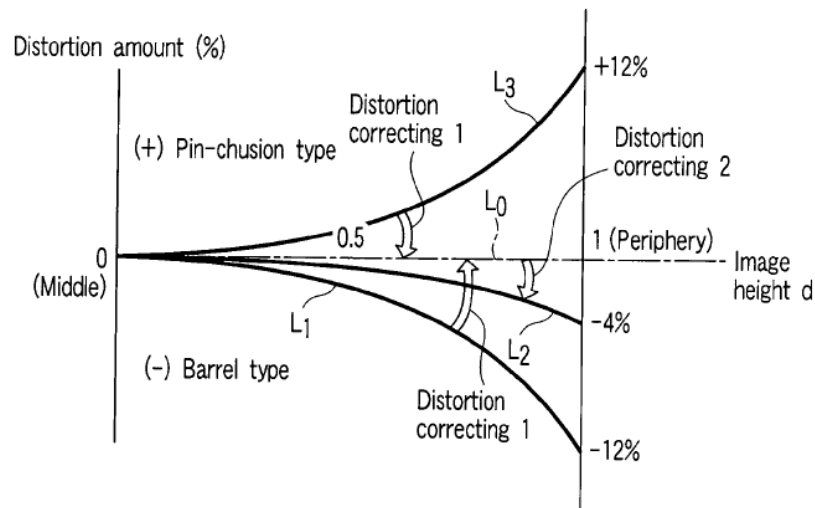


FIG. 11D

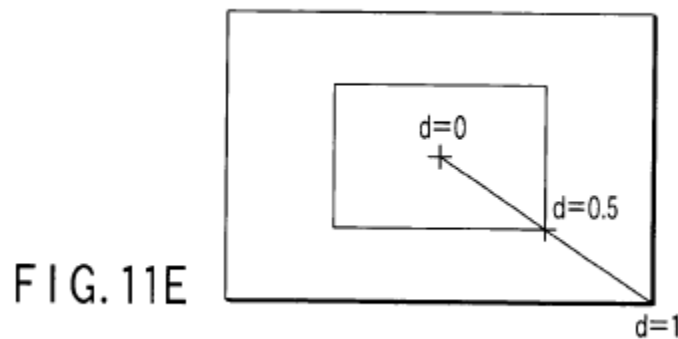


FIG. 11E

(EX1004, [0109]-[0111], FIG. 11D-11E.)

12. Claim 11

- a. **[Preamble]** *A method for simulating image distortion of a virtual lens in a video, the method comprising:*

91. Okubo meets the preamble as described above for claim 1.

- b. **[11A]** *accessing input images, the input images including fields of view of a scene captured through a lens of a camera, the input images*

depicting the scene with an input lens distortion centered in the fields of view;

92. Okubo meets this element as described above for [1C].

- c. ***[11B] selecting sub-frames representing portions of the input images, the sub-frames including reduced fields of view of the scene smaller than the fields of view of the input images,***

93. Okubo meets this element as described above for [1D].

- d. ***[11C] the sub-frames including different lens distortion effects as a function of the input lens distortion present in the input images, different positions of areas of the input images included within the reduced fields of view, and a size of the areas of the input images included within the reduced fields of view; and***

94. Okubo meets this element as described above for [1E].

- e. ***[11D] generating output images based on a desired lens distortion and the different lens distortion effects in the sub-frames, the desired lens distortion and the input lens distortion exhibiting consistent lens characteristics,***

95. Okubo meets this element as described above for [1F].

- f. **[11E] *wherein the output images include the sub-frames remapped from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the reduced fields of view to transform the different lens distortion effects present in the sub-frames to the desired lens distortion such that portions of the scene depicted in the sub-frames appear to have been captured using the reduced fields of view.***

96. Okubo meets this element as described above for [1G].

13. Claim 12

- a. **[Preamble] *The method of claim 11,***

97. Okubo meets the preamble as described above for claim 11.

- b. **[12A] *wherein image stabilization is applied to the input images.***

98. Okubo meets this element as described above for [2A].

14. Claim 13

- a. **[Preamble] *The method of claim 11,***

99. Okubo meets the preamble as described above for claim 11.

- b. **[13A] *wherein the sub-frames are selected based on metadata associated with the input images.***

100. Okubo meets this element as described above for [3A].

15. Claim 14

- a. **[Preamble] *The method of claim 13,***

101. Okubo meets the preamble as described above for claim 13.

- b. **[14A] *wherein the metadata indicates motion of the camera that captured the input images.***

102. Okubo meets this element as described above for [4A].

16. Claim 15

- a. **[Preamble] *The method of claim 13,***

103. Okubo meets the preamble as described above for claim 13.

- b. **[15A] *wherein the metadata indicates orientation of the camera that captured the input images.***

104. Okubo meets this element as described above for [5A].

17. Claim 16

- a. **[Preamble] *The method of claim 11,***

105. Okubo meets the preamble as described above for claim 11.

- b. **[16A] *wherein the output images are combined as video frames of an output video.***

106. Okubo meets this element as described above for [6A].

18. Claim 17

- a. **[Preamble] *The method of claim 16,***

107. Okubo meets the preamble as described above for claim 16.

- b. ***[17A] wherein remapping of the sub-frames from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the reduced fields of view results in the output video having consistent frame-to-frame lens characteristics.***

108. Okubo meets this element as described above for [7A].

19. Claim 18

- a. ***[Preamble] The method of claim 17,***

109. Okubo meets the preamble as described above for claim 17.

- b. ***[18A] wherein the different positions of the areas of the input images included within the reduced fields of view simulate virtual re-pointing of the camera using the reduced fields of view.***

110. Okubo meets this element as described above for [8A].

20. Claim 19

- a. ***[Preamble] The method of claim 18,***

111. Okubo meets the preamble as described above for claim 18.

- b. ***[19A] wherein the method is performed by one or more processors included in the camera.***

112. Okubo meets this element as described above for [9A].

21. Claim 20

- a. ***[Preamble] The method of claim 19,***

113. Okubo meets the preamble as described above for claim 19.

- b. [20A] *wherein the lens includes a wide angle lens, and*

114. Okubo meets this element as described above for [10A].

- c. [20B] *lens characteristics of the wide angle lens causes straight lines in the scene to appear as curved lines near edges of the input images.*

115. Okubo meets this element as described above for [10B].

B. Ground 2: Claims 1-20 Are Obvious Based On Okubo In View Of Sokeila

116. For the reasons set forth herein, it is my view that claims 1-20 of the '052 patent are rendered obvious by Okubo in view of Sokeila.

1. Summary of Sokeila

117. Sokeila is a U.S. Patent Application that was filed on April 16, 2013, and issued on March 31, 2015. Sokeila is thus prior art to the '052 patent under at least 35 U.S.C. §§ 102(a)(1) and (a)(2). Sokeila was not cited or considered during prosecution of the '052 patent.

118. Sokeila relates to cropping images in a digital video stabilization system using an adaptively predicted cropping factor. (EX1005, 1:22-46.) As Sokeila explains, it is desirable to minimize the extent to which a frame's field of view is reduced by cropping. (EX1005, 1:22-46.) Sokeila discloses adaptively predicting a cropping factor, such as on a frame-by-frame-frame basis, by taking video data into consideration, thus reducing the extent to which frames are cropped

unnecessarily. (EX1005, 1:22-46, 2:33-61.) For example, Sokeila discloses adjusting the cropping factor based on motion or a detected object of interest in an image, such as a face, and cropping non-centrally or non-symmetrically with respect to the image. (EX1005, 2:62-3:3, 3:30-41.)

119. In an embodiment, Sokeila discloses that a camera includes an adaptive stabilization module 12, which can “predict, calculate, or estimate” cropping factors to be applied to video image frames that are stored in a ring buffer from the camera. (EX1005, 4:25-29, 6:25-42, FIGS. 1, 3.) FIG. 3 illustrates:

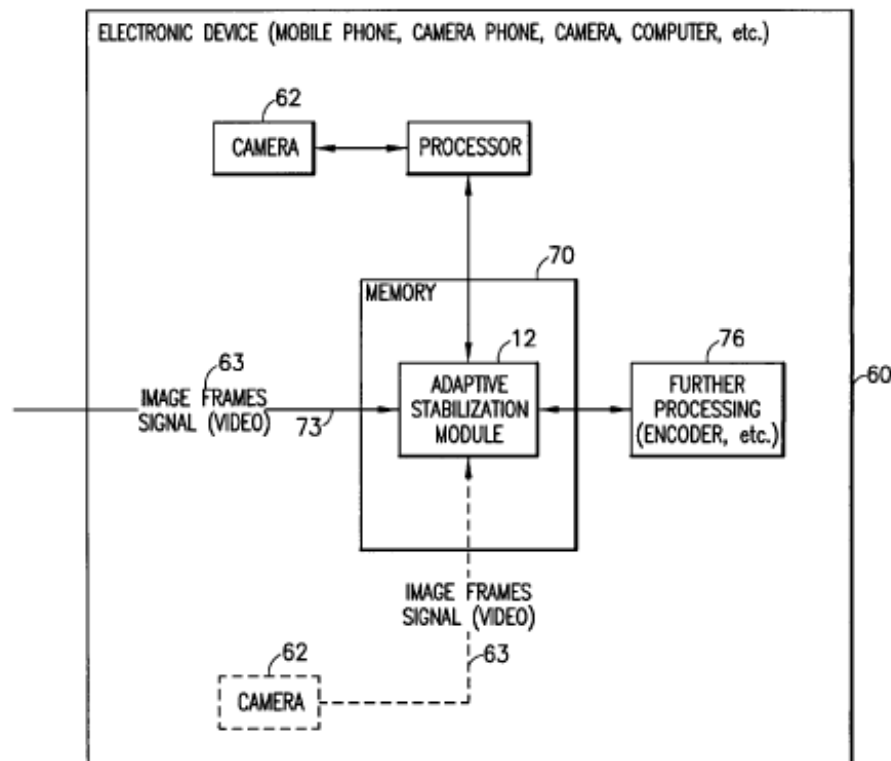


FIG.3

(EX1005, FIG. 3.)

2. Motivation to Combine Okubo and Sokeila with Reasonable Expectation of Success

120. A POSITA as of the 2015 priority date would have been motivated to combine Okubo and Sokeila to meet the claim limitations with a reasonable expectation of success.

121. First, Okubo and Sokeila both relate to a common problem of stabilizing video frames. (EX1004, [0005]; EX1005, 2:29-040.) Sokeila explains that when stabilizing an image, it is preferable to optimize the field of view by avoiding cropping the frame more than is necessary: doing so can optimize video quality, enhance sharpness, and take up less memory storage space. (EX1005, 1:22-36, 3:42-47, 5:25-36.) Sokeila discloses achieving these benefits by “smoothly and intelligently” selecting adaptive cropping factors on a frame-by-frame basis; Sokeila’s techniques are thus advantageous over Okubo, which has fixed cropping factors that are based on metadata, such as described above in Section A.2.e. (EX1004, [0087]-[0091], FIG. 6B; EX1005, 2:41-61.) The POSITA would have been motivated to combine Sokeila with Okubo to realize the above specific technical advantages.

122. Second, Okubo discloses cropping sub-frames from an input CCD image, such as described above in Section A.2.e, but does not expressly teach how

the sub-frames can be cropped, sized, or positioned based on the content of the image. The POSITA would thus have been motivated to look to Sokeila to understand how the sub-frames of Okubo could be beneficially sized and positioned with respect to the CCD image.

123. Third, Okubo and Sokeila use analogous electronic and optical components, such as cameras, processors, and data storage, in common and well-understood ways to implement solutions to the common problem of video stabilization. The POSITA's combination of Okubo and Sokeila thus would have yielded predictable results with a reasonable expectation of success.

3. Claim 1

- a. [Preamble] *A system that simulates image distortion of a virtual lens in a video, the system comprising:***

124. Okubo in view of Sokeila meets the preamble for the reasons described in Section A.2.a.

- b. [1A] *one or more processors; and***

125. Okubo in view of Sokeila meets this element for the reasons described in Section A.2.b. Further, Sokeila discloses that the adaptive stabilization module can be implemented as a computer program executed by a processor. (EX1005, 6:60-7:4.)

- c. ***[1B] a non-transitory computer-readable storage medium storing instructions that when executed cause the one or more processors to perform steps including:***

126. Okubo in view of Sokeila meets this element for the reasons described in Section A.2.c. Further, Sokeila discloses that the adaptive stabilization module can be implemented as a computer program stored in non-transitory computer readable memory 70. (EX1005, 6:60-7:4.)

- d. ***[1C] accessing input images, the input images including fields of view of a scene captured through a lens of a camera, the input images depicting the scene with an input lens distortion centered in the fields of view;***

127. Okubo in view of Sokeila meets this element for the reasons described in Section A.2.d. Further, Sokeila discloses using a digital camera to receive (or capture) and access a plurality of image frames of a scene. (EX1005, 2:62-65, 5:51-61.)

- e. ***[1D] selecting sub-frames representing portions of the input images, the sub-frames including reduced fields of view of the scene smaller than the fields of view of the input images,***

128. Okubo in view of Sokeila meets this element for the reasons described in Section A.2.e. Further, Sokeila discloses selecting sub-frames by cropping an input image using an adaptively determined cropping factor. (EX1005, 1:40-46.)

For example, Sokeila discloses that a device such as a camera can perform a process described in FIG. 2:

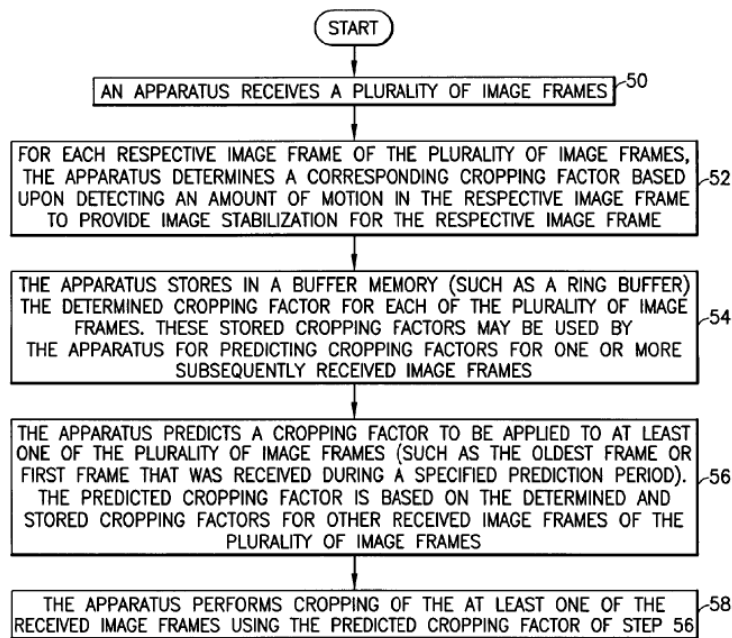


FIG.2

(EX1005, 5:37-50, FIG. 2.)

129. For example, at step 50 of the above process, the camera receives or captures a plurality of image frames from a camera. (EX1005, 5:51-55, FIG. 2.) At step 52, a cropping factor can be determined based on motion detected in the image frame; at step 56, a cropping factor can be predicted based on stored cropping factors; and at step 58, at least one received image frame is cropped using the predicted cropping factor. (EX1005, 5:51-6:9, FIG. 2.) The cropping factors result in a reduced field of view compared to the input image, such as shown by the

positive cropping factors indicated in Table 1 of Sokeila, indicating that the cropped sub-frames are smaller than the input image:

TABLE 1

Cropping Factor Table											
	Frame Number										
	N	N-1	N-2	N-3	N-4	N-5	N-6	N-7	N-8	N-9	N-10
Determined cropping for individual frames (as step 20 in FIG. 1)	1%	1%	1%	3%	1%	6%	6%	8%	2%	1%	1%
Predicted smooth cropping (step 24 in FIG. 1)	1%	2%	3%	4%	5%	6%	7%	8%	6%	4%	2%

(EX1005, 5:2-10, TABLE 1.)

- f. ***[1E] the sub-frames including different lens distortion effects as a function of the input lens distortion present in the input images, different positions of areas of the input images included within the reduced fields of view, and a size of the areas of the input images included within the reduced fields of view; and***

130. Okubo in view of Sokeila meets this element for the reasons described in Section A.2.f. Additionally, Sokeila discloses performing cropping “non-centrally or non-symmetrically with respect to one or more image boundaries,” so as to “avoid cropping an important subject” (such as a face or another object of interest) detected in the frame. (EX1005, 3:30-41.) The POSITA would understand this to disclose selecting sub-frames by cropping based on different

positions of areas of the input images, at least because the "important subject" may occupy different areas within the input images (e.g., as a face or object of interest moves across the frame). In addition to the reasons described above for Section A.2.f, the sub-frames can include different lens distortion effects as a function of different positions or sizes of areas of the input images, for the additional reason that cropping based on differently centered or differently symmetric areas of the input images can result in the sub-frame including different distortion effects, analogous to the reasons described in Section A.2.f with respect to FIGs. 11D and 11E.

- g. [1F] *generating output images based on a desired lens distortion and the different lens distortion effects in the sub-frames, the desired lens distortion and the input lens distortion exhibiting consistent lens characteristics,***

131. Okubo in view of Sokeila meets this element for the reasons described in Section A.2.g.

- h. [1G] *wherein the output images include the sub-frames remapped from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the reduced fields of view to transform the different lens distortion effects present in the sub-frames to the desired lens distortion such that portions of the scene depicted in the sub-frames appear to have been captured using the reduced fields of view.***

132. Okubo in view of Sokeila meets this element for the reasons described in Section A.2.h.

4. Claim 2

a. [Preamble] *The system of claim 1,*

133. Okubo in view of Sokeila meets the preamble as described above for claim 1.

b. [2A] *wherein image stabilization is applied to the input images.*

134. Okubo in view of Sokeila meets this element for the reasons described in Section A.3.b. Further, Sokeila discloses that its adaptive cropping is used for “video stabilization.” (EX1005, 2:41-44.) In Sokeila, an adaptive stabilization module 12 can apply image stabilization to input images from camera 11, such as shown in FIG. 1:

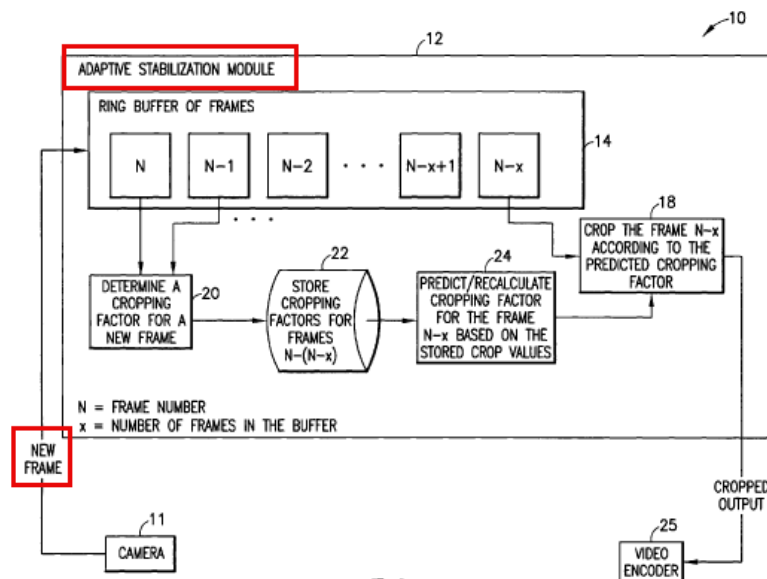


FIG.1

(EX1005, 4:1-8, FIG. 1 (annotated).)

5. Claim 3

a. [Preamble] *The system of claim 1,*

135. Okubo in view of Sokeila meets the preamble as described above for claim 1.

b. [3A] *wherein the sub-frames are selected based on metadata associated with the input images.*

136. Okubo in view of Sokeila meets this element for the reasons described in Section A.4.b. Further, Sokeila discloses selecting sub-frames using an adaptive cropping factor, such as described above for [1D]. Sokeila further discloses that the adaptive cropping factor can be based on metadata for the input image, such as a detected amount of motion in an image; a detection of an object of interest, such

as a face; or information from frame analysis or hardware sensor analysis.

(EX1005, 2:62-3:12, 3:30-41.)

6. Claim 4

a. [Preamble] *The system of claim 3,*

137. Okubo in view of Sokeila meets the preamble as described above for claim 3.

b. [4A] *wherein the metadata indicates motion of the camera that captured the input images.*

138. Okubo in view of Sokeila meets this element for the reasons described in Section A.5.b. Further, Sokeila discloses selecting sub-frames using an adaptive cropping factor, such as described above for [1D]. Sokeila further discloses that the adaptive cropping factor can be based on a detected amount of motion for a video frame. (EX1005, 2:62-3:12.)

7. Claim 5

a. [Preamble] *The system of claim 3,*

139. Okubo in view of Sokeila meets the preamble as described above for claim 3.

b. [5A] *wherein the metadata indicates orientation of the camera that captured the input images.*

140. Okubo in view of Sokeila meets this element for the reasons described in Section A.6.b. Further, Sokeila discloses that the metadata indicates an

orientation of the camera. For example, Sokeila describes that “if a face is detected and the image frame only requires horizontal stabilization, a vertical crop only of the image frame could be implemented.” (EX1005, 3:30-41.) To the extent not expressly disclosed in Sokeila, it would have been obvious to the POSITA that metadata (*e.g.*, face detection data) indicating whether only horizontal stabilization is needed indicates an orientation of the camera (*e.g.*, with respect to the horizontal).

8. Claim 6

a. [Preamble] *The system of claim 1,*

141. Okubo in view of Sokeila meets the preamble as described above for claim 1.

b. [6A] *wherein the output images are combined as video frames of an output video.*

142. Okubo in view of Sokeila meets this element for the reasons described in Section A.7.b. Further, Sokeila discloses that cropped output frames of the adaptive stabilization module 12 are provided to a video encoder 25, such as shown in FIG. 1, which the POSITA would understand to disclose combining the output frames into a video using the video encoder:

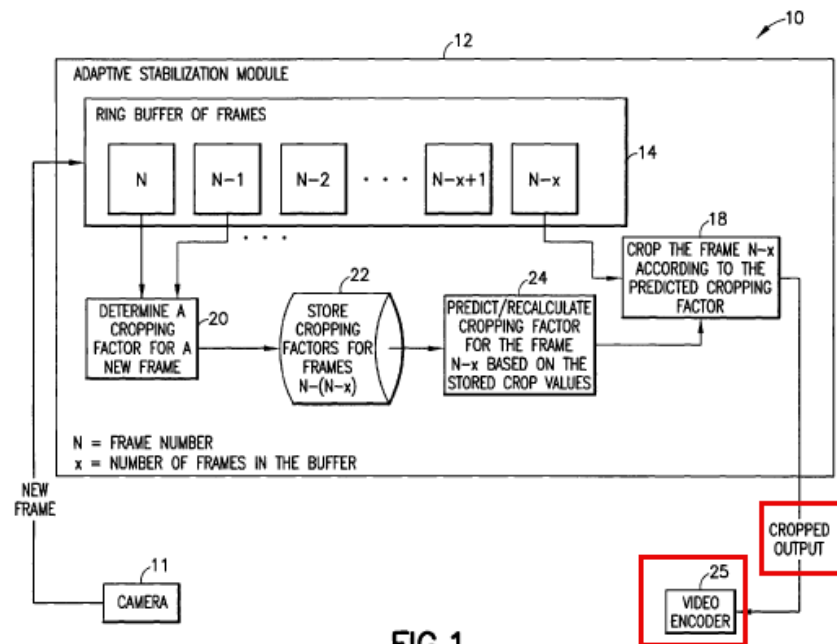


FIG.1

(EX1005, 4:1-7, FIG. 1 (annotated).)

9. Claim 7

a. [Preamble] *The system of claim 6,*

143. Okubo in view of Sokeila meets the preamble as described above for claim 6.

b. [7A] *wherein remapping of the sub-frames from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the reduced fields of view results in the output video having consistent frame-to-frame lens characteristics.*

144. Okubo in view of Sokeila meets this element for the reasons described in Section A.8.b. Further, Sokeila discloses that “an optimal cropping factor or a

minimized cropping factor may be used based on the future prediction to make the cropping factor change smoothly over time,” which the POSITA would understand based on experience with image or video processing to result in consistent frame-to-frame lens characteristics. (EX1005, 2:41-61.)

10. Claim 8

a. [Preamble] *The system of claim 7,*

145. Okubo in view of Sokeila meets the preamble as described above for claim 7.

b. [8A] *wherein the different positions of the areas of the input images included within the reduced fields of view simulate virtual re-pointing of the camera using the reduced fields of view.*

146. Okubo in view of Sokeila meets this element for the reasons described in Section A.9.b. Further, Sokeila discloses detecting an object of interest (*e.g.*, a face) within a video frame, and performing cropping “non-centrally or non-symmetrically with respect to one or more image boundaries,” so as to “avoid cropping an important subject” detected in the frame. (EX1005, 3:30-41.) The POSITA would understand cropping non-centrally or non-symmetrically with respect to the image to meet the claimed virtual re-pointing, at least because cropping an image non-centrally will have the effect of re-centering (re-pointing) the cropped image with respect to the input image.

11. Claim 9

a. [Preamble] *The system of claim 8,*

147. Okubo in view of Sokeila meets the preamble as described above for claim 8.

b. [9A] *wherein the one or more processors and the non-transitory computer-readable storage medium are included in the camera.*

148. Okubo in view of Sokeila meets this element for the reasons described in Section A.10.b. Further, Sokeila discloses that a processor and memory can be included in an electronic device that is a camera, for example as illustrated in FIG.

3:

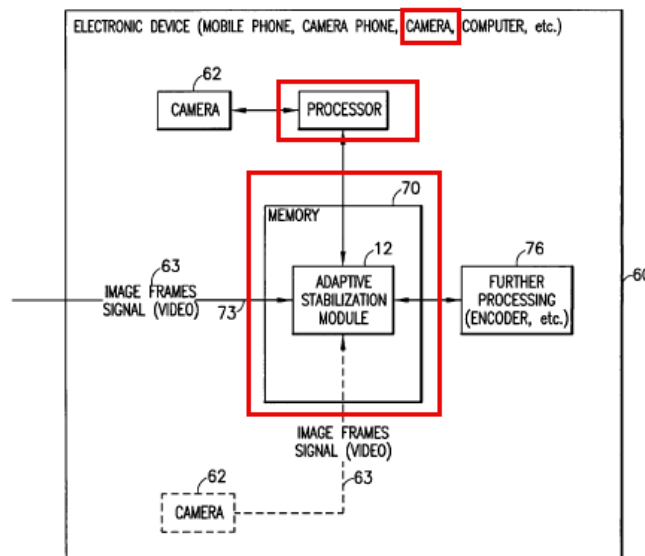


FIG.3

(EX1005, FIG. 3 (annotated).)

12. Claim 10

a. [Preamble] *The system of claim 9,*

149. Okubo in view of Sokeila meets the preamble as described above for claim 9.

b. [10A] *wherein the lens includes a wide angle lens, and*

150. Okubo in view of Sokeila meets this element for the reasons described in Section A.11.b. Further, Sokeila discloses that it is directed to solving a problem (unnecessarily reduced field of view) that is “especially problematic in wide angle applications.” (EX1005, 1:26-30.)

c. [10B] *lens characteristics of the wide angle lens causes straight lines in the scene to appear as curved lines near edges of the input images.*

151. Okubo in view of Sokeila meets this element for the reasons described in Section A.11.c.

13. Claim 11

a. [Preamble] *A method for simulating image distortion of a virtual lens in a video, the method comprising:*

152. Okubo in view of Sokeila meets the preamble as described above for claim 1.

b. [11A] *accessing input images, the input images including fields of view of a scene captured through a lens of a camera, the input images depicting the scene with an input lens distortion centered in the fields of view;*

153. Okubo in view of Sokeila meets this element as described above for [1C].

- c. ***[11B] selecting sub-frames representing portions of the input images, the sub-frames including reduced fields of view of the scene smaller than the fields of view of the input images,***

154. Okubo in view of Sokeila meets this element as described above for [1D].

- d. ***[11C] the sub-frames including different lens distortion effects as a function of the input lens distortion present in the input images, different positions of areas of the input images included within the reduced fields of view, and a size of the areas of the input images included within the reduced fields of view; and***

155. Okubo in view of Sokeila meets this element as described above for [1E].

- e. ***[11D] generating output images based on a desired lens distortion and the different lens distortion effects in the sub-frames, the desired lens distortion and the input lens distortion exhibiting consistent lens characteristics,***

156. Okubo in view of Sokeila meets this element as described above for [1F].

- f. ***[11E] wherein the output images include the sub-frames remapped from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the***

reduced fields of view to transform the different lens distortion effects present in the sub-frames to the desired lens distortion such that portions of the scene depicted in the sub-frames appear to have been captured using the reduced fields of view.

157. Okubo in view of Sokeila meets this element as described above for [1G].

14. Claim 12

a. [Preamble] *The method of claim 11,*

158. Okubo in view of Sokeila meets the preamble as described above for claim 11.

b. [12A] *wherein image stabilization is applied to the input images.*

159. Okubo in view of Sokeila meets this element as described above for [2A].

15. Claim 13

a. [Preamble] *The method of claim 11,*

160. Okubo in view of Sokeila meets the preamble as described above for claim 11.

b. [13A] *wherein the sub-frames are selected based on metadata associated with the input images.*

161. Okubo in view of Sokeila meets this element as described above for [3A].

16. Claim 14

a. [Preamble] *The method of claim 13,*

162. Okubo in view of Sokeila meets the preamble as described above for claim 13.

b. [14A] *wherein the metadata indicates motion of the camera that captured the input images.*

163. Okubo in view of Sokeila meets this element as described above for [4A].

17. Claim 15

a. [Preamble] *The method of claim 13,*

164. Okubo in view of Sokeila meets the preamble as described above for claim 13.

b. [15A] *wherein the metadata indicates orientation of the camera that captured the input images.*

165. Okubo in view of Sokeila meets this element as described above for [5A].

18. Claim 16

a. [Preamble] *The method of claim 11,*

166. Okubo in view of Sokeila meets the preamble as described above for claim 11.

- b. **[16A] *wherein the output images are combined as video frames of an output video.***

167. Okubo in view of Sokeila meets this element as described above for [6A].

19. Claim 17

- a. **[Preamble] *The method of claim 16,***

168. Okubo in view of Sokeila meets the preamble as described above for claim 16.

- b. **[17A] *wherein remapping of the sub-frames from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the reduced fields of view results in the output video having consistent frame-to-frame lens characteristics.***

169. Okubo in view of Sokeila meets this element as described above for [7A].

20. Claim 18

- a. **[Preamble] *The method of claim 17,***

170. Okubo in view of Sokeila meets the preamble as described above for claim 17.

- b. **[18A] *wherein the different positions of the areas of the input images included within the reduced fields of view simulate virtual re-pointing of the camera using the reduced fields of view.***

171. Okubo in view of Sokeila meets this element as described above for [8A].

21. Claim 19

- a. **[Preamble] *The method of claim 18,***

172. Okubo in view of Sokeila meets the preamble as described above for claim 18.

- b. **[19A] *wherein the method is performed by one or more processors included in the camera.***

173. Okubo in view of Sokeila meets this element as described above for [9A].

22. Claim 20

- a. **[Preamble] *The method of claim 19,***

174. Okubo in view of Sokeila meets the preamble as described above for claim 19.

- b. **[20A] *wherein the lens includes a wide angle lens, and***

175. Okubo in view of Sokeila meets this element as described above for [10A].

- c. **[20B] *lens characteristics of the wide angle lens causes straight lines in the scene to appear as curved lines near edges of the input images.***

176. Okubo in view of Sokeila meets this element as described above for [10B].

C. Ground 3: Claims 1-20 Are Obvious Based On Eder

177. For the reasons set forth herein, it is my view that claims 1-20 of the '052 patent are rendered obvious by Eder.

1. Summary of Eder

178. Eder is a U.S. Patent Application that was filed on April 19, 2011, published on October 20, 2011, and issued on January 19, 2016. (EX1009.) Eder is thus prior art to the '052 patent under at least 35 U.S.C. §§ 102(a)(1) and (a)(2). Eder was not cited or considered during prosecution of the '052 patent.

179. Eder discloses a rear view image improvement system for a vehicle. (EX1009, 1:51-56.) An image corresponding to an exterior rear-facing side mirror of the vehicle is captured by a camera with a wide-angle lens, modified, and then presented to the driver using a display device. (EX1009, 1:15-18, 1:36-50, 4:3-7, Fig. 5.) In embodiments, the exterior mirror may be included or replaced with a camera system that provides the same field of view. (EX1009, 2:42-49.) Figs. 4

and 5 show examples of a vehicle 8 with camera 6 and display device 20 for driver 9:

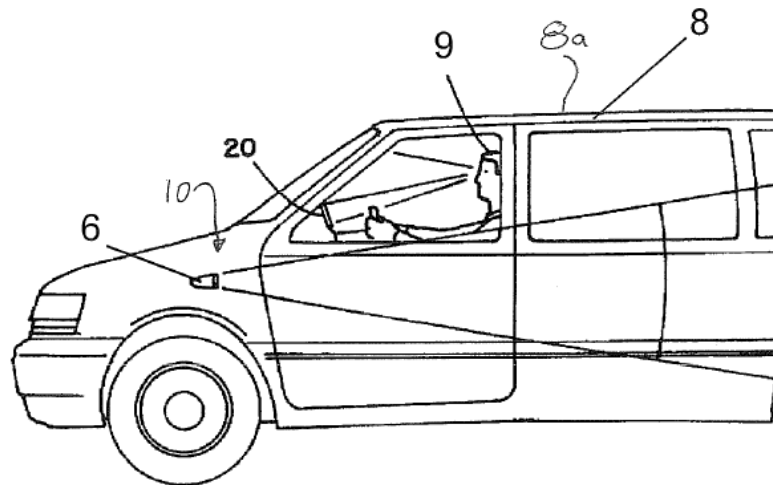


Fig. 4

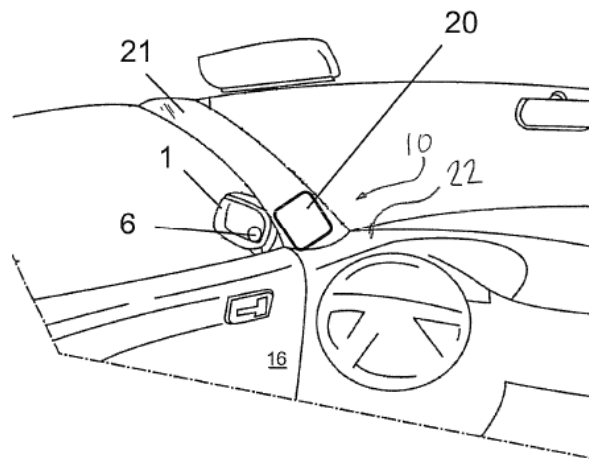


Fig. 5

(EX1009, 2:60-3:33, Figs. 4, 5.)

180. The captured images are modified to simulate the lens distortion that the driver would expect to see in the mirror. (EX1009, 1:36-62, 4:3-7.) Fig. 6 illustrates an example process, in which an image is recorded (60), rectified (63), distorted (65), and displayed to the driver (20):

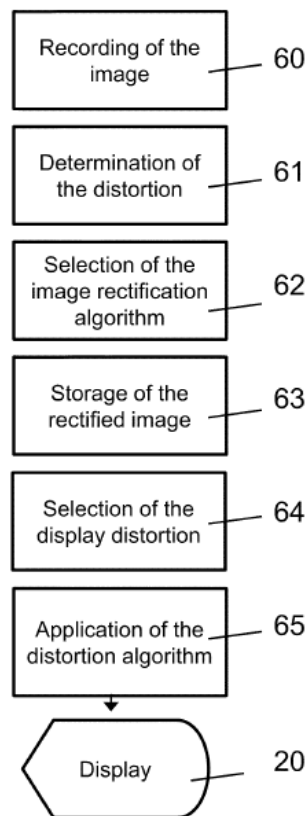


Fig. 6

(EX1009, 4:3-5:67, Fig. 6.)

2. Claim 1

- a. **[Preamble] *A system that simulates image distortion of a virtual lens in a video, the system comprising:***

181. Eder meets the preamble. For example, Eder discloses an “exterior mirror simulation” with image data recording and a device for displaying the data for the driver of a vehicle. (EX1009, 1:9-11.) The images are transmitted by video data to the display device. (EX1009, 3:67-4:2.) In Eder, the image of a wide-angle camera is distorted, and post-distortion is applied to the image, “in order to give this image the same view as that of the desired mirror glass.” (EX1009, 4:3-7.)

b. [1A] *one or more processors; and*

182. Eder meets this element. For example, Eder discloses that the vehicle includes a “computation unit” with “processing capacities.” The computation unit can include, *e.g.*, a DSP, an FPGA, a microprocessor, an ASIC, or a combination thereof. (EX1009, 3:48-58.)

c. [1B] *a non-transitory computer-readable storage medium storing instructions that when executed cause the one or more processors to perform steps including:*

183. Eder meets this element. For example, Eder discloses that the computation unit is programmable; for instance, a computer-readable medium can include read only memory (ROM) or binary image data that can be programmed by a user. (EX1009, 3:48-58.)

d. [1C] *accessing input images, the input images including fields of view of a scene captured through a lens of a camera, the input images*

***depicting the scene with an input lens distortion
centered in the fields of view;***

184. Eder meets this element. For example, Eder discloses that “real-time wide-angle video images” are captured and converted to electrical signals by a camera 6, illustrated in Fig. 3:

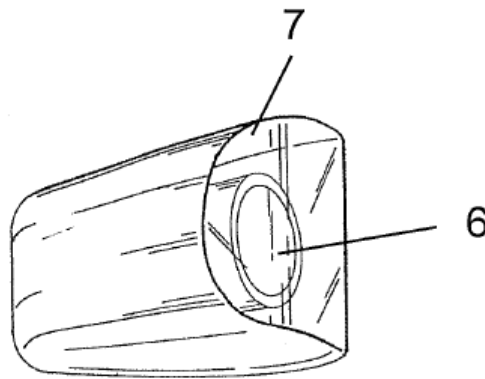


Fig. 3

(EX1009, 3:14-20, Fig. 3.)

185. The camera 6 captures input images including a field of view of a scene (*e.g.*, a scene facing rearwards from the vehicle 8). (EX1009, 3:34-37, 4:3-7.) The camera 6 includes a “wide angle lens” that imparts a perspective effect and a visual distortion (*e.g.*, barrel distortion). (EX1009, 4:14-31, 6:16.) The POSITA would understand based on experience with image and video processing that this input lens distortion may be centered in the field of view, at least because such distortion is illustrated in Fig. 8 as centered in the field of view:

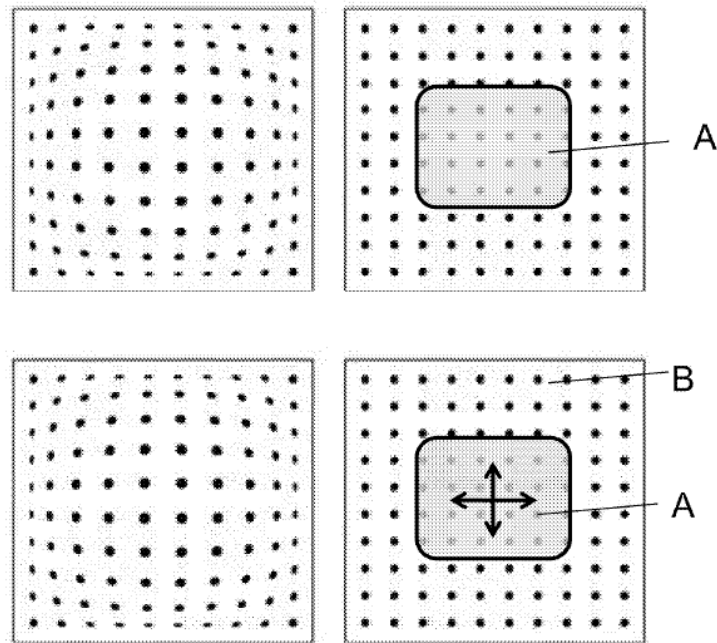


Fig. 8

(EX1009, 2:10, 4:64-5:34, Fig. 8.)

- e. **[1D] selecting sub-frames representing portions of the input images, the sub-frames including reduced fields of view of the scene smaller than the fields of view of the input images,**

186. Eder meets this element. For example, Eder claims methods that include applying an image rectification algorithm to a “subset of the total pixels in the image to create a rectified image.” (EX1009, 6:19-20, 8:3-4, *see also* 6:39-41, 8:21-23.) As the POSITA would recognize based on experience with image and video processing, a subset of the total pixels of an input image represents a portion of that input image, at least because, as a general matter, a subset of a group of

pixels represents a portion of that group of pixels. For instance, as annotated below with respect to Fig. 8, area A represents a subset, and thus a portion, of the total pixels B of the input image:

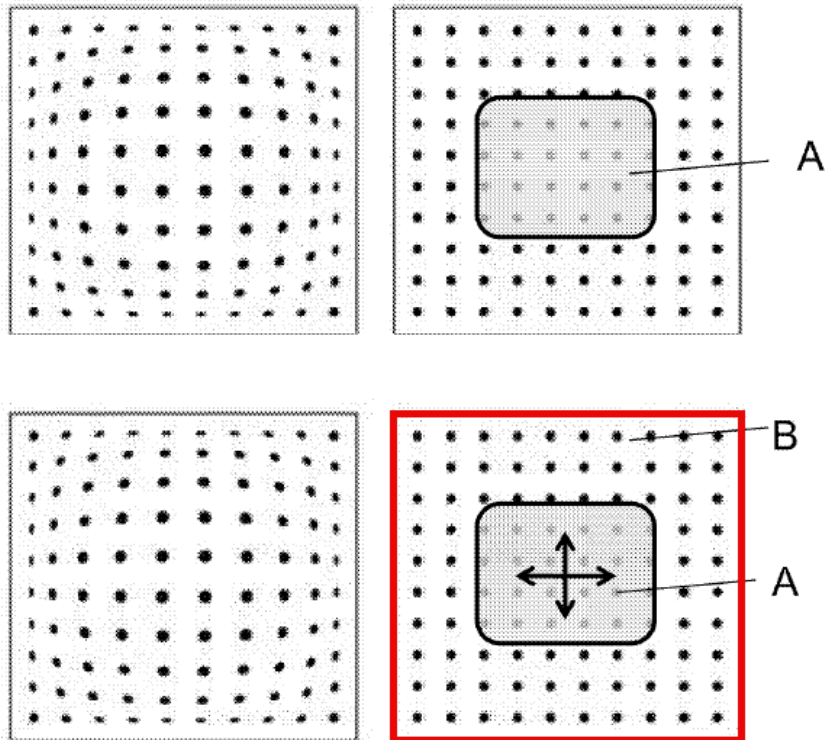


Fig. 8

(EX1009, 2:10, 5:4-16, Fig. 8 (annotated).)

187. Similarly, the POSITA would recognize based on experience with image and video processing that the subset of the total pixels of an input image includes a reduced field of view of the scene depicted in that image, smaller than the fields of view of the input image. For instance, Eder discloses that the camera

captures “real-time wide-angle video images” that include a field of view of a scene, as described above for [1C]. (EX1009, 3:14-20, 3:34-37, 4:3-7.) The POSITA would recognize based on experience with image and video processing that a subset of the total pixels that represent such wide-angle video images will include a smaller field of view of the scene than the field of view depicted by the total pixels, for at least the reasons described above with respect to Fig. 8. This is true even if the input image is viewed to also include a larger field of view (*e.g.*, via wide angle additional lens 5, described below), at least because the claim requires only that the subset “includes” the reduced field of view and is not limited to providing only the reduced field of view.

188. Additionally, Eder discloses selecting sub-frames representing portions of the input images at least by “adapting the field of view to the driver’s position.” (EX1009, 5:26-5:34, Fig. 8.) For example, Eder discloses (with respect to Fig. 8, above) that a “mirror adjustment” can be performed by “moving section A on the optical sensor, so that other pixels of the optical sensors are visualized.” (EX1009, 5:26-5:34, Fig. 8.)

- f. ***[1E] the sub-frames including different lens distortion effects as a function of the input lens distortion present in the input images, different positions of areas of the input images included within the reduced fields of view, and a size of the areas of the input images included within the reduced fields of view; and***

189. Eder meets this element. For example, Eder discloses applying optical distortion correction to the sub-frames of the input images as part of an image rectification process. (EX1009, 4:3-25, 6:19-20, 8:3-4.) For instance, claims 1 and 12 of Eder recite “applying the image rectification algorithm to subset of the total pixels in the image to create a rectified image”. (EX1009, 6:19-20, 8:3-4.)

190. The sub-frames include different lens distortion effects as a function of the input lens distortion present in the input images. For example, Eder explains that the optical distortion correction of the image rectification process “facilitates the removal of a perspective effect and a visual distortion, which is caused by a wide angle lens used in the camera 6.” (EX1009, 4:15-18.) The optical distortion correction uses a mathematical model of the distortion to determine the correct position of the pixels, which are recorded in the input images. (EX1009, 4:18-25.) For example, distortion co-efficient values k_1 and k_2 can be used to eliminate various distortion effects (*e.g.*, barrel distortion) created by the use of a wide angle

lens. (EX1009, 4:26-31.) Different distortion effects in the sub-frame can also be provided by the inclusion of additional mirror 5, which may be a convex lens, such as described below. (EX1009, 2:23-31.)

191. The lens distortion effects are also a function of different positions of areas of the input images included within the reduced fields of view. For example, Eder explains that lines on one side of an input image (*i.e.*, a first position of area of the input image) may be barrel distorted, and lines on the other side of the image (*i.e.*, a second position of area of the input image) may be pin-cushion distorted. (EX1009, 4:40-50.) Thus, as the POSITA would recognize, different lens distortion effects (*e.g.*, barrel distortion or pin-cushion distortion) are present in the images as a function of the sub-frame's position within the input image (*e.g.*, on "one side" of the image or on the "other side" of the image).

192. Similarly, the lens distortion effects are also a function of a size of the areas of the input images included within the reduced fields of view. This is at least because, as the POSITA would recognize, the size of the input images included within the sub-frames' reduced fields of view determines the degree to which such lens distortion effects in the input image (*e.g.*, barrel distortion or pin-cushion distortion) are included within the sub-frames. For instance, as described above, such lens distortion effects may be present on the sides of the image, such

that they are included in larger sub-frames that approach the sides of the image.

(EX1009, 4:40-50.)

- g. ***[1F] generating output images based on a desired lens distortion and the different lens distortion effects in the sub-frames, the desired lens distortion and the input lens distortion exhibiting consistent lens characteristics,***

193. Eder meets this element. For example, Eder discloses that continuous input images are modified and are output to the display device as video data.

(EX1009, 3:34-41.) Fig. 6 illustrates an example process:

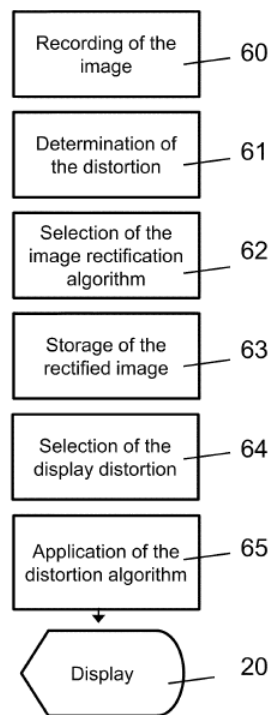


Fig. 6

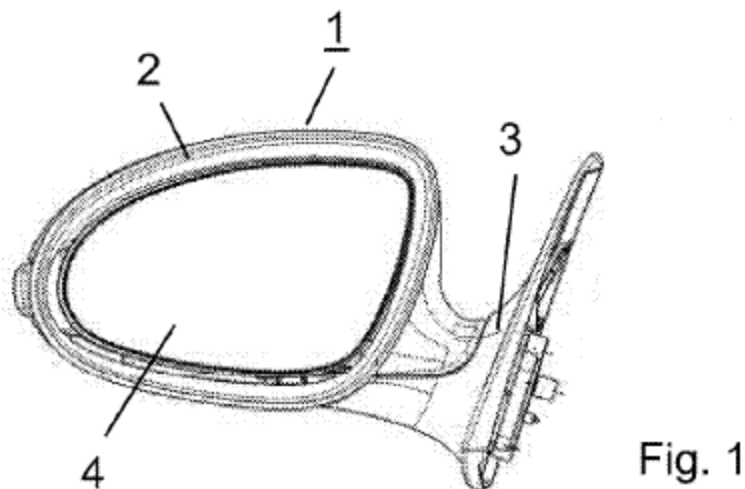
(EX1009, 4:3-50, Fig. 6.)

194. As Eder discloses, the input images are modified by an image rectification process (62, 63), such as described above. (EX1009, 4:3-50, Fig. 6.) The image rectification process results in “low-error image[s].” (EX1009, 4:51-52.) The low-error images, from which the output images are generated (*e.g.*, stages 63-65) are based on the different lens distortion effects in the sub-frames as described above for [1E]. For example, the image rectification process modifies the input images based on characteristics of the lens distortion effects, such as by using distortion co-efficient values k_1 and k_2 for real-time image correction. (EX1009, 4:26-50.)

195. At stages 64 and 65, post-distortion is applied to the low-error images, “in order to give this image the same view as that of the desired mirror glass.” (EX1009, 4:3-7, 4:64-5:16.) Applying the post-distortion process meets the claimed desired lens distortion at least by imparting the distortion of the desired mirror glass, in order to give the images the same view as the desired mirror glass. (EX1009, 4:3-7.)¹

¹ The POSITA would understand Eder’s mirror glass distortion to meet the claimed lens distortion, at least because mirrors and lenses are analogous optical structures with analogous geometry that can exhibit analogous distortion properties, and

196. Eder discloses that in some embodiments, the vehicle can include an exterior mirror configured for mirror glass 4; however, in some embodiments, the exterior mirror can be replaced with a camera system that provides the same field of view. (EX1009, 2:14-17, 2:42-49.) Fig. 1 illustrates an example exterior mirror:

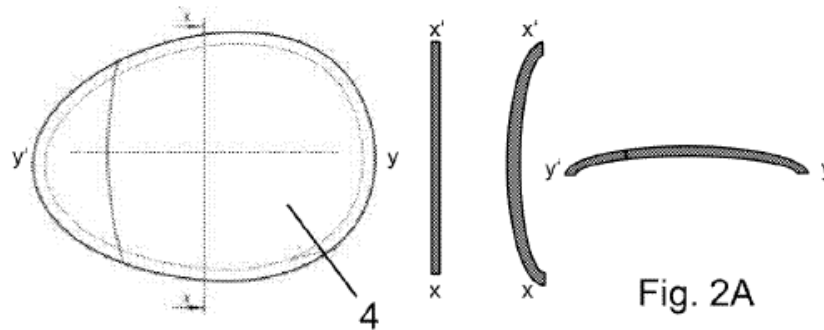


(EX1009, 2:14-17, Fig. 1.)

based further on the POSITA's experience with image and video processing.

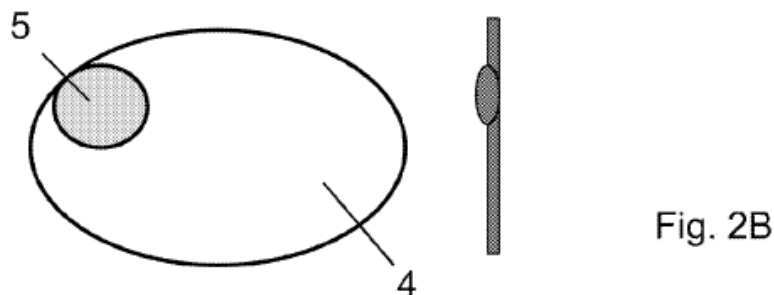
(EX1010, 42.) For example, Eder discloses that additional mirror 5 can be provided "in the form of a convex additional lens." (EX1009, 2:23-26.) The claimed desired lens distortion is thus met at least by the distortion properties of the additional mirror 5.

197. Eder discloses that a desired mirror glass 4 can include flat plane glass, or a mirror glass with a curvature radius, such as shown in Fig. 2A:



(EX1009, 2:32-37, Fig. 2A.)

198. Mirror glass 4 can also include convex mirror glass; and/or glass with an aspherical component. (EX1009, 2:35-37.) Further, mirror glass 4 can also include an additional lens 5, also referred to as a spot mirror or a blind spot mirror, which may be a convex additional lens used on the front or rear side of the mirror glass 4, as shown in Fig. 2B:



(EX1009, 2:18-31, Fig. 2B.)

199. As Eder explains, the post-distortion stages 64, 65 generate the output images based on a desired mirror glass such as shown above. For example, at stage 64, an algorithm can be selected in order to distort the low-error image “as would be shown in mirror glass with an aspheric curve,” *e.g.*, by moving pixel values to “obtain the impression of curved mirror glass.” (EX1009, 4:64-5:3.) The post-distortion can be carried out at stage 65, such as by applying a transformation to the image pixels to distort the pixels appropriately and optimally display the resulting image. (EX1009, 5:4-21.)

200. The desired lens distortion (*e.g.*, distortion of the desired mirror glass) and the input lens distortion (*e.g.*, barrel distortion or pin-cushion distortion of a wide angle lens) exhibit consistent lens characteristics at least in that the camera system can provide the same field of view as the exterior mirror. (EX1009, 2:42-49.) To the extent the claim requires that the desired lens distortion and the input lens distortion exhibit distortion characteristics of the lens of the camera, this is met at least because Eder discloses that the desired lens distortion may be that of a wide angle additional lens 5, thus exhibiting distortion characteristics of the wide angle lens of the camera 6. (EX1009, 2:23-31.)

- h. ***[1G] wherein the output images include the sub-frames remapped from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the***

reduced fields of view to transform the different lens distortion effects present in the sub-frames to the desired lens distortion such that portions of the scene depicted in the sub-frames appear to have been captured using the reduced fields of view.

201. Eder meets this element. As described in Eder, the sub-frames are remapped from the input lens distortion to the desired lens distortion. For example, as described above for [1F], Eder discloses applying a rectification process 62, 63 to sub-frames of input images, to produce a low-error image based on different lens distortion effects in those sub-frames. (EX1009, 4:3-7, 4:64-5:16.) As Eder explains, this is performed by applying a mathematical model of the input lens distortion that corrects, or remaps, the pixel position of the continuous images, such as described above. (EX1009, 4:14-25.)

202. In stage 65 of the example process shown in Fig. 6, a post-distortion process is then applied to the low-error image in order to give the image “the same view as that of the desired mirror glass.” (EX1009, 4:3-7.) For example, an algorithm is applied by which “the pixel values must be moved in a certain area in order to obtain the impression of curved mirror glass.” (EX1009, 4:64-5:3.) The sub-frames are thus remapped from the input lens distortion to the desired lens distortion at least by the rectification process (62, 63) followed by the post-distortion process (65). This is analogous to the “two-step transformation”

described in the '052 patent, in which a first step is performed to “remove the lens distortion present in the sub-frame,” and a second step is then performed to “re-introduce a lens distortion effect.” (EX1001, 12:25-42.)

203. By giving the low-error image the same view as the desired mirror glass, and obtaining the impression of the desired mirror glass (*e.g.*, curved mirror glass), Eder transforms the lens distortion effects of the sub-frames to the desired lens distortion, such that portions of the scene in the sub-frames appear to have been captured using the reduced fields of view.

204. As an example of the above, Eder discloses that a larger field of view can be provided when the vehicle is in reverse, and a smaller field of view can be provided when the vehicle is in forward drive. (EX1009, 5:26-49.) Fig. 7, which illustrates an “alternative process” to Fig. 6, illustrates:

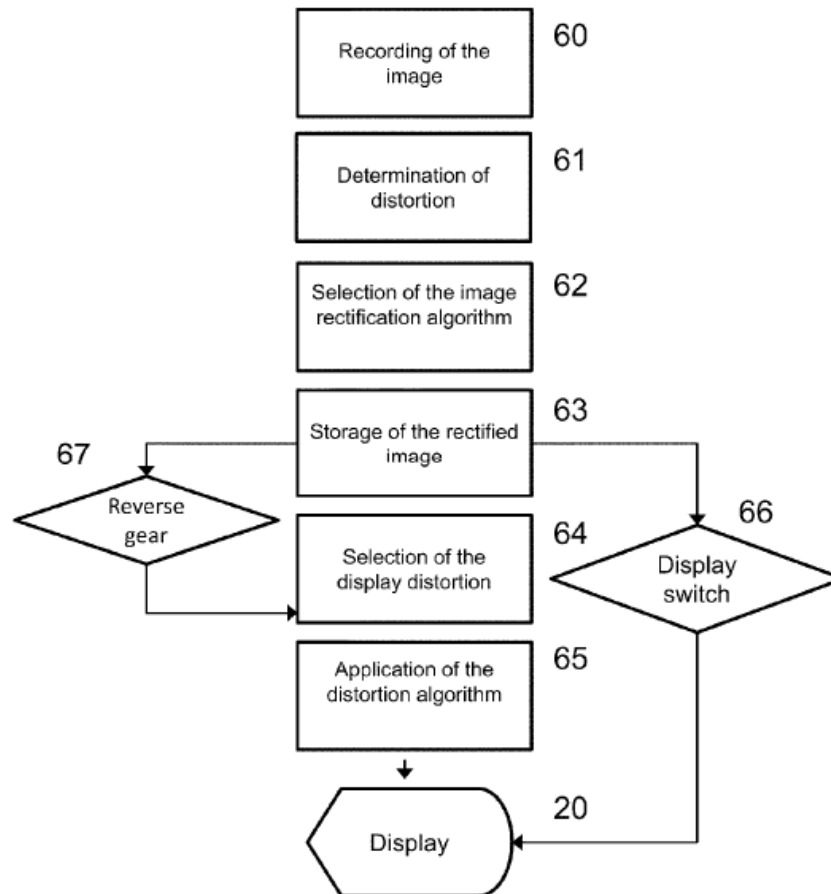


Fig. 7

(EX1009, 2:10, 5:26-49, Fig. 7.)

205. For instance, as illustrated in Fig. 7, a selector switch 67 indicates whether the vehicle is in reverse or in forward drive, and the sub-frames present the larger field of view (“enlarged rear view”) or the smaller field of view (*e.g.*, the “predetermined display mode”) accordingly, such that the portions of the scene depicted in the sub-frames (*e.g.*, the enlarged rear view or predetermined display

mode) appear to have been captured using their respective reduced fields of view.
(EX1009, 2:10, 5:26-49, Fig. 7.)

3. Claim 2

a. [Preamble] *The system of claim 1,*

206. Eder meets the preamble as described above for claim 1.

b. [2A] *wherein image stabilization is applied to the input images.*

207. Eder meets this element. For example, Eder discloses optical distortion correction in which the “correct position of the pixels” is determined, and the “pixel position of the continuous images” is corrected. (EX1009, 4:18-25.) For example, the image rectification process (63), which is applied to input images before generating output images, as described above, can use a part of the vehicle as a reference to determine the correct position of the pixels. (EX1009, 3:37-41.) The POSITA would understand this process to meet the claimed image stabilization at least because correcting the positions of pixels in a series of continuous images can exhibit the effect of stabilizing those images.

208. Furthermore, to the extent not expressly disclosed in Eder, it would have been obvious to the POSITA to utilize Eder’s image rectification process, which corrects the pixel positions as described above, to stabilize the images. This is at least because doing so would apply techniques expressly described in Eder to

improve vehicle safety, by enabling a driver to easily focus on and understand rear mirror images; would advance Eder's goals of improving the images presented on a conventional rear view mirror, and improving the driver's ability to identify dangers. (EX1009, 1:51-62, 2:23-28.)

4. Claim 3

a. [Preamble] *The system of claim 1,*

209. Eder meets the preamble as described above for claim 1.

b. [3A] *wherein the sub-frames are selected based on metadata associated with the input images.*

210. Eder meets this element. For example, Eder discloses the sub-frames are selected based on metadata associated with the input images (*e.g.*, reverse gear, forward gear). (EX1009, 5:39-49.) For instance, selector switch 67 provides metadata indicating whether the vehicle is in forward or reverse gear; and that metadata is used to select a "larger field of view" if the metadata indicates the vehicle is in reverse gear. (EX1009, 5:39-49.) Conversely, a smaller field of view is selected if the metadata indicates the vehicle is in forward gear. (EX1009, 5:39-49.) Fig. 7 illustrates the selector switch 67:

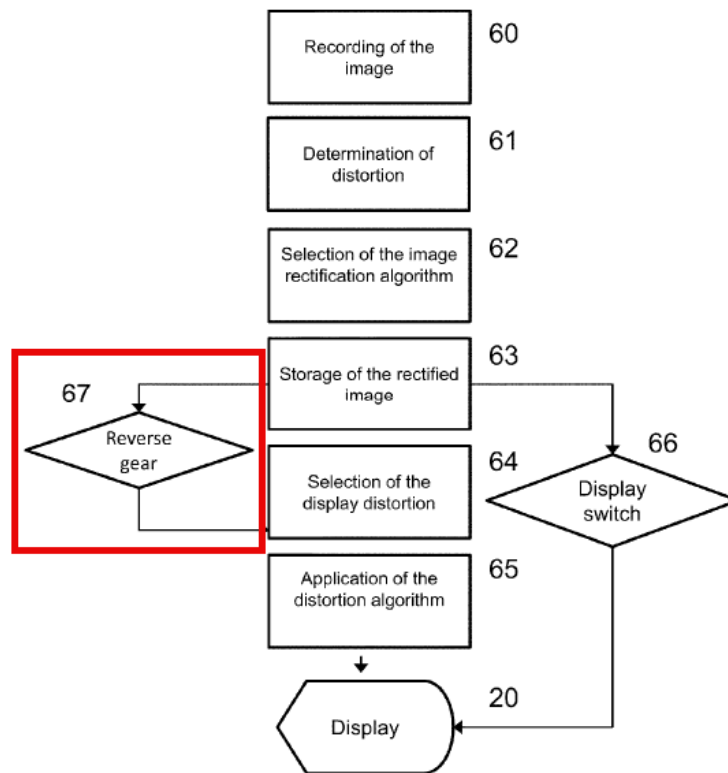


Fig. 7

(EX1009, Fig. 7 (annotated).)

5. Claim 4

a. [Preamble] *The system of claim 3,*

211. Eder meets the preamble as described above for claim 3.

b. [4A] *wherein the metadata indicates motion of the camera that captured the input images.*

212. Eder meets this element as described above for [3A]. For example, the selector switch 67 indicates whether the vehicle (and thus camera 6, *see* EX1009 Figs. 4, 5) is in forward motion or reverse motion. (EX1009, 5:39-49.)

6. Claim 5

a. [Preamble] *The system of claim 3,*

213. Eder meets the preamble as described above for claim 3.

b. [5A] *wherein the metadata indicates orientation of the camera that captured the input images.*

214. Eder meets this element. For example, Eder discloses that distortion co-efficient values k_1 and k_2 , as described above for claim 1, can be adjusted or coordinated based on known straight lines recorded in an image. (EX1009, 4:32-50.) For instance, the distortion center can be registered based on “the straightest horizontal and vertical lines, such that the distortion center from which sub-frames may be selected is situated where the two lines intersect. (EX1009, 4:32-50.) As the POSITA would recognize, based on the POSITA’s experience with image and video processing, lines known to be horizontal and vertical lines in the input images meet metadata indicating the orientation of the camera that captured the images, at least because such lines indicate the orientation of the camera relative to a horizontal or vertical axis. (EX1009, 4:32-50.)

7. Claim 6

a. [Preamble] *The system of claim 1,*

215. Eder meets the preamble as described above for claim 1.

b. [6A] *wherein the output images are combined as video frames of an output video.*

216. Eder meets this element. For example, Eder discloses the output images are combined as video frames of an output video, at least by the rear view assembly 10 “deliver[ing] real-time wide-angle video images to the driver 9”.

(EX1009, 3:10-15.) For instance, Eder’s image rectification module “modifies the continuous images, which are transmitted to the display device 20 as video data.”

(EX1009, 3:37-41.)

8. Claim 7

a. [Preamble] *The system of claim 6,*

217. Eder meets the preamble as described above for claim 6.

b. [7A] *wherein remapping of the sub-frames from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the reduced fields of view results in the output video having consistent frame-to-frame lens characteristics.*

218. Eder meets this element for at least the reasons described above for [6A]. For example, Eder’s rear view assembly 10 “delivers real-time wide-angle video images to the driver 9” such that the images have “the same view as that of the desired mirror glass.” (EX1009, 3:10-15, 4:3-7.) The POSITA would recognize that such video images would exhibit consistent frame-to-frame lens characteristics, at least because they otherwise would not have the same view as the same desired mirror glass.

9. Claim 8

a. [Preamble] *The system of claim 7,*

219. Eder meets the preamble as described above for claim 7.

b. [8A] *wherein the different positions of the areas of the input images included within the reduced fields of view simulate virtual re-pointing of the camera using the reduced fields of view.*

220. Eder meets this element. For example, Eder discloses adapting the field of view to the driver's position, such as by "moving section A on the optical sensor, so that other pixels of the optical sensors are visualized," or by recalculating the image of the optical sensor. (EX1009, 5:26-34.) Fig. 8 illustrates:

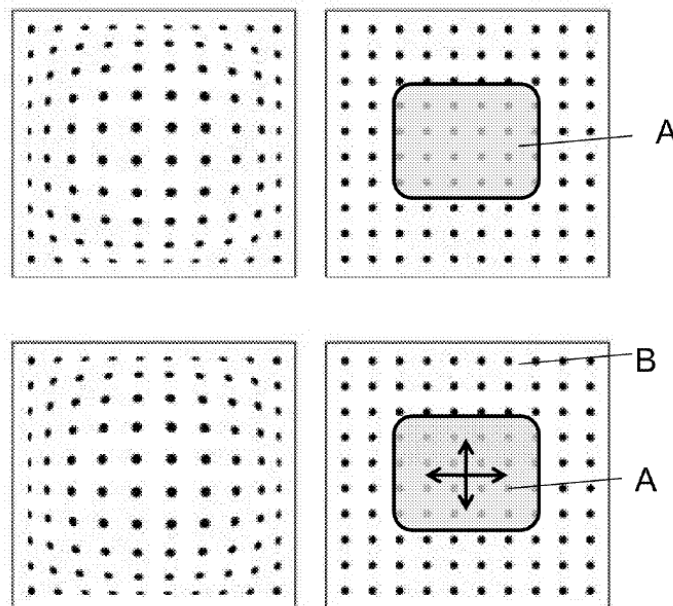


Fig. 8

(EX1009, 2:10, Fig. 8.)

221. As Eder discloses, this “mirror adjustment” is analogous to a conventional mirror, in which an electric drive adapts the mirror to the driver’s perspective, thus re-pointing the field of view for the driver. (EX1009, 5:26-34.)

10. Claim 9

a. [Preamble] *The system of claim 8,*

222. Eder meets the preamble as described above for claim 8.

b. [9A] *wherein the one or more processors and the non-transitory computer-readable storage medium are included in the camera.*

223. Eder meets this element. For example, Eder discloses that the image rectification process can be performed by a computation unit (*e.g.*, a processor, DSP, FPGA, or ASIC) such as described above for [1A], according to programming of a computer-readable medium (*e.g.*, a ROM) such as described above for [1B]. (EX1009, 3:48-62.) Eder further discloses that this image rectification can be “*formed integrally* with the imaging means”—understood, in context, to refer to inclusion of the processor and computer-readable medium components within the camera 6 that performs the imaging. (EX1009, 3:58-62.)

11. Claim 10

a. [Preamble] *The system of claim 9,*

224. Eder meets the preamble as described above for claim 9.

b. [10A] *wherein the lens includes a wide angle lens, and*

225. Eder meets this element as described above for [1C]. For example, Eder discloses the camera 6 includes a “wide angle lens” that imparts a perspective effect and a visual distortion (*e.g.*, barrel distortion). (EX1009, 4:14-31, 6:16.)

c. [10B] *lens characteristics of the wide angle lens causes straight lines in the scene to appear as curved lines near edges of the input images.*

226. Eder meets this element as described above for [1C]. For example, the POSITA would recognize that the perspective effect and visual distortion can cause straight lines in the scene to appear as curved lines near edges of the input images. (EX1009, 4:14-31.) For instance, Eder discloses that “lines on one side of the image” may be affected by barrel distortion or pin-cushion distortion. (EX1009, 4:42-50.) The POSITA would recognize that such distortion would result in the appearance of curved lines, such as shown in Fig. 8 and Fig. 2A:

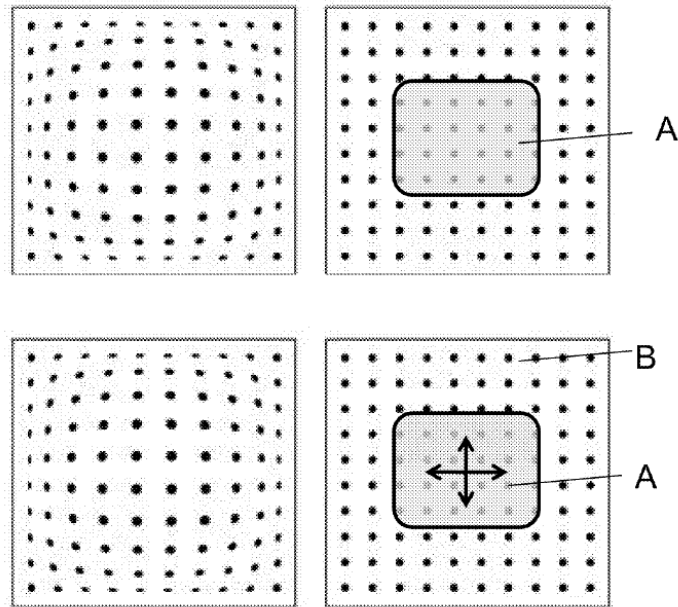


Fig. 8

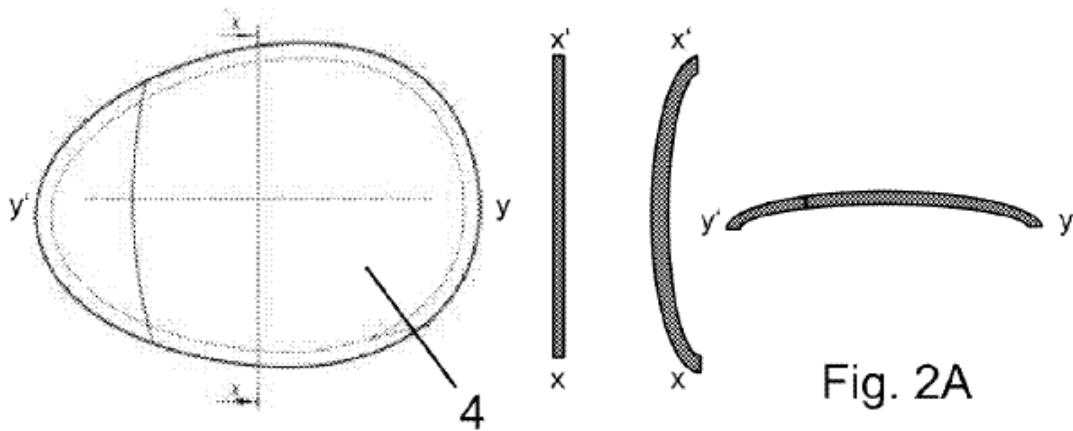


Fig. 2A

(EX1009, 2:10, 2:32-37, Figs. 2A, 8.)

12. Claim 11

- a. [Preamble] *A method for simulating image distortion of a virtual lens in a video, the method comprising:*

227. Eder meets the preamble as described above for claim 1.

- b. ***[11A] accessing input images, the input images including fields of view of a scene captured through a lens of a camera, the input images depicting the scene with an input lens distortion centered in the fields of view;***

228. Eder meets this element as described above for [1C].

- c. ***[11B] selecting sub-frames representing portions of the input images, the sub-frames including reduced fields of view of the scene smaller than the fields of view of the input images,***

229. Eder meets this element as described above for [1D].

- d. ***[11C] the sub-frames including different lens distortion effects as a function of the input lens distortion present in the input images, different positions of areas of the input images included within the reduced fields of view, and a size of the areas of the input images included within the reduced fields of view; and***

230. Eder meets this element as described above for [1E].

- e. ***[11D] generating output images based on a desired lens distortion and the different lens distortion effects in the sub-frames, the desired lens distortion and the input lens distortion exhibiting consistent lens characteristics,***

231. Eder meets this element as described above for [1F].

- f. ***[11E] wherein the output images include the sub-frames remapped from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the***

reduced fields of view to transform the different lens distortion effects present in the sub-frames to the desired lens distortion such that portions of the scene depicted in the sub-frames appear to have been captured using the reduced fields of view.

232. Eder meets this element as described above for [1G].

13. Claim 12

a. [Preamble] *The method of claim 11,*

233. Eder meets the preamble as described above for claim 11.

b. [12A] *wherein image stabilization is applied to the input images.*

234. Eder meets this element as described above for [2A].

14. Claim 13

a. [Preamble] *The method of claim 11,*

235. Eder meets the preamble as described above for claim 11.

b. [13A] *wherein the sub-frames are selected based on metadata associated with the input images.*

236. Eder meets this element as described above for [3A].

15. Claim 14

a. [Preamble] *The method of claim 13,*

237. Eder meets the preamble as described above for claim 13.

- b. **[14A] *wherein the metadata indicates motion of the camera that captured the input images.***

238. Eder meets this element as described above for [4A].

16. Claim 15

- a. **[Preamble] *The method of claim 13,***

239. Eder meets the preamble as described above for claim 13.

- b. **[15A] *wherein the metadata indicates orientation of the camera that captured the input images.***

240. Eder meets this element as described above for [5A].

17. Claim 16

- a. **[Preamble] *The method of claim 11,***

241. Eder meets the preamble as described above for claim 11.

- b. **[16A] *wherein the output images are combined as video frames of an output video.***

242. Eder meets this element as described above for [6A].

18. Claim 17

- a. **[Preamble] *The method of claim 16,***

243. Eder meets the preamble as described above for claim 16.

- b. **[17A] *wherein remapping of the sub-frames from the input lens distortion centered in the fields of view of the input images to the desired lens distortion centered in the reduced fields of view***

results in the output video having consistent frame-to-frame lens characteristics.

244. Eder meets this element as described above for [7A].

19. Claim 18

a. [Preamble] *The method of claim 17,*

245. Eder meets the preamble as described above for claim 17.

b. [18A] *wherein the different positions of the areas of the input images included within the reduced fields of view simulate virtual re-pointing of the camera using the reduced fields of view.*

246. Eder meets this element as described above for [8A].

20. Claim 19

a. [Preamble] *The method of claim 18,*

247. Eder meets the preamble as described above for claim 18.

b. [19A] *wherein the method is performed by one or more processors included in the camera.*

248. Eder meets this element as described above for [9A].

21. Claim 20

a. [Preamble] *The method of claim 19,*

249. Eder meets the preamble as described above for claim 19.

b. [20A] *wherein the lens includes a wide angle lens, and*

250. Eder meets this element as described above for [10A].

- c. **[20B] *lens characteristics of the wide angle lens causes straight lines in the scene to appear as curved lines near edges of the input images.***

251. Eder meets this element as described above for [10B].

* * *

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code.

Dated:

10/2/24


Dr. Aggelos Katsaggelos