

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.

Petitioner

v.

IMMERVISION, INC.

Patent Owner

Case IPR2023-00471

Patent No. 6,844,990

DECLARATION OF JAMES F. MUNRO

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I. INTRODUCTION

I, James F. Munro, declare as follows:

1. I have been retained by Patent Owner ImmerVision, Inc. (“ImmerVision”) to provide expert opinion and testimony in connection with an *inter partes* review of U.S. Patent No. 6,844,990 (“the ‘990 patent”) assigned to ImmerVision.
2. I was retained in this matter by ImmerVision through its counsel, Panitch Schwarze, as an expert witness in the field of optics design and image processing. I charge a rate of \$400 per hour for my services. My compensation in this matter is in no way dependent or contingent on my opinions and testimony or on the ultimate outcome of the case.
3. I have reviewed the ‘990 patent, as well as the Petition and the references cited therein.
4. In this declaration, I set forth the independent opinions that I have reached and the basis for those opinions using the information currently available to me. Such opinions are based on my education, career, and relevant experience in optics and lens design unless otherwise noted. A list of documents I have reviewed and, in some cases, relied upon in forming my opinions are presented below. I reserve the right to supplement or revise my opinions should additional documents or other information be provided to me.

II. QUALIFICATIONS

5. My *curriculum vitae* (“CV”), a copy of which is attached, provides details on my education, experience, publications, and other qualifications.

Notable points of interest are described below.

6. I received a Bachelor of Science degree in Electrical Engineering in 1982 from Michigan Technological University, graduating with High Honors. As part of a five-year program I was able to specialize in analog electrical engineering, digital electrical engineering, and minored in computer/software engineering. I obtained a Master of Science degree in Optics in 1990 from the University of Rochester. The optics program at the University of Rochester is recognized world-wide as the pre-eminent institute for optics research and education; relevant studies include geometric optics, instrumentation optics, and electronic image processing. I obtained a Master of Business Administration degree from the William E. Simon Graduate School of Business at the University of Rochester in 2000. Classes of interest include entrepreneurship, operations, and marketing.

7. I have been employed in industry for over forty years, advancing to such titles as Director of Research and Development and Vice President of Engineering. In these capacities I managed multi-disciplinary research and engineering teams composed of Mechanical, Electrical, Software, and Optical engineers.

8. I have been the CTO and co-owner of Munro Design & Technologies, LLC, since its founding in 2007. Through Munro Design & Technologies I perform optical and optics-related consulting services for a variety of technology companies in the Northeastern portion of the US. Munro Design & Technologies is also a technology development company in which I invent, patent, and monetize optics-related technologies.

9. I have invented and received 40 US patents for optical technologies in the fields of 3D-imaging systems, 2D-imaging systems, laser range-finding, LED illumination systems and luminaires, lenses, infusion pump flow-rate metrology, barcode scanners, back-lights, displacement-measuring metrology, photo-bioreactors for green energy, and post-quantum cryptography, most of which I am the sole and/or the first named inventor.

10. During my career I personally designed over 100 lens systems of varying complexity, for my clients, employer, or Munro Design and Technologies. Further, I was responsible for integrating several of these lenses into an imaging system which consisted of the lens, an image sensor, software that processed the image, as well as the supporting mechanical and electrical infrastructure.

11. I have a high degree of proficiency developing image processing algorithms, as well as writing software that implements those algorithms, and then troubleshooting, debugging, and optimizing the performance of the software.

III. MATERIALS CONSIDERED

12. In forming my opinions expressed in this declaration, I have considered and relied upon my education, background, and experience. In addition, I have reviewed and, in some cases, relied upon the following list of materials in the preparation of this declaration.

Materials Considered
Petition for <i>Inter Partes</i> Review of U.S. Patent No. 6,844,990 filed by Apple, Inc. (“Apple”) on January 18, 2023
Patent Owner Preliminary Response filed by ImmerVision on April 13, 2023
Petitioner’s Reply to Patent Owner’s Preliminary Response filed by Apple on May 30, 2023
Patent Owner’s Sur-Reply filed by ImmerVision on June 6, 2023
Decision Granting Institution of <i>Inter Partes</i> Review on July 11, 2023
APPLE-1001 – U.S. Patent No. 6,844,990
APPLE-1002 – Prosecution History of ‘990 Patent
APPLE-1003 – Declaration of David Kessler, Ph.D.
APPLE-1006 – U.S. Patent No. 5,686,957 (Baker)
APPLE-1007 – “Fish Eye Lens” by K. Miyamoto
APPLE-1009 – U.S. Patent No. 3,953,111 (Fisher)
APPLE-1010 – U.S. Patent No. 6,128,145 (Nagaoka)
APPLE-1011 – Reexamination File History for the ‘990 Patent
APPLE-1012 – EP 1028389 A2 (Shiota)
APPLE-1013 – Rebiai et al., “Image Distortion from Zoom Lenses: Modeling and Digital Correction,” 1992 IBC International Broadcasting Convention (July 1992)
APPLE-1014 – JP 2000-242773 (Matsui)
APPLE-1015 – U.S. Patent No. 5,861,999 (Tada)
APPLE-1016 – Zeljko Andreic, “Simple 180° field-of-view F-theta all-sky camera,” SPIE Proc. 1500 (Oct. 1, 1991)
APPLE-1017 – Abed Kassim et al., “Optical Performance of axial gradient and aspheric surface lenses: study and analysis,” SPIE’s 1994 International Symposium on Optics, Imaging, and Instrumentation, Vol. 2263 (Sept. 30, 1994)

Materials Considered
APPLE-1018 – Susan Houde-Walter, “Recent Progress In Gradient-Index Optics,” SPIE Proc. 0935 (Apr. 8, 1988) (“Houde-Walter”)
APPLE-1019 – Petition for <i>Inter Partes</i> Review of U.S. Patent No. 6,844,990, filed by Panasonic System Networks Co., Ltd. (IPR2014-01438)
APPLE-1020 – Paul K. Manhart et al., “Fundamentals of macro axial gradient index optical design and engineering,” SPIE Opt. Eng. 36(6), 1607-1621 (June 1997)
Keating, <i>Geometric, Physical, and Visual Optics</i> , 2002, Butterworths
Archarya & Ray, <i>Image Processing Principles and Applications</i> , 2005, Wiley
E2v EV76C560 image sensor data sheet https://imaging.teledyne-e2v.com/content/uploads/2019/01/DSC_EV76C560.pdf
U.S. Patent Application Publication US 2004/0201764 to Honda

13. To the best of my knowledge, each of the above papers and exhibits is a true and accurate copy of what they purport to be. An expert in the field would reasonably rely on them to formulate opinions such as those set forth in this declaration.

IV. APPLICABLE LEGAL STANDARDS

14. I am not an attorney, and I am not offering any legal opinions in this declaration nor am I qualified to do so. However, I have been informed by counsel regarding several legal standards that I am to apply in framing my technical opinions and conclusions.

15. I understand from counsel that a patent claim is invalid if the claimed invention would have been obvious to a person of ordinary skill in the art (a “POSA”) at the time of the invention. This means that even if all of the

requirements of the claim cannot be found in a single prior art reference that would anticipate the claim, the claim can still be invalid.

16. I understand from counsel that an obviousness analysis involves comparing a claim to the prior art to determine whether the claimed invention would have been obvious to a POSA at the time of the invention in view of the prior art and in light of the general knowledge in the art as a whole.

17. I also understand from counsel that obviousness is ultimately a legal conclusion based on underlying facts of four general types, all of which must be considered: (1) the scope and content of the prior art; (2) the level of the POSA; (3) the differences between the claimed invention and the prior art; and (4) any objective indicia of non-obviousness.

18. I also understand from counsel that obviousness may be established by combining or modifying the teachings of the prior art. Specific teachings, suggestions, or motivations to combine any first prior art reference with a second prior art reference can be explicit or implicit, but must have existed before the date of invention. I further understand from counsel that in some circumstances obviousness may be established by a single prior art reference.

19. I understand from counsel that prior art references themselves may be one source of a specific teaching or suggestion to combine features of the prior art, but that such suggestions or motivations to combine art may come from the

knowledge of a POSA. Specifically, a rationale to combine the teachings of references may include logic or common sense available to a POSA.

20. I understand from counsel that a prior art reference may be relied upon for all that it teaches, including uses beyond its primary purpose. I understand that teaching away, *e.g.*, discouragement from making the proposed modification, is strong evidence that the prior art references are not combinable. I also understand from counsel that a disclosure of more than one alternative does not necessarily constitute a teaching away.

21. I understand from counsel that to support a combination of multiple prior art references, there must be a rationale explaining why a skilled artisan would combine the references in the manner claimed and how the proposed combination meets each and every claim element.

22. I further understand from counsel that whether there is a reasonable expectation of success from combining prior art references in a particular way is also relevant to the analysis. I understand there may be a number of rationales that may support a conclusion of obviousness, including:

- Combining prior art elements according to known methods to yield predictable results;
- Substitution of one known element for another to obtain predictable results;
- Use of a known technique to improve similar devices (methods, or products) in the same way;

- Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;
- “Obvious to try” – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- Known work in one field of endeavor 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 variations are predictable to one of ordinary skill in the art; and
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art teachings to arrive at the claimed invention.

23. I understand that it is not proper to use hindsight to combine prior art references or elements of prior art references to reconstruct the invention using the claims as a guide. For example, an obviousness reconstruction should only take into account knowledge within the level of ordinary skill in the art at the time the claimed invention was made, and not utilize knowledge gleaned only from the patent’s disclosure. When it appears hindsight bias is being used, I understand the modification or combination is not considered obvious.

24. I understand that so-called objective indicia may be relevant to the determination of whether a claim is obvious should the Patent Owner allege such evidence. Such objective indicia can include evidence of commercial success caused by an invention, evidence of a long-felt need that was solved by an invention, evidence that others copied an invention, or evidence that an invention achieved a surprising result. I understand that such evidence must have a nexus, or

causal relationship to the elements of a claim, in order to be relevant to the obviousness or non-obviousness of the claim.

V. LEVEL OF SKILL IN THE ART

25. Dr. Kessler proposed that a person of ordinary skill in the art (POSA) at the time of the invention would have had at least a bachelor's degree in Physics, Optical Engineering, and/or Electrical Engineering and at least five years' experience in developing and designing optical products or systems and have familiarity with image processing algorithms and optical design software. APPLE 1003, ¶ 24. While I do not necessarily agree with Dr. Kessler's opinion, it does not materially affect my analysis, and for purposes of this document only, I have assumed the same level of skill in the art as Dr. Kessler has proposed.

Additionally, based on my education, training, and professional experience, I met at least these minimum qualifications to be a POSA as of the relevant time-frame of the invention of the '990 patent, which I have taken to be May 11, 2001 for the purposes of this declaration.

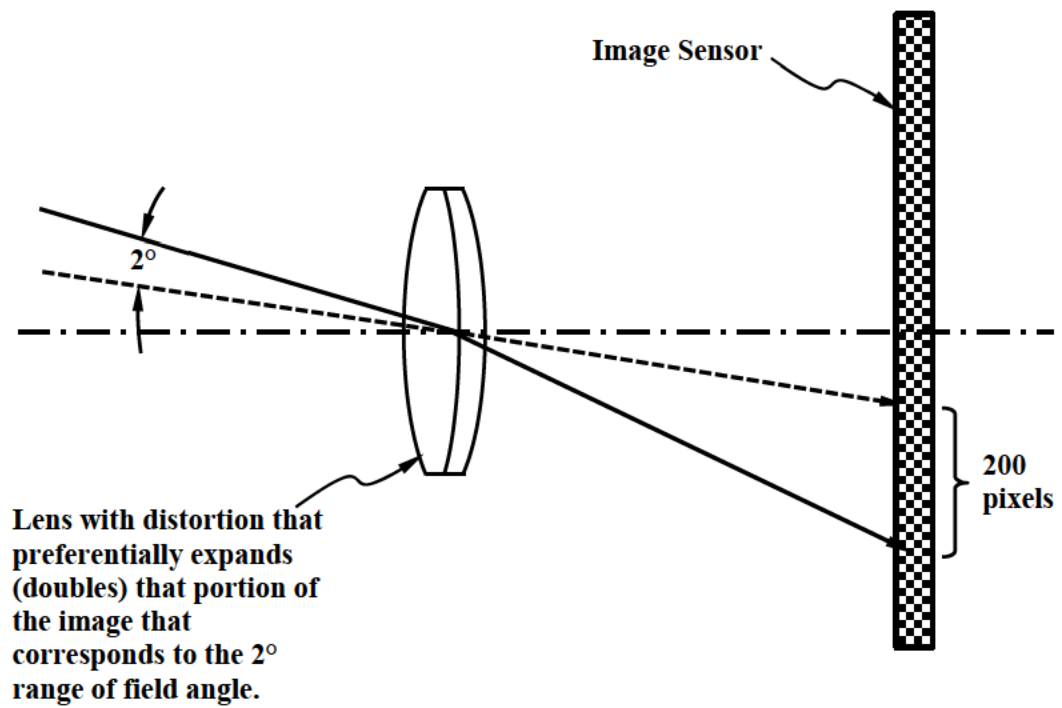
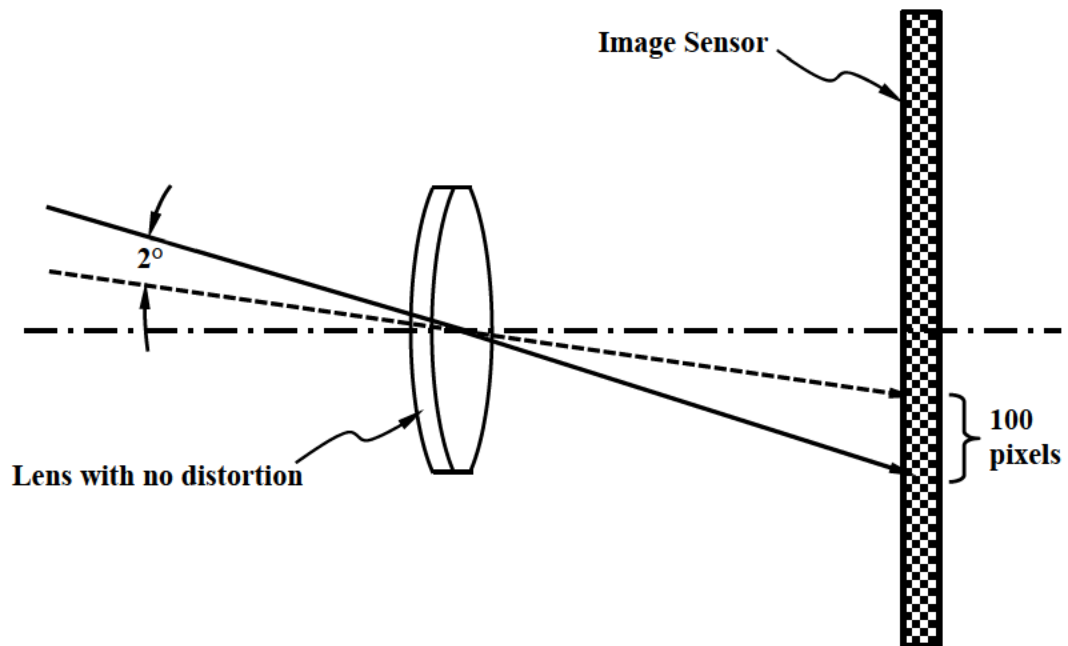
VI. '990 PATENT AND CLAIM SUMMARY

26. The '990 patent teaches, at a high level, an optical means for capturing a panoramic image as well as an accompanying algorithm for removing the distortion present in the captured panoramic image, wherein the capturing entails intentionally distorting the image by preferentially expanding a portion of

the panoramic image to beneficially enhance the resolution of the image in that zone, and the distortion removal process accounts for the zonal expansion in the distortion removal process.

27. When the resolution of a portion of an image is enhanced by intentionally distorting the image, then that portion of the image that is enlarged as a result of the distortion is projected onto a greater number of pixels than it otherwise would have been. In so doing, the enhanced portion of the image is sampled at a greater rate, generally in pixels per degrees of field angle, and as such a higher resolution of the imaged object is obtained in the region of the expanded image.

28. As an example, if two degrees of field angle are nominally imaged onto 100 pixels, then if distortion is introduced into the lens during the design of the lens such that these two degrees of field angle are imaged onto 200 pixels, then the resolution of the image has essentially doubled for features in object space within those two degrees. This is illustrated in the Figure below.



29. Of course the opposite can be true as well, such that if regions of the image do not need augmented resolution, then those regions can be compressed such that, for example, the two degrees of field angle are imaged onto only 50 pixels.

30. The expansion or compression of images in this manner can be highly beneficial for the efficient use of bandwidth (Fisher, Column 1) or for digital image processing in which higher sampling rates are preferred for those portions of images that have large amounts of detail per the Nyquist-Shannon sampling theorem (Acharya and Ray, Section 2.3.1, pages 23-25). However, when those expanded / compressed images are viewed by people, the fat and thin “carnival mirror” distortion effects present in the image can be distractive at best, objectionable, and unintelligible at worst. Accordingly, it is desirable to clean up and remove these expansion / compression distortion effects with image processing methods such that the final image displayed or presented to a person is as clear and coherent as possible.

31. Accordingly, there are two complementary parts to the ‘990 patent: 1) a lens or imaging portion (columns 7 through 9) and 2) an algorithmic portion (columns 10 through 15), which is implemented in computer code and that processes the captured image. Importantly, both parts teach that the expanded portion of the image is accompanied by a compressed portion of the image, that the

expansion and/or compression is non-linear, and that the amount of non-linear expansion or compression exceeds 10% when compared to a nominal linear expansion or compression.

32. For example, Figure 9, copied below, illustrates the concept of non-linear image expansion and compression, and the deviation of the expansion and contraction with respect to a linear expansion or compression. In Figure 9, the horizontal axis, α , is the angle of a light ray entering the camera from a panoramic scene, measured from the central optical axis of the camera. Note that the values of the horizontal axis go from 0 degrees (the optical axis) to over 90 degrees, 90 degrees corresponding to a large panoramic angle corresponding to a point on the scene way off to a side. The vertical axis is labelled “dr”, for “relative distance”, which is equal to the radial distance in the image plane where an incoming ray of angle α lands, divided by the maximum radius of the image. Accordingly, dr is dimensionless (it is a linear quantity divided by a linear quantity) and has values from 0 meaning the ray is on axis, to 1.0 meaning the ray is at the extreme edge of the image.

33. For reference in Figure 9 the inventors included a prior-art linear representation of the relationship between field angle α and image height dr, shown by the straight dotted line.

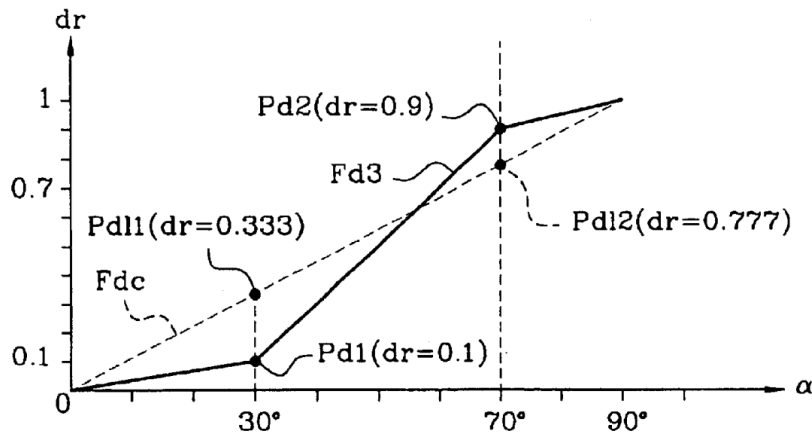


Fig. 9

34. Note that Figure 9 also presents a 3-segment piece-wise linear line, shown as the solid line, that is decidedly not linear. Indeed, the segment from 0 to 30° has relatively low slope, and corresponds to image compression because the resulting height of the image made by the incoming 30° light rays is substantially lower than it otherwise would have been. The segment from 30° to 70° has relatively higher slope and corresponds to image expansion. Lastly, the segment from 70° to 90° has relatively lower slope and also corresponds to a zone of image compression.

35. A key element of the '990 patent is the amount of non-linearity in the curve of Figure 9, as a curve that has no non-linearity trivially defaults to the linear α -dr curve of the prior art. Accordingly, the inventors prescribe a measure of the amount of non-linearity present in a non-linear α -dr curve (see the equation of line

56 of column 8), and in Figure 9 the amount of non-linearity at $\alpha = 30^\circ$ is -70% and the amount of non-linearity at $\alpha = 70^\circ$ is +15.8%.

36. The characteristics of a lens that can produce a non-linear image expansion/compression lens are described in columns 7 through 9, as mentioned earlier. The algorithm (described at columns 10 through 15) that can back-out or eliminate the non-linear compression/expansions of the image, which can be visually distressing, relies on a priori knowledge of the α -dr curve (which becomes known during the process of designing the lens) and the relative image height dr; note that dr is known and available to the algorithm based on the location of a pixel within the image, and the outer image radius, while field angle α is not known (except indirectly through the application of the α -dr curve).

37. Accordingly, the elements of claim 27 capture both the optical means for capturing a panoramic image as well as an accompanying algorithm for removing the distortion present in the captured panoramic image. Claim elements are directed to generating an image having a non-linear distribution function (i.e., the α -dr curve), the amount of non-linearity in the distribution function exceeding 10%, and having at least one expanded zone and one compressed zone in the image. Further, the elements of claim 27 are also directed to algorithmically removing the non-linear distortions within the image by using the non-linear distribution function (i.e., the α -dr curve) and the size of the image.

VII. CLAIM CONSTRUCTION

38. I understand that Petitioner proposed constructions for a number of terms from claim 27 of the ‘990 patent. While I do not agree with the interpretations set forth by the Petitioner, it does not materially affect my analysis based on the prior art submitted. Accordingly, for purposes of my declaration only, I have adopted Petitioner’s constructions for claim 27.

VIII. ANALYSIS OF THE CHALLENGED CLAIMS AND ASSERTED REFERENCES

A. Asserted References

1. Overview of Baker

39. The Baker ‘957 patent prescribes a video conferencing system that includes an imaging system with a hemispherical field of view such that all the participants at one end of a video conference call can be imaged and seen at once by the party at another end of the call. Baker, columns 1-2. In one embodiment in particular, the imager is located near the center of a table pointing upward toward the ceiling, and the participants – being seated about the periphery of the table – are within the hemispherical field of view (albeit at the edge of the field of view) of the imager and are therefore imaged by the conferencing system and seen by the party at another end of the call. Baker, columns 12-13.

40. Note that in this embodiment a substantial portion of the image captured by the hemispherical imager is the ceiling, which has no information

content and is therefore an underutilized portion of the image. Further, since the participants of the conference are at the periphery of the image, the periphery is therefore a highly utilized portion of the image. Baker, columns 10-13.

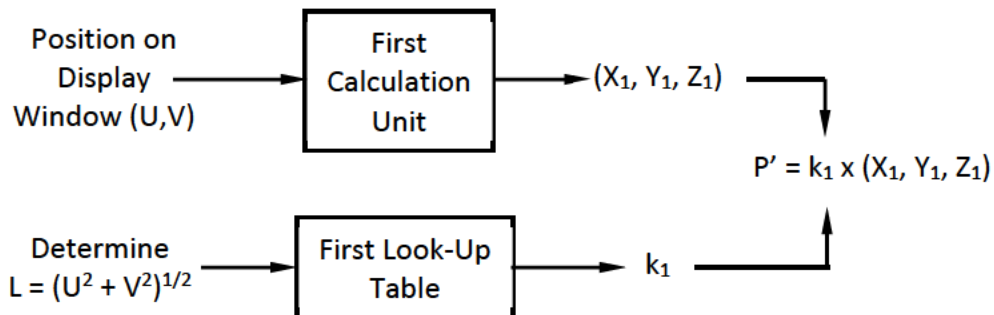
41. Accordingly, Baker teaches the concept of “warping” the image by virtue of the hemispherical imaging lens such that the periphery of the image is expanded and therefore has greater resolution while compressing the central portion of the image. Baker, columns 10-13. Baker speaks of adjusting the magnification of the image as a function of zone, or field angle, to accomplish the image warping when implemented by the use of a gradient index (GRIN) lens or by the use of fiber optics. Baker, columns 10-13. Baker also speaks of removing the warped characteristics of the captured warped image through a specialized electronic processor such that the processed (i.e., de-warped) image is suitable for presentation to the remote party of the video conference. Baker, column 6.

2. Overview of Shiota

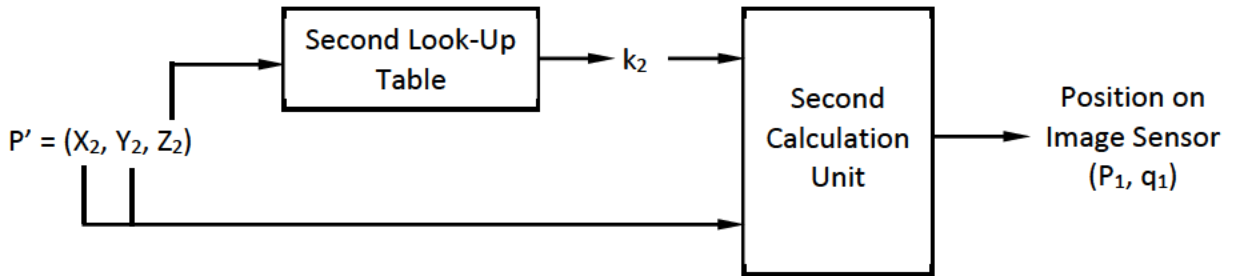
42. The Shiota ‘389 patent application prescribes an electronic arithmetic processing unit configured for the purpose of transforming an electronic image captured with a fisheye lens and having significant amounts of optical distortion into a plane electronic image that is substantially free of distortion that is suitable for display. Shiota, ¶¶ [0001]-[0007]. Shiota ‘389 also teaches a mathematical algorithm for the image transformation, the algorithm having inputs consisting of

1) the electronic image captured with a fisheye lens, and 2) the scale or zoom factor (i.e., the magnification) of the image. Shiota, ¶¶ [0020]-[0042].

43. In a preferred embodiment the transformation process occurs in two stages, with each stage comprising a Look-Up-Table (LUT) and a mathematical calculation unit, in which, importantly, all four functional blocks are implemented in electronic hardware instead of software. Shiota, ¶¶ [0010]-[0017], [0045]-[0046]. The LUT of the first stage translates an input value of “L”, the distance from origin of the unit hemisphere of the imaginary object face, to k_1 , which is a coefficient that relates the point $P' = (X_2, Y_2, Z_2)$ to the intermediate point (X_1, Y_1, Z_1) that is output by the first calculation unit. That is, $X_2 = k_1 \times X_1$, $Y_2 = k_1 \times Y_1$, and $Z_2 = k_1 \times Z_1$. This calculation is made simple in part because the distance from the X, Y, Z origin to any point on the hemisphere is set to 1, including from the X, Y, Z origin to the origin X_0, Y_0, Z_0 of the display window image (U, V coordinate system), negating a need for trigonometric equations. Shiota, ¶¶ [0022], [0028]-[0032]. This Step of the image transformation is shown diagrammatically in the following figure for clarity.



44. The output of the first stage, P' , is then input to a second stage in which the Z_2 coordinate of P' is converted to a second coefficient, k_2 , in a second LUT, and the X_2 and Y_2 coordinates along with k_2 are input to a second calculation unit that computes $P_1 = k_2 \times X_2$ and $q_1 = k_2 \times Y_2$ wherein P_1 and q_1 are the desired coordinates on the image produced by the fish-eye lens. These calculations are again simplified at least with the help of the aforementioned hemisphere radius being set to 1, as well as because the radius of the fisheye image is also set to 1, also eliminating the need for trigonometric calculations. Shiota, ¶¶ [0023], [0033]-[0042]. This Step of the image transformation is shown diagrammatically in the following figure for clarity.



45. As mentioned earlier, the first and second Look-Up-Tables and the first and second Calculation Units are implemented in electronic hardware instead of software. Shiota, ¶¶ [0045]-[0046]. A hardware implementation has the benefit

of faster execution speed so more pixels per second, for example, can be processed than can be processed on a generic computer processor, such as that found a desktop PC. However, the processing hardware prescribed by Shiota, even though simple and low cost, is custom circuitry that can only be used for mathematical coordinate transformations needed for image distortion correction.

3. Overview of Fisher

46. The Fisher '111 patent prescribes a lens that can produce images of a wide field of view and present the resulting image onto a vidicon television camera which then electronically transmits the electronic image to a projector which then displays the wide field of view image through a projection lens. Fisher, columns 1-3.

47. A key feature of this patent is that the central portion of the imaged wide field of view is preferentially and non-linearly expanded to maximize the resolution of the central portion of the image transmitted by the vidicon. Fisher, column 2. Further, the projection lens has an inverse non-linear transfer function that substantially removes any distortions in the image produced by the wide field of view imaging lens. Fisher, column 3.

48. Nonetheless, this patent is primarily concerned with the characteristics of the non-linear wide field of view imaging lens. Indeed, detailed optical

prescription information is provided for the imaging lens, and the claims of this patent are all directed to the wide field of view imaging lens as well.

B. Claim 27 Would Not Have Been Obvious Over Baker and Shiota

49. Petitioner has argued that Baker, who prescribes the use of a wide field of view lens which preferentially expands and compresses different zones of the field of view, in combination with Shiota, who teaches an algorithm that is able to correct or remove the preferential expansions or contractions within the image so the image appears undistorted to the user, together renders obvious all elements of claim 27. I disagree with this assessment.

50. Indeed, at least one important element of claim 27 – concerning the algorithmic correction of the distorted image – is not present in Shiota (nor in Baker). In particular, as written in claim 27, the “correcting the non-linearity of the initial image” uses “at least ... a size L of the obtained image”. The quantity L is defined in line 47 of column 13: “L is the size of the image disk, in number of pixels”. Accordingly, L is a dimensioned quantity as a characteristic of the image obtained by the lens, having units of pixels, or equivalently has units of length since a pixel is measured by its width (typically in micrometers). For example, the E2V EV76C560 image sensor data sheet specifies that its square pixels are 5.3 micrometers x 5.3 micrometers in size.

51. Petitioner and Dr. Kessler do not point to any such disclosure in Shiota because Shiota is silent on the use of image size. APPLE 1003, ¶¶ 199-212. Instead, they rely on paragraph 23 in Shiota, which teaches "... a fisheye image is projected in a circle of radius 1 of an image of an object positioning at 90 degrees ($Z=0$) from the front of the lens. At the time of actual use, magnification adjustment is performed". In this text no mention is made of the size of the image, nor of any dimensioned quantity that could be understood to be a proxy for image size, or for that matter even suggests that the size of the image could be used in the distortion correction process. Rather, Dr. Kessler focuses on the concept of magnification.

52. First, it is well known in the field of optics that magnification is a ratio of two quantities, such as image height divided by object height, and as such magnification is a dimensionless number. Indeed, according to Keating, page 350, "*Again, the angular magnification M is dimensionless but is conventionally labelled with an X* ", as well as Example 17.2, Example 17.3, and the trailing text in Section 13.3 of Keating. Accordingly, one of ordinary skill in the art would not have initially concluded that Shiota's reference to magnification in paragraph 23 was meant to indicate that a linear quantity, such as image size L , was to be used for purposes of correcting the distortion in the image.

53. Second, further context in Shiota indicates what is intended by “magnification adjustment” in paragraph 23. As part of his argument, Dr. Kessler ties the “magnification adjustment” in paragraph 23 to phrases in subsequent paragraphs 24 and 26. APPLE 1003, ¶ 205.

54. In paragraph 24 Shiota presents a discussion of the image transformation process, which leads directly from the “magnification adjustment” sentence concluding paragraph 23. In this discussion, Shiota, as part of the transformation process, “Information of the view points (ϕ , θ , α) and the scale factor (zoom ratio) as the size of the plane image is information inputted by the operator through a keyboard...”. This relates to the orientation and distance of the “plane image” (the displayed image having a u , v coordinate system) with respect to the hemispherical face. Shiota ¶¶ 22, 24, 28 The view point angles (ϕ , θ , α) are shown in Fig. 1 of Shiota and are chosen by the operator, as the operator selects which part of the overall image to view on the display. Shiota, ¶¶ 4, 24. Similarly, the operator will select a scale factor or zoom ratio as a size of the plane image. Shiota, ¶ 24. This is similar to the “enlargement (zoom)” operation described at column 14, lines 37-48, where the user selects a “zoom” parameter that moves the display window DW toward or away from the hemisphere HS to determine how much of the image is to be shown in the display window DW. In Shiota, since the plane image must have its center in contact with the hemisphere surface to enable

the simplified calculations (Shiota, ¶ 22), a similar zoom effect can be achieved by allowing the operator to adjust the size of the plane image, which is how one of ordinary skill in the art would understand the “scale factor (zoom ratio)” description in paragraph 24.

55. Similarly, paragraph 26 reads: “The parameters can be easily obtained from the information of the angle information (ϕ , θ , α) of the view point and the magnification of the image”. The “parameters” mentioned in paragraph 26, namely (X_0, Y_0, Z_0) , ∂u_x , ∂v_x , ∂u_y , ∂v_y , ∂u_z , ∂v_z are defined in paragraph 25 and are not related to the size of the fisheye image. Paragraph 26 then references back to the characteristics listed in paragraph 24, namely the “angle information” (ϕ , θ , α) and “magnification of the image”, which one of ordinary skill in the art would understand to be referring back to the “scale factor (zoom ratio)” information selected by the operator, since this information is important for obtaining the parameters listed above.

56. Within this context, and as Dr. Kessler acknowledged (APPLE 1003, ¶ 205) the relationship between paragraphs 23-26 in this section about positioning relationships of coordinate systems, paragraph 23 is understood as referring to the same magnification and scale factor (zoom ratio) as paragraphs 24 and 26, which defines in part the orientation of the plane image with respect to the hemisphere for purposes of displaying the final image following transformation. Nothing in this

section of Shiota suggests that the size of the fisheye image in pixels, or equivalent length measurement, is used as part of Shiota's transformation process, and the overall context of paragraphs 23-26 indicates that "magnification" is about selecting the portions of the image for display, not correcting image distortion using the fisheye image size.

57. Further, because Baker makes no mention of utilizing the size of the image disk (in pixels, micrometers, or any other unit of measure) in the de-warping image processing algorithm, then even if Baker is combined with Shiota, the "size L of the obtained image" is still missing from the operation of correcting the non-linearity of the initial image. Accordingly, claim 27 would still not have been obvious.

58. Dr. Kessler has also argued in multiple instances that "A POSITA would have thus understood that these reference to "magnification adjustment" and variation in image size based on size of the image disk/sensor refers to an adjustment that accounts for the actual size of the image pickup device – and by extension, the actual size of the image – as part of the image transformation." Petition pages 50-51. It is important to note that the size of the image and the size of the image sensor are not necessarily linked as Dr. Kessler suggests, nor does the size of the image sensor necessarily drive projection characteristics of the lens. In particular, the "size of the image disk" does not have the same meaning as the size

of the image sensor. For example, an image sensor can, for a variety of reasons, be intentionally underfilled or overfilled by an image produced by a lens. An example of underfilling is shown in Fig. 2 of the '990 patent, where the image 3 does not cover the entire image sensor and leaves dark edges 4. Indeed, image sensors (see for example e2v Semiconductors EV76C560 Image Sensor Data Sheet, pages 11-19) often incorporate so-called Regions of Interest that can accommodate images that underfill the sensor so that only that region (of interest) that contains image data is actually output by the image sensor. Overfilling occurs when the image sensor is smaller than the image disk projected by the lens, such as what is shown in Fig. 11 of U.S. Patent Application Publication US 2004/0201764 to Honda, where the image area of the sensor 31 captures only a center portion of the overall image circle 30. Thus, the person of ordinary skill in the art would not necessarily be led down the path suggested by Dr. Kessler – that accounting for actual size of the pickup device requires consideration of the actual size of the image during the transformation.

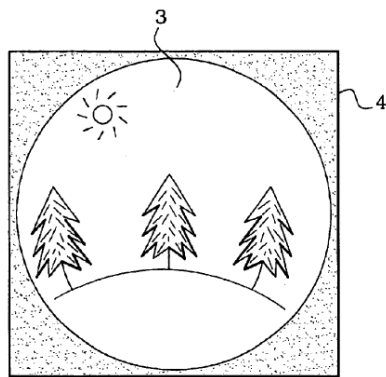
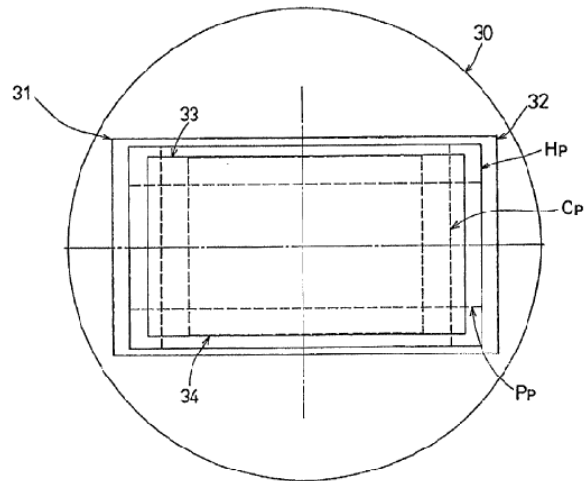


Fig. 2

FIG.11



C. Fisher Is Not Relied Upon for Claim 27

59. Because Petitioner did not rely upon Fisher in connection with claim 27 or the above-described features relating to using the image size to correct the non-linearity of the image (APPLE 1003, ¶¶ 242-259), then Fisher has no bearing on the preceding analysis in regard to claim 27.

D. Dependent Claims

60. In reviewing the dependent claims, I do not find that Dr. Kessler has added any analysis that addresses the issues I highlight above. APPLE 1003, ¶¶ 214-240. It is therefore my understanding that because claim 27 is not proved obvious, then none of the asserted dependent claims can be obvious either.

IX. CONCLUSION

61. 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 further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the Patent Owner's position in this *Inter Partes* Review proceeding.

Dated: 10/10/2023

James F. Munro
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Optical engineer, researcher, and inventor possessing broad knowledge of optics and related technologies. Strongly driven by the desire to create value through the strategic application of that knowledge and capture that value through the use of intellectual property. Highly proficient in executing the front end of the new product development process including the steps of ideation and invention, research, patent development and prosecution, prototyping, and advanced product development.

Credentials and Achievements

- MS Optics, U. of Rochester
- BSEE, Michigan Tech
- MBA, U. of Rochester
- Reviewer for SPIE J. Optical Engineering
- Reviewer for SPIE J. Electronic Imaging
- 40 issued US patents, 6 pending

Technology Areas of Expertise and Competence

- Optical Engineering
- Electrical Engineering
- Software Engineering
- Engineering Systems
- Algorithms
- Statistics (regression, ANOVA, DOE, etc.)
- Sequential (lens) design with Zemax
- Non-sequential raytracing with TracePro
- 2D and 3D imaging
- Optical metrology

Specific Optical Technology Development Experience

- Lens Design
- Spaceborne optical systems
- Spectrometry
- Interferometry
- Rangefinding / LiDAR
- Confocal chromatic probes
- LED Optics / Backlights / Luminaires
- Solar concentrators
- Laser systems and ablation
- Nephelometer particle metrology

PROFESSIONAL EXPERIENCE

Munro Design & Technologies

CTO & Consultant

2009 to present

Ontario, New York

- Subject matter expert for a Phase I SBIR with US Space Force for a space-based 3D imager.
- Won a contract from the US Air Force for the development of a novel non-rastering non-stereoscopic 3D video camera.
- Developing post-quantum encryption technology for secure end-to-end communications for IOT devices.
- Wrote proposals and won two NYSERDA awards in the field of solar conversion.
- Consulting projects in the areas of 3D scanners, lens design, image processing, LED illumination, analog circuit design, remote sensing and many others.

OptiPro Systems, LLC, a manufacturer of machinery and metrology systems for optical component fabrication.

Director, R&D

2019 to present

Ontario, New York

- Key leadership position responsible for new technology development, including the steps of invention, intellectual property development, R&D, prototyping and development activities, for a family of high-performance products for optical surface metrology.
- Managing a small department of researchers having degrees in Physics, Math, and Optics up to and including the level of PhD.
- Authored and won numerous SBIR proposals from the Department of Energy and NASA for sub-nanometer surface metrology of large-area mirrors.
- As an individual contributor, used Zemax and TracePro to analyze and optimize several optical metrology systems.

Reflexite, a manufacturer of microstructured optical films

Scientist

1999 to 2009

Rochester, New York

- Key technical leadership position responsible for new business unit development, including the steps of invention, intellectual property development, R&D, prototyping and development activities, for a variety of microstructured optical films.
- Primary contact for optical and electronic technology issues within the company.
- Engaged in extensive face-to-face customer activities, including determining customer requirements, problem solving, generating new product specifications, and apprising the customer of project status and final product performance.
- As an individual contributor, used Zemax and TracePro to analyze and optimize several optical systems in lighting, backlighting, rear projection screens, and LED collimators.

Spectronic Instruments, a manufacturer of spectrometry and fluorometry instrumentation

VP, Engineering & Product Manager

1997 – 1999

Rochester, New York

- Supervised and directed a multidisciplinary department of fifteen engineers engaged in R&D and new product development for photometric, spectrophotometric, and spectrofluorometric products.
- Designed, prototyped, and ushered into Manufacturing the optics of a small form-factor spectrograph.

PSC Inc., a high-volume manufacturer of bar-code scanning devices

Engineering Manager

1993 – 1997

Webster, New York

- Engineering responsibility for all barcode scanners in production.
- Supervised and directed the efforts of a twelve member engineering organization consisting of Optical, Electrical, Mechanical, and Software Engineers.
- Wrote a raytrace program in C for the design and optimization of the optics of a hand-held barcode scanner.

Hampshire Instruments, a manufacturer of X-Ray lithography systems

Senior Optical Engineer

1992 - 1993

Rochester, New York

- Used Code V to design CCD camera imaging optics for the wafer-to-mask gapping and alignment systems of a proximity (non-projection) X-Ray lithographic stepper system.

GCA/Tropel, a manufacturer of photolithographic lenses and industrial interferometers

Senior Member, Technical Staff 1988 – 1992 Fairport, New York

- Supervised and directed a team in the development of a small aperture grazing incidence interferometer. Project was aggressively scheduled, and completed in four months.
- Completed extensive theoretical analysis for interferometer accuracy and repeatability, and directed the implementation of novel methods needed to achieve required interferometer performance.

Harris Corporation, a manufacturer of two-way long-range radio systems

Electrical Engineer 1982 – 1988 Rochester, New York

- Directed a team of software engineers in the development of a remote control system.
- Wrote software for remote control of HF radio systems.

Issued Patents

11,598,849	Signal generating systems for three-dimensional imaging systems and methods thereof
11,451,390	Methods for minimizing an error condition with separately generated secret keys based upon one or more shared characteristics and devices thereof
11,428,786	Dual waveforms for three-dimensional imaging systems and methods thereof
11,255,795	Drip chamber with integrated optics
11,169,027	Interferometer systems and methods thereof
11,169,026	Optical measurement systems and methods thereof
11,029,502	Optical imaging assembly and system with optical distortion correction
11,016,179	Digital image processing systems for three dimensional imaging systems with image intensifiers and methods thereof
11,013,860	Drip chamber with hydrophobic interior surface
10,558,024	Optical imaging assembly and system with optical distortion correction
10,429,312	Drip chamber with integrated optics
10,406,284	Optical imaging system with multiple imaging channel optical sensing
10,314,972	Drip chamber with hydrophobic interior surface
10,297,044	Method for calibrating an optical scanner and devices thereof
10,048,064	Optical three-dimensional scanners and methods thereof
9,801,996	Drip chamber with hydrophobic interior surface
9,791,676	Optical imaging assembly and system with optical distortion correction
9,504,100	Selective radiation utilization apparatus for high-efficiency photobioreactor illumination and methods thereof
9,476,825	Optical imaging system with multiple imaging channel optical sensing
9,360,658	Optical imaging assembly and system with optical distortion correction
9,352,081	Drip chamber with hydrophobic interior surface
9,234,850	Drip chamber with integrated optics
9,128,051	Optical imaging system for air bubble and empty bag detection in an infusion tube
8,662,716	Side-emitting optical elements and methods thereof
8,320,562	Methods for creating secret keys based upon one or more shared characteristics and systems thereof
8,254,665	Systems for capturing three-dimensional one or more images and methods thereof
8,235,556	Condensing element, array, and methods thereof
8,226,262	TIRing condensing element and methods thereof
8,205,995	Optical device and system for privacy or contrast enhancement and methods of use thereof
8,057,715	Method for making an optical device and system for privacy or contrast enhancement
7,980,727	Monolithic tiring condensing arrays and methods thereof
7,847,886	Parabolic lenticular collimating films and methods thereof
7,706,073	Collimating microlens array
7,679,828	Method and apparatus for aperture sculpting in a microlens array film

7,202,941	Apparatus for high accuracy distance and velocity measurement and methods thereof
6,978,676	Distance measuring systems and methods thereof
6,874,913	Asymmetric alternating prism arrays
6,854,855	Asymmetric alternating prism arrays
6,006,991	Method and apparatus for reading both of standard and fluorescent bar codes
5,979,769	Combination range laser scanner utilizing periodic range switching