

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE, INC.
Petitioner

v.

IMMERVISION, INC.
("ImmerVision"),
Patent Owner

Case IPR2023-00471
Patent No. 6,844,990

DECLARATION OF DR. DAVID KESSLER, Ph.D.

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I. INTRODUCTION

1. My name is Dr. David Kessler, and I have been retained by counsel for Petitioner Apple, Inc. (“Apple” or “Petitioner”) as an expert witness to provide assistance regarding U.S. Patent No. 6,844,990 (the “’990 Patent”). Specifically, I have been asked to consider the validity of claims 27, 2, 4, 29, and 30 of the ’990 Patent (“Challenged Claims”) in view of prior art, obviousness considerations, and understanding of a person of ordinary skill in the art at the time of the invention (“POSITA”) as it relates to the ’990 Patent

2. I am being compensated for my time at my standard consulting rate. I am also being reimbursed for expenses that I incur during the course of this work. My compensation is not contingent upon the results of my study, the substance of my opinions, or the outcome of any proceeding involving the challenged claims. I have no financial interest in the outcome of this matter or on the pending litigation between Petitioner and Patent Owner.

3. My analysis here is based on my years of education, research and experience, as well as my investigation and study of relevant materials, including those cited herein.

4. I may rely upon these materials, my knowledge and experience, and/or additional materials to rebut arguments raised by the Patent Owner. Further, I may

also consider additional documents and information in forming any necessary opinions, including documents that may not yet have been provided to me.

5. My analysis of the materials produced in this proceeding is ongoing and I will continue to review any new material as it is provided. This declaration represents only those opinions I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information and on my continuing analysis of the materials already provided.

II. BACKGROUND AND QUALIFICATIONS

6. My education and experience are described more fully in the attached *curriculum vitae* (APPLE-1004). For ease of reference, I have highlighted certain information below.

7. I have over forty years of academic and industry experience in optics. I am proficient in several topics/fields, including, e.g., aberrations theory, physical optics, optical systems architecture and design, and major optical CADs.

8. Since 2006, I have been the owner of Kessler Optics & Photonics Solutions Ltd., which provides consulting services relating to optical designs and optical systems architecture primarily in imaging systems; projection systems; display technologies; AR/VR systems; medical imaging systems like digital retina

and cornea microscopes; intra oral cameras based on mobile phone cameras; military digital simulators and more.

9. For most of the period between 1982 and 2006, I managed an advanced optical design team at Kodak Research Labs. During my time at Kodak Research Labs, my projects included, among others, designing and developing digital cameras, designing of anti-aliasing filters for cameras, designing medical digital imaging systems like digital fundus CCD cameras, CCD scanners, laser systems including some using f-theta lenses, designing scan/process/print systems (where films were scanned, digitally processed to correct color, grain, exposure and artifacts, and then printed to paper at high speeds).; The first digital cinema projectors; Extended depth of focus (EDOF) cameras (where phase filters are introduced into the camera lens , images captured and algorithms used to resurrect the image with a resulting extended focus range;

10. I am a recipient of a Tech Emmy Award for the high-speed CCD scanner for real time telecine (system for conversion of a movie from film to HD video).

11. My full portfolio and my current projects are on my web site at www.KesslerOptics.com.

12. While at Kodak, I taught advanced optical design over two academic years as a visiting professor at Tel-Aviv University. More recently, I have conducted a number of advanced optical designs courses for corporate optical design teams.

13. I have a Bachelor of Science (BSc.) in physics and mathematics from The Hebrew University of Jerusalem. I have a Master of Science degree (MSc.) in physics and electro-optics from the School of Applied Sciences and Technology at The Hebrew University of Jerusalem. I have a Ph.D. in optical sciences from the Optical Sciences Center at the University of Arizona. My dissertation title is “Image quality criteria in the presence of moderately large aberrations” (which are the criteria to be chosen for usage in the merit function while optimizing lenses and other optical systems).

14. Additionally, I have familiarity with image processing algorithms. For example, as part of my Ph.D. program at the Optical Sciences Center at the University of Arizona, I studied under Prof. J. Gaskill who is the author of “Linear Systems Fourier Transformations in Optics.” Indeed, my dissertation deals with merit functions used in optical CAD programs that are associated with processing algorithms for image improvement.

15. Further still, a number of projects I led and/or participated in required post-capture image processing, some of which are referenced below:

16. Central photofinishing labs at Kodak where film was scanned and the scanned image was then processed using image processing algorithms to correct for defects in, e.g., correct exposure, low contrast, color gamut, grain, and resolution and printed at rates of 10,000 an hour;

17. I also analyzed and worked on Extended Depth of Focus (EDOF) cameras. These cameras, such as by CDM, DBLUR, XCEED and others, use phase elements in the camera to intentionally aberrate the captured images, which are then processed using image processing algorithms to retrieve the image at an increased depth of focus.

18. In lenticular imaging (also referred to as dynamic imaging) where about 30 images are combined as thin stripes at a focal plane of the lenticular lenses, we used image processing algorithms for the assembly of the images to provide a motion sensation;

19. In the laser printer space—which was one of my major activities in the first 14 years at Kodak—image interpolation algorithms were routinely used to facilitate correction for distortion.

20. Additionally, in a paper I published with colleagues, which is titled “Continuous tone printing using LCOS” (Digest of the Technical Papers, SID International Symposium, Vol. XXXVII, Page 174-177, June 2006), we described dithering and interpolation algorithms to significantly increase the resolution.

Relatedly, there are additional four papers on my site at <http://www.kessleroptics.com/publications>, dealing with multi spot laser printers or multichannel printers where interleaving was used and image processing was center to the ability to produce clean contiguous prints. In another paper on my website under “presentations,” and which is titled ”Image Quality Issues: the Optical Designer Point of View,” the issue of artifacts is covered and I discuss there the mitigation of such artifacts by either optical means or by image processing.

21. I also have designed and analyzed a number of Light Field (LF) cameras and microscopes for the two modalities of LF systems, namely temporal and spatial. Notably, LF systems rely heavily on image processing algorithms to capture images over a large depth of field.

22. I am a named inventor on 104 U.S. patents almost all related to optical systems and imaging systems and have been a listed author on 25 papers.

23. I am a fellow of the SPIE, the International Society of Optical Engineering, and I am a member of organizations such as OPTICA and SID.

III. LEVEL OF ORDINARY SKILL IN THE ART

24. In my opinion, a person of ordinary skill in the art (“POSITA”) relating to, and at the time of, the ’990 Patent’s Critical Date would have had at least a bachelor’s degree in Physics, Optical Engineering, and/or Electrical Engineering and at least five years of experience in developing and designing optical imaging systems

and have familiarity with image processing algorithms and optical design software. Additional education in a relevant field, or relevant industry experience may compensate for a deficit in one of the other aspects of the requirements stated above.

25. Based on my knowledge, skill, and experience, I have a good understanding of the capabilities of the POSITA. Indeed, I have taught, participated in organizations, recruited, and worked closely with many such persons over the course of my career. For example, from my industry experience, I am familiar with what an engineer would have known and found predictable in the art. From teaching and supervising my post-graduate students, I also have an understanding of the knowledge that a person with this academic experience possesses. Furthermore, I possess those capabilities myself.

IV. MATERIALS CONSIDERED AND RELIED UPON

26. In reaching the conclusions described in this declaration, I have relied on the documents and materials referenced below as well as those identified in this declaration, including the '990 Patent, the prosecution history of the '990 Patent, and prior art references cited herein. These materials include patents, related documents, and printed publications. Each of these materials is a type of document that experts in my field would have reasonably relied upon when forming their opinions.

27. I have also relied on my education, training, research, knowledge, and personal and professional experience in the relevant technologies and systems that were already in use prior to, and within the timeframe of the earliest priority date of the claimed subject matter in the '990 Patent, which I have been informed by counsel is May 11, 2001 ("Critical Date").

- APPLE-1001: U.S. Patent No. 6,844,990 ("the '990 patent")
- APPLE-1002: Prosecution History of the '990 Patent ("Original Prosecution History")
- APPLE-1006: U.S. Patent No. 5,686,957 to Baker ("Baker")
- APPLE-1007: "Fish Eye Lens" by K Miyamoto (Feb. 19, 1964) ("Miyamoto")
- APPLE-1009: U.S. Patent No. 3,953,111 to Fisher et al. ("Fisher")
- APPLE-1010: U.S. Patent No. 6,128,145 to Nagaoka ("Nagaoka")
- APPLE-1011: Reexamination File History of the '990 Patent ("Reexam History")
- APPLE-1012: EP 1028389 to Shiota et al. ("Shiota")
- APPLE-1013: Rebiai et al., "Image Distortion from Zoom Lenses: Modeling and Digital Correction," 1992 IBC International Broadcasting Convention (July 1992) ("Rebiai")
- APPLE-1014: JP 2000-242773 to Matsui et al. ("Matsui")
- APPLE-1015: U.S. Patent No. 5,861,999 to Tada ("Tada")
- APPLE-1016: Zeljko Andreic, "A simple 180° field-of-view F-theta all-sky camera," SPIE Proc. 1500 (Oct. 1, 1991) ("Andreic")

- 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) (“Kassim”)
- APPLE-1018: Susan Houde-Walter, “Recent Progress In Gradient-Index Optics,” SPIE Proc. 0935 (Apr. 8, 1988) (“Houde-Walter”)
- 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) (“Manhart”)

V. LEGAL STANDARDS

A. Legal Standards for Prior Art

28. I understand that a patent or other publication must first qualify as prior art before it can be used to invalidate a patent claim.

29. I understand that a U.S. or foreign patent qualifies as prior art to a patent if the date of issuance of the U.S. or foreign patent is prior to the invention of the patent. I further understand that a printed publication, such as an article published in a magazine or trade publication, qualifies as prior art to a patent if the date of publication is prior to the invention of the patent. My understanding is that, for such prior art references, a patentee may attempt to show that the claimed invention was conceived prior to the issuance of the U.S. foreign patent or publication of the printed materials. To do so, it is my understanding that patentee must prove with corroborating evidence that the named inventors conceived of the complete claimed

invention before the prior art and were diligent in reducing the claimed inventions to practice.

30. I understand that, regardless of the date of invention of the patent, a U.S. or foreign patent qualifies as prior art to a patent if the date of issuance of the U.S. or foreign patent is more than one year before the earliest effective filing date of the patent. I further understand that a printed publication, such as an article published in a magazine or trade publication, constitutes prior art to a patent if the publication occurs more than one year before the earliest effective filing date of the patent, again regardless of the date of invention of the patent.

31. I understand that a U.S. patent or published U.S. application qualifies as prior art to a patent if the application for that patent was filed in the United States before the invention of the patent. My understanding is that, for such prior art references, a patentee may attempt to show that the claimed invention was conceived prior to the filing in the United States of the purported prior art U.S. patent or application. To do so, it is my understanding that patentee must prove with corroborating evidence that the named inventors conceived of the complete claimed invention before the prior art and were diligent in reducing the claimed inventions to practice.

32. I understand that to qualify as prior art, a reference must contain an enabling disclosure that allows one of ordinary skill to practice the claims without undue experimentation.

33. I understand that documents and materials that qualify as prior art can be used to invalidate a patent claim as anticipated or as obvious.

B. Legal Standard for Priority Date

34. I understand that the “priority date” or “earliest effective filing date” of a patent is the date on which it is filed, or the date on which an earlier-filed U.S. or international patent application was filed if the patentee claims the benefit of priority to that earlier-filed U.S. or international patent application. I further understand that although a foreign priority document may be used to try to overcome certain prior art references, the effective filing date is not the filing date of a foreign priority document.

C. Legal Standard for Obviousness

35. My understanding is that a patent claim is invalid as obvious only if the subject matter of the claimed invention “as a whole” would have been obvious to one of ordinary skill at the time the invention was made. To determine the differences between a prior art reference (or a proposed combination of prior art references) and the claims, the question of obviousness is not whether the differences themselves would have been obvious, but whether the claimed invention as a whole

would have been obvious. Also, obviousness grounds cannot be sustained by mere conclusory statements. Rather, it is necessary to provide some articulated reasoning with rational underpinning to support the legal conclusion of obviousness.

36. I understand that a patent claim that comprises several elements is not proved obvious by simply showing that each of its elements was independently known in the prior art. In my evaluation of whether any claim of the '990 Patent would have been obvious, I considered whether the Petition, or any evidence submitted in this proceeding, presented an articulated reason with a rational basis that would have motivated one of ordinary skill to combine the elements or concepts from the prior art in the same way as in the claimed invention.

37. It is my understanding that there is no single way to define the line between true inventiveness on one hand—which is patentable—and the application of common sense and ordinary skill to solve a problem on the other hand—which is not patentable. For instance, factors such as market forces or other design incentives may be the source of what produced a change, rather than true inventiveness.

38. I understand that the decision-maker may consider whether the change was merely the predictable result of using prior art elements according to their known functions, or whether it was the result of true inventiveness. And, the decision-maker may also consider whether there is some teaching or suggestion in the prior art to make the modification or combination of elements recited in the claim

at issue. Also, the decision-maker may consider whether the innovation applies a known technique that had been used to improve a similar device or method in a similar way. The decision-maker may also consider whether the claimed invention would have been obvious to try, meaning that the claimed innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art.

39. I have been instructed by counsel that if any of these considerations are relied upon to reach a conclusion of obviousness, the law requires that the analysis of such a consideration must be made explicit. I understand that the decision-maker must be careful not to determine obviousness using the benefit of hindsight and that many true inventions might seem obvious after the fact. I understand that the decision-maker should consider obviousness from the position of one of ordinary skill at the time the claimed invention was made, and that the decision-maker should not consider what is known today or what is learned from the teaching of the patent.

40. I understand that in order to determine whether a patent claim is obvious, one must make certain factual findings regarding the claimed invention and the prior art. Specifically, I understand that the following factors must be evaluated to determine whether a claim is obvious: the scope and content of the prior art; the difference or differences, if any, between the claim of the patent and the prior art; the level of ordinary skill in the art at the time the claimed invention was made; and,

if available, the objective indicia of non-obviousness, also known as “secondary considerations.”

41. I understand that the secondary considerations include: commercial success of a product due to the merits of the claimed invention; a long felt need for the solution provided by the claimed invention; unsuccessful attempts by others to find the solution provided by the claimed invention; copying of the claimed invention by others; unexpected and superior results from the claimed invention; acceptance by others of the claimed invention as shown by praise from others in the field or from the licensing of the claimed invention; teaching away from the conventional wisdom in the art at the time of the invention; independent invention of the claimed invention by others before or at about the same time as the named inventor thought of it; and other evidence tending to show obviousness.

42. I understand that, to establish a secondary consideration, the evidence must demonstrate a nexus between that secondary consideration and the claimed invention.

VI. OVERVIEW OF THE RELEVANT TECHNOLOGY

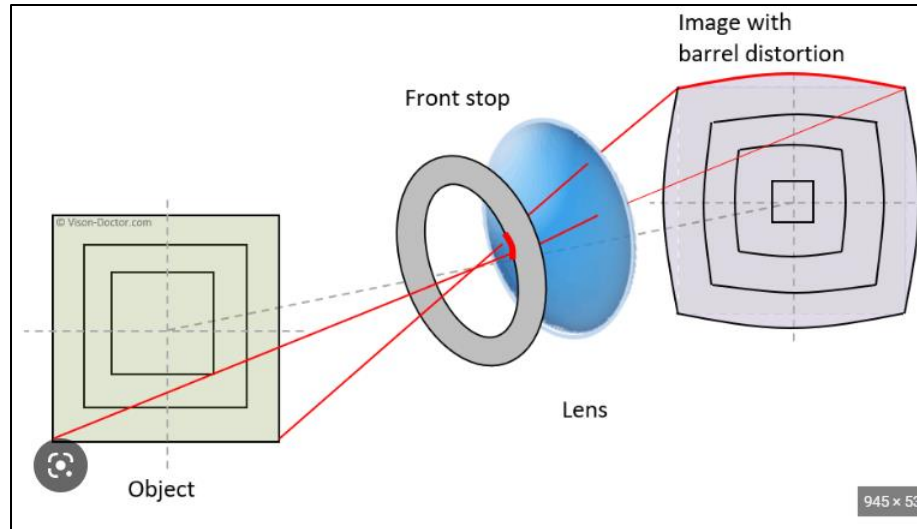
A. Rectilinear Imaging

43. Since near the beginning of photography (around the year 1840), lenses were designed and used to provide images. Lenses used in photography have to focus a beam of light coming from an object placed at a distance away from the

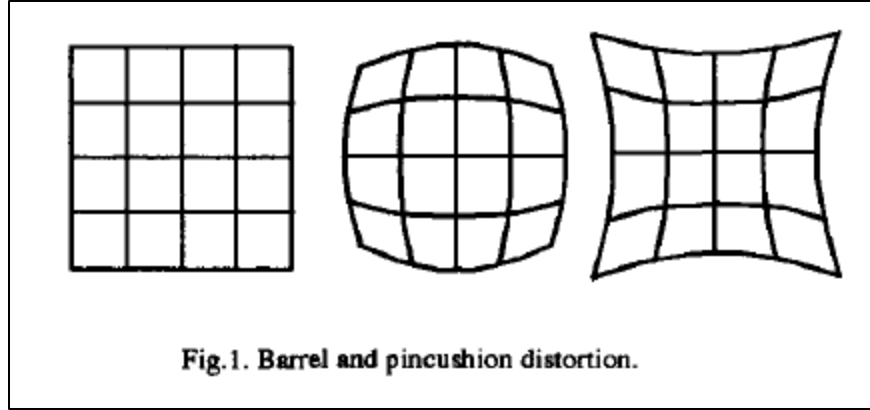
smallest spot/point at the image plane, where an image capture device is positioned (e.g., photographic film or an image sensor such as a charge-coupled device (CCD))).

44. In addition to getting the small focused spot/point at the image plane, optical designers of imaging lenses generally had to consider the location of this spot at the sensor. Their main concern was and still is to control distortion in the lenses.

45. Distortion is the deviation of the spot at the image plane from the position it should be at.



46. However, when distortion is present, it can be readily seen, as shown in the images below, which show a comparison of an image with no distortion relative to images with distortion, namely barrel and pincushion distortion.



APPLE-1013, 1 (showing no distortion in first image from left; showing barrel and pincushion distortion in second and third images from left).

47. In other words, before 2001, optical lens designers were striving and largely still are, to provide distortion free rectilinear imaging. In a rectilinear imaging lens with no distortion present, the ideal position r_i of an image point as a function of the field angle θ is given by the following function:

$$r_i(\theta) = f * \tan(\theta) \quad (1)$$

where f is the focal length of the lens and θ is the field angle in degrees. This function is the necessary and sufficient condition for distortion free rectilinear imaging.

48. In reality though, lenses have some distortion and the actual position of an image point as a function of the field angle is given by $r(\theta)$. The default definition of distortion $D_{ist}(\theta)$ in optics is the difference of the actual position $r(\theta)$ of the image at the image sensor relative to the ideal position $r_i(\theta)$, which can be represented using the following equation:

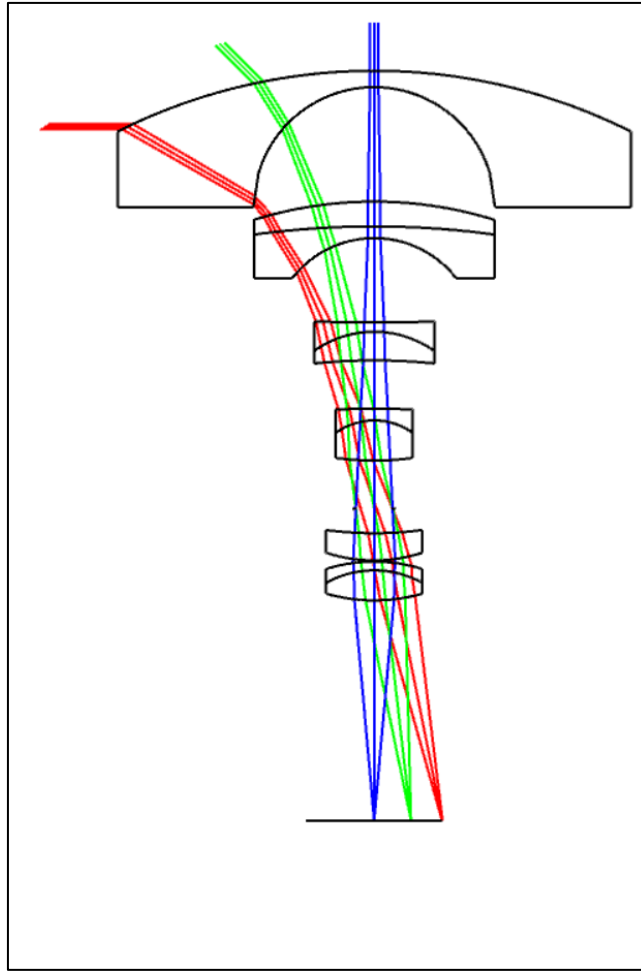
$$Dist(\phi) = 100 * \frac{\mathbf{r}(\phi) - \mathbf{r}_i(\phi)}{\mathbf{r}_i(\phi)} \quad (2)$$

49. Until the inception of digital cameras in the mid-1980s, cameras generally used film to capture images. Lenses in such film cameras had to provide rectilinear imaging since there was no easy way to correct pincushion or barrel distortion other than with the lenses. Thus, almost all lenses at the time were using the $f \cdot \tan(\theta)$ function as the design reference for the image distribution curve and designers generally strived to achieve a certain limited amount of distortion in the captured images.

B. Panoramic/Fisheye Lenses

50. Panoramic imaging began shortly after the invention of photography in 1839. The desire to show overviews of cities and landscapes prompted photographers to create panoramas. Cameras capable of capturing panoramic scenes were either swing-lens cameras, where the lens rotated while the film remained stationary, or 360-degree rotation cameras, where both the camera and the film rotated.

51. Another way to create a panoramic image in “one shot” without swinging the camera was by using a fisheye lens. A fisheye lens covers a hemispherical field of view and when pointed up, the rays shown in red below can in a single shot capture a panoramic image onto a ring on the image plane. *See also* APPLE-1007.



52. Fisheye lenses date back to the inventor Robert W. Woods who developed a lens based on how a fish would view the world beneath the water. However, fisheye lenses did not rise to prominence until the 1960s when the fisheye lens was finally mass-produced.

53. Fisheye lenses cannot be rectilinear. They have large distortion against the $f \cdot \tan(\theta)$ curve needed for rectilinear imaging. This distortion effectively stems from flattening the hemisphere. See APPLE-1007, 1. Fisheye lenses thus use a different reference function, which is represented using the following function:

$$r_i(\theta) = f * \theta \quad (3)$$

See id. This function represents “linear” imaging in this domain and is referred to as the “f-theta” condition. Thus, distortion in fisheyes can be represented using the same equation as shown in equation (1) but with a different reference function, namely the f-theta reference shown above in equation (3).

54. Fisheye lenses are also panoramic lenses because they capture the 360° view when pointing up. Thus, a POSITA would have understood that panoramic lenses include hemispherical and fisheye lenses.

55. Most panoramic lenses use “f-theta” mapping as their design reference and the distortion they aim to control is relative to this linear mapping function. However, there were, and are, applications where lenses with different “image distribution curves” have been implemented.

56. Although the term “image distribution function” is not commonly used in the field, a POSITA would have understood it to be the same as or similar to a lens’s mapping or projection. In 1964, Miyamoto identified different image projections in panoramic lenses. APPLE-1007, 1-2. Miyamoto identified four different image distribution functions or projections, as shown below:

$$r' = f \tan \phi, \quad (1)$$

$$r' = 2f \tan(\phi/2), \quad (2)$$

$$r' = f\phi, \quad (3)$$

$$r' = 2f \sin(\phi/2), \quad (4)$$

where f is the focal length.

57. Miyamoto provided the following graphical representation of the image distribution curves for these four projections:

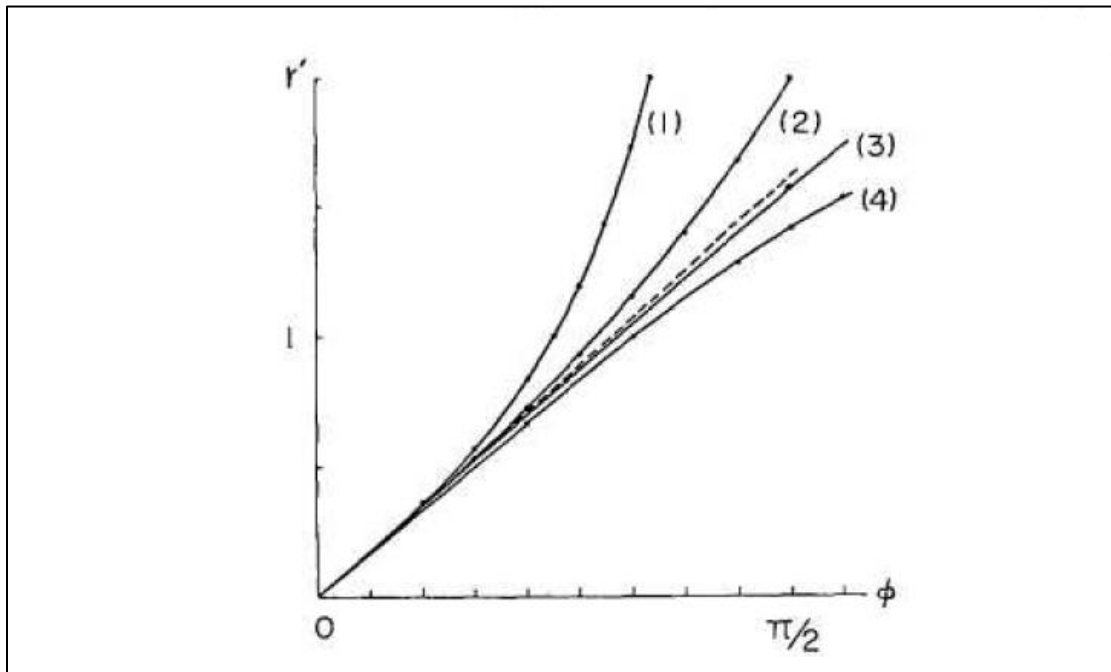


Fig. 1: Curves of different projections. (1) Ordinary projection, (2) stereographic projection, (3) equidistance projection, (4) equisolid angle projection

58. Miyamoto notes that curve 1 is for “camera lenses” and refers to this as an “ordinary projection.” This image distribution is typically used for rectilinear imaging, as I have discussed above. Miyamoto refers to the second curve (curve (2))

as “stereographic projection” and notes “[t]his projection is very similar to our psychological perception of whole sky.” APPLE-1007, 1. Miyamoto refers to the third curve (curve (3)) as “equidistance projection,” which has also been referred to as f-theta projection or the “linear mapping” function, as discussed above. Miyamoto refers to the fourth curve (curve (4)) as “equisolid angle projection” and states that this type of projection or image distribution is preferred when the application calls for uniform brightness with no fall off as a function of the field angle. *See id.*, 1-2.

59. These are just some examples of image distribution curves; however, it was well known before 2001 to have additional or different types of image distribution functions or projections curves, including those disclosed in Fisher, Nagaoka, among many other references from this period.

60. Regardless of the image distribution function used for a particular type of lens, each image distribution function has a characteristic advantage, e.g., in resolution and/or brightness over the field of view. Depending on the application and the requirements presented to an optical designer, the designer would be motivated to choose a particular image distribution and design the lens to have a certain type of deviation, namely distortion, of the designer’s choice. In particular, if the designer seeks to increase the resolution by expanding a certain segment of the field of view—the designer would readily look for a published image distribution

curve, a combination of them, or come up with their own trigonometric function of the field or a polynomial one, suitable for the particular application.

61. Looking at Miyamoto's projections (shown above), a POSITA would have understood that curves 1, 2, and 4 have divergence from a linear function (curve (3)) for various field angles and in some instances, these deviations are larger than 10%. In fact, as observed from the above figure from Miyamoto, each of the curves has at least two zones of distortion. Using curve 3 as an example, one segment of the field reflects a slope that is smaller or less inclined compared to the linear function/curve (curve (3)) and thus, this portion of the image reflected by curve is compressed, and another segment of the field reflects a slope that is larger or more inclined than that of the linear curve and thus this portion of the image is expanded.

C. Optical Designers Understood How to Implement a Particular Image Distribution Function in their Optical Designs

62. Prior to 2001, optical designers used optical design software/programs (also referred to as optical CADs) such as Code V, Accos, Zemax, etc. All optical CADs feature operands for constructing the merit function, which informs the program of the performance that the lens is required to have (my own 1981 Ph.D. dissertation subject was about comparing different ways of constructing the merit function). The programs have some built-in merit functions for getting the spot (image point) sizes small at the image and also for correcting for the most common f-tan-theta and f-theta distortions.

63. Prior to 2001, an optical designer would have been able to design for almost any functional form presented to him/her for the particular application. The designer would have done so, e.g., by adding operands into the merit function, where the operands would specify the desired locations of the image spots/points at the image sensor, for a number of input field points. The designer would then be able to calculate the desired image points using the chosen image distribution function/mapping.

64. The designer would then chose as a starting point for the optical design, a lens with a “design form” which the designer predicts or estimates, either from prior art or from prior experience, to perform over the required field. The designer would then perform an “optimization run” where the optical CAD program would reduce the merit function value and thus tweak the curvatures of the surfaces of the chosen lens and its corresponding lens elements, the distances between the elements, as well as their thicknesses and refractive indices, to achieve the desired image distribution function and also the smallest image point/spot sizes at the image plane.

65. In other words, the optimization run seeks to reduce the optical aberrations. Note that that the five main monochromatic aberrations are spherical aberration, coma, astigmatism, field curvature and distortion, where distortion would be against the chosen image distribution curve.

D. Using Aspherics to Control Distortion

66. Until about the mid-1980s, lenses were based on standard lens elements that have spherical surfaces (i.e., spherical lenses).

67. Aspherics are surfaces which are commonly described as follows:

$$Z(s) = \frac{Cs^2}{1 + \sqrt{1 - (1 + k)C^2s^2}} + A_4s^4 + A_6s^6 + A_8s^8 + \dots \quad (4)$$

where s is the radial distance from the axis, z is the surface sag, k is a conic constant, and C is the curvature. A_4 , A_6 , etc. are additional coefficients.

68. Aspheric surfaces started to become practical in about the mid-1980s. In general, the more an optical designer asks the CAD program to do, e.g., a more complex image distribution function of higher resolution, or higher fields, the more variables the designer would have to provide it.

69. Before the use of aspherics, optical designers sought to achieve their desired image distribution functions by adding more spherical elements to the optical design. Aspherics in contrast provide better performance without increasing the number of elements in the optical design. While aspherics became progressively more acceptable and practical from the mid-1980s to early 2000s, there were still discussions and papers through this period promoting an equally efficient way to increase the numbers of variables using a Gradient Index glass or plastic (GRIN). See, e.g., APPLE-1016, APPLE-1017, APPLE-1018, APPLE-1020, APPLE-1006.

Such a GRIN element could generally be made with an unisotropic index of refraction such as in :

$$n(r) = n_0 + n_2 r^2 + n_4 r^4 + n_6 r^6 + \dots \quad (5)$$

where the index of refraction $n(r)$ changes axially as a function of r , which is the distance from the axis and where the coefficients n_2, n_4, n_6 , etc. would be used as variables.

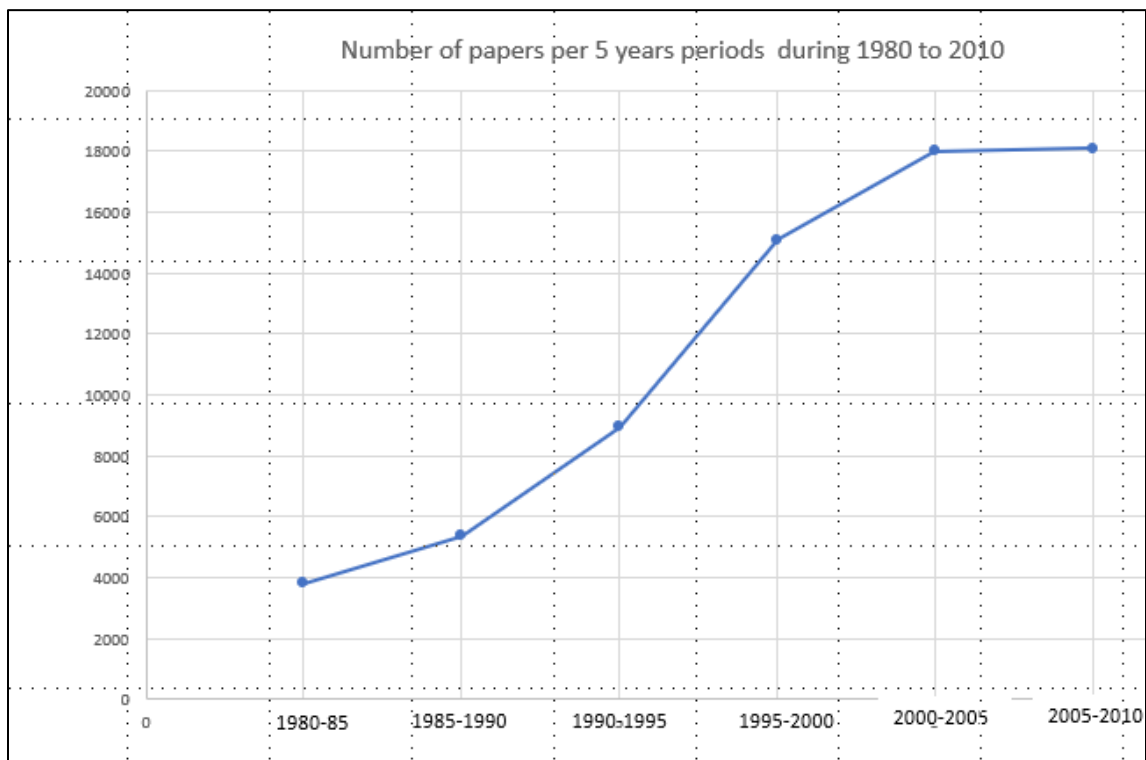
E. Post-Capture Image Processing

70. In 1989, Steven Sasson, working at the Physics Division of Kodak Research Labs (same division of about 300 people I also worked in at the time) developed the first self-contained digital single-lens reflex (DSLR) camera. Electronic cameras since that time have sought to take advantage of post-capture processing of the images to improve the quality of the captured image, namely the distortion and lateral color. This capability was initially used on military, medical, commercial systems, and in specialty areas such as panoramic/fisheye imaging.

F. Panoramic Imaging and Digital Image Processing

71. Panoramic lenses, as discussed above, cannot provide rectilinear imaging. Rectification of the captured panoramic images before sending the images to be displayed thus relies on mapping or warping of the images using image processing algorithms.

72. This area was heavily researched between 1980 and 2000. Indeed, as an indication of the vast amount of work in the area, I searched on google scholar using the search terms of: “hemispherical lens” or “panoramic lens,” “imaging processing” and “display.” The references include predominantly published papers and about 10% of the references are patents. Similar results are obtained when the term



73. This is consistent with my understanding and familiarity with the use of image processing of images (e.g., panoramic images). In general, processing of the panoramic image to rectify the image before projection or display the display is akin to controlling the distortion against the chosen functional reference. Since the beginning of digital cameras, and much before 2001, it was well known to optical

designers (e.g., optical designers (at Kodak or elsewhere)) that some aberrations can be corrected digitally—specifically distortion and lateral color.

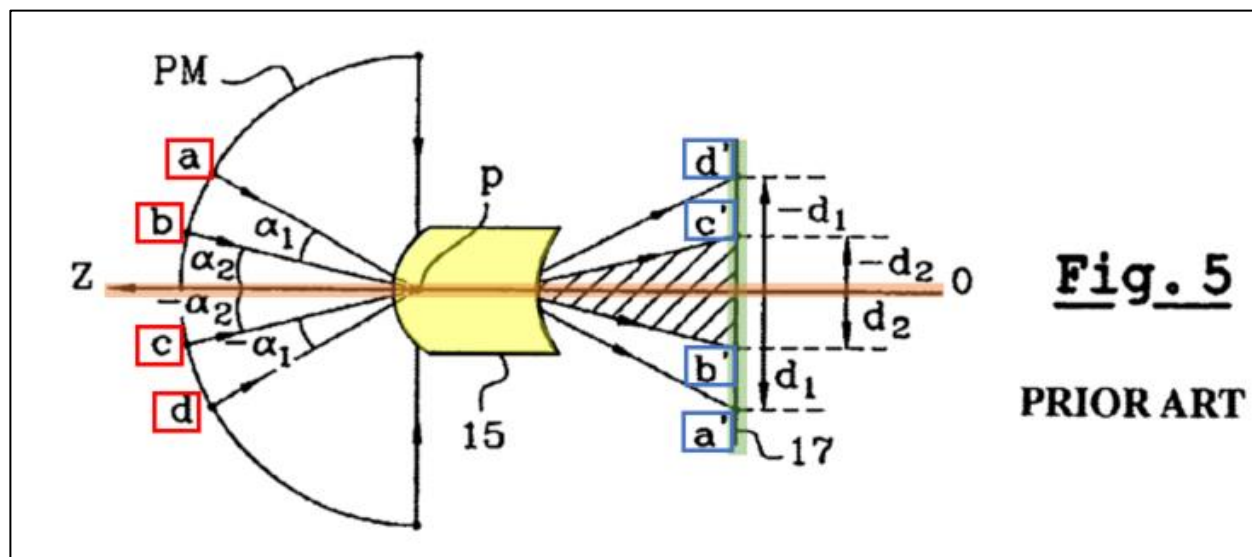
74. This capability of post-capture image processing algorithms was used, e.g., in scanners and cameras, to relax the requirement for the sometime difficult to control lateral color (for example, resorting to apochromatic glasses, which are more expensive than achromatic ones). Similarly, for distortion and before 2001, image correction algorithms were known to provide distortion control and rectification by the addition of on-board processing (i.e., processing capabilities to process the image captured via the camera lens) while allowing for some relaxing in lens resolution and other design aspects otherwise needed to provide such distortion correction. Such post-capture image processing was instrumental in the development of digital cameras and CCD scanners.

VII. THE '990 PATENT

A. Overview

75. The '990 Patent is directed to “a method for capturing a digital panoramic image” using “a panoramic objective lens.” APPLE-1001, Abstract. According to the '990 Patent, Figure 5 (reproduced and annotated below) represents a conventional system “for taking panoramic shots,” and includes a panoramic objective lens 15 (yellow below) having an optical axis OZ (orange below) and a

digital image sensor 17 (green below) arranged in the image plane of the objective lens 15. APPLE-1001, 6:66-7:2.



76. As shown, object points (e.g., a, b, c, d – red above) are projected through the panoramic objective lens and captured as respective image points (e.g., a', b', c', and d' – blue above) at the image sensor 17 (green above). APPLE-1001, 7:2-14.

77. The field angle of each of the object points is identified above as α_1 , α_2 , $-\alpha_2$, $-\alpha_1$ ¹, and represents the “angle that an incident light ray passing through the

¹ In Figure 5, angle α_1 is incorrectly identified as the angle between the points “a” and “b”. The angle α_1 and $-\alpha_1$ should have been shown as being between “a” and the axis OZ, and the angle between “d” and the axis OZ, respectively. APPLE-1001, 7:10-11.

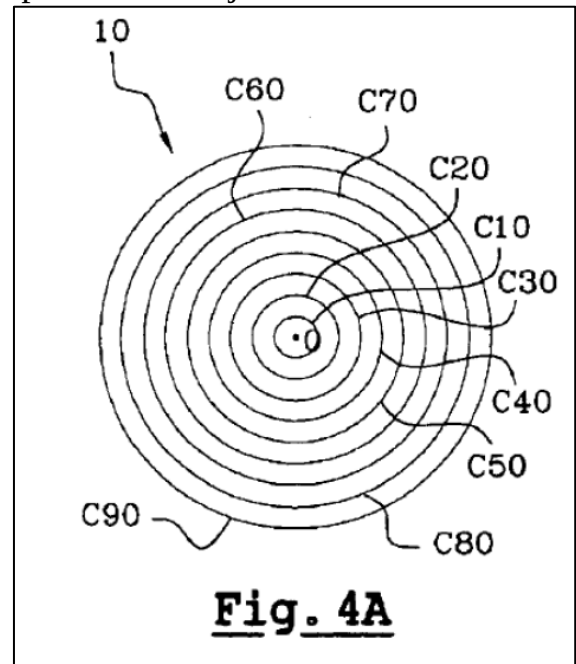
object point considered and through the center of the panorama PM, marked by a point “p” on FIG. 5, has relative to the optical axis OZ of the objective lens.” APPLE-1001, 7:2-10.

78. On the image sensor 17, image points a', b, c', and d' are located at distances from the center of the image respectively equal to d1, d2, -d2, -d1. APPLE-1001, 7:11-14.

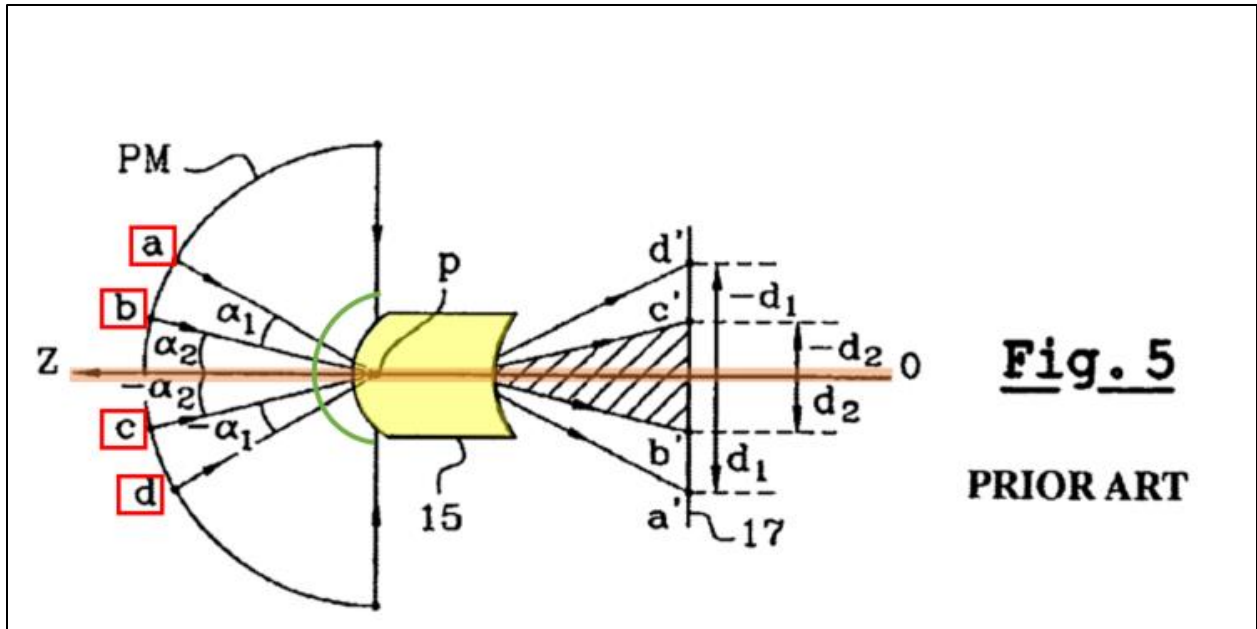
79. According to the '990 Patent, the distribution of the image points according to the field angle of the object points is linear in a prior art panoramic objective lenses. APPLE-1001, 17:14-19. As used in the '990 Patent, “linearity” refers to a ratio of proportionality between the distance of an image point measured relative to the center of the image and the field angle of the corresponding object point. APPLE-1001, 7:24-28. Thus, the distances d1 and d2 are linked by the following relation: $d1/\alpha_1 = d2/\alpha_2$. APPLE-1001, 7:20-22.

80. Since the angle α_1 for object point a is twice angle α_2 for object point b (i.e., $\alpha_1 = 2\alpha_2$), the distance d1 of the corresponding image point a' will be twice the distance d2 of the corresponding image point b' (i.e., $d1 = 2d2$). *Id.*

81. Due to such linearity in prior art panoramic objective lenses and the axial symmetry of panoramic objective lenses, the '990 patent explains that image points corresponding to object points having an identical field angle form equally spaced concentric circles C10, C20 through C90 on an image disk 10, as shown in Figure 4A (right). APPLE-1001, 1:30-32, 2:14-18, 18:17-23, 2:24-29.

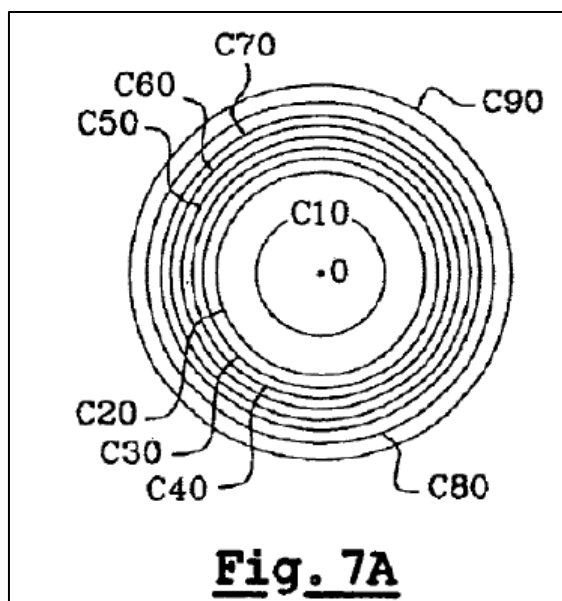


82. Also, because of axial symmetry, the field angle of an object point is between 0° and 90° for an objective lens having an aperture of 180° , e.g., as shown by the green semicircle shown below. APPLE-1001, 1:30-32, 2:22-23, 18:17-23, FIG. 4 (annotated).



83. The '990 Patent claims to provide a panoramic objective lens having an image point distribution function that is not linear relative to the field angle of object points, thereby creating at least one zone of the image that is expanded while at least another zone of the image is compressed. APPLE-1001, Abstract. The '990 Patent, explains that such a lens is that the expanded zones of the image cover more pixels of the image sensor than if they were not expanded, and thus benefit from better definition. APPLE-1001, 4:3-6.

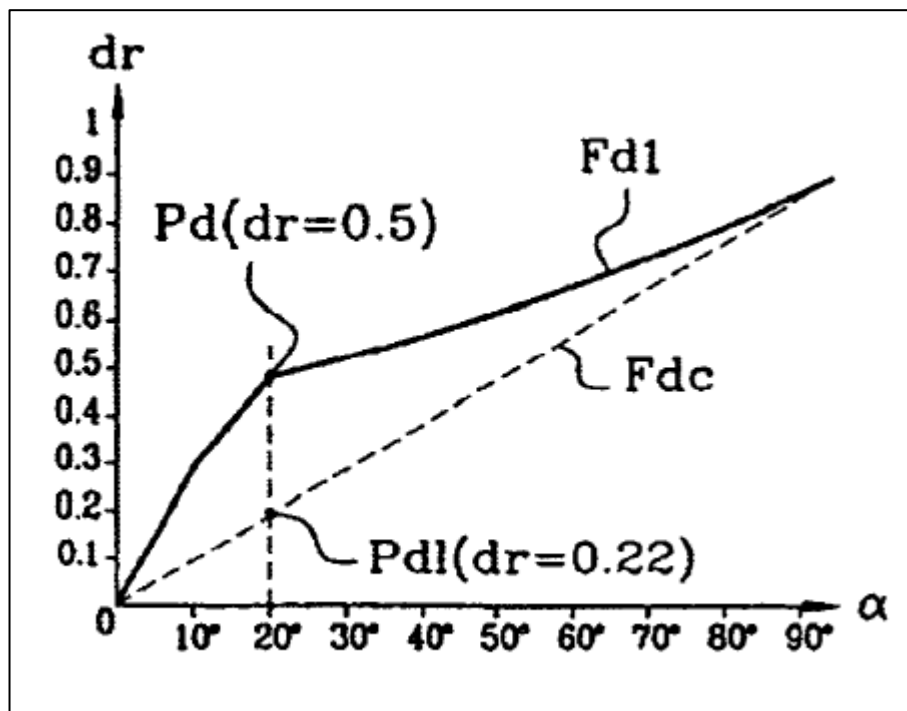
84. The '990 Patent states that the parts of the image to be expanded and compressed, respectively, can be chosen according to the intended application. APPLE-1001, 7:66-8:5, 4:6-10. Figure 7A (below) illustrates one such application by providing an image distribution function of a panoramic objective lens that expands the center of the image:



APPLE-1001, Fig. 7A, 8:12-14.

85. As seen by comparing Fig. 7A with 4A, the circles C10 and C20 are further from the center of the image and further from each other than the circles C10 and C20 obtained with a classical panoramic objective lens, while the circles C30 to C90 are closer to each other. APPLE-1001, 8:21-26. This panoramic image thus has an expanded zone in the center and a compressed zone towards the edge of the image disk. APPLE-1001, 8:26-28.

86. Another way the '990 Patent illustrates the expanded and compressed zones of a panoramic lens is by using a curve of a corresponding image point distribution function as shown in FIG. 7B (reproduced below), where the X-axis represents the field angle of the object point (in degrees) and the Y-axis represents the relative distance of an image point in relation to the center of the image. APPLE-1001, 8:29-38. Note that relative distance is 0 at center of the image or at field angle of 0° , and the relative distance is 1 at the edge/periphery of the image or at the field angle of 90°).



APPLE-1001, Fig. 7B (annotated).

87. As shown, the curve of the function $Fd1$ has a higher gradient than the straight or linear line Fdc for angles α of between 0° and 20° , and then a lesser gradient after 20° and up to 90° . APPLE-1001, 8:38-41. A higher gradient relative

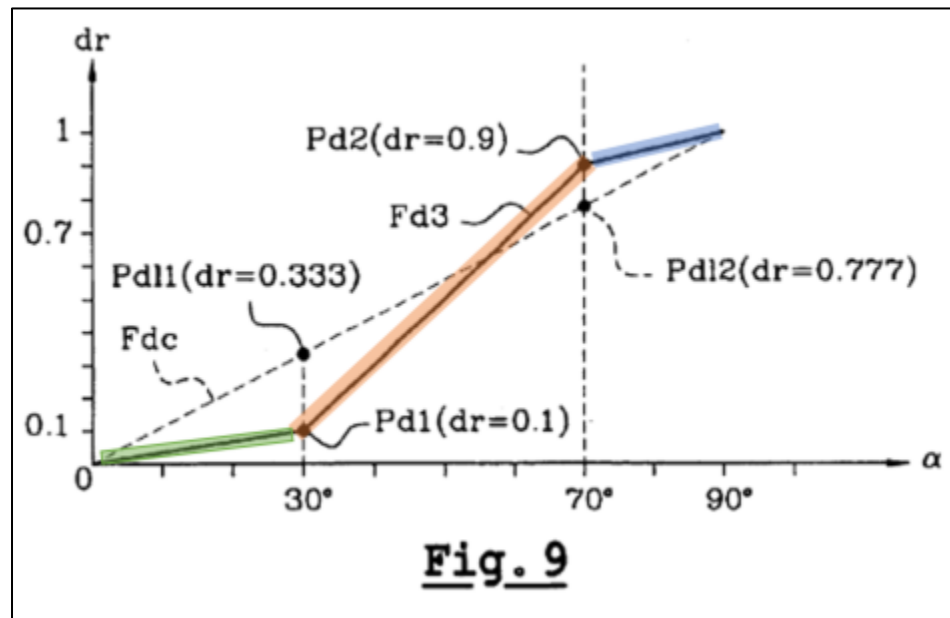
to the linear/straight line means an expansion of the image and a lower gradient means a compression of the image. APPLE-1001, 8:41-43.

88. The '990 Patent describes using this curve to calculate a point of maximum divergence "Pd." APPLE-1001, 8:44-45. The point of maximum divergence is the point with the greatest gap in relative distance dr in relation to the corresponding point on the linear distribution straight line (Fdc). APPLE-1001, 8:45-49. In Figure 7B, the point of maximum divergence is at $\alpha=20^\circ$ and has a relative distance dr equal to 0.5 from the center of the image (i.e., halfway between the center and the periphery of the image), while the corresponding point on the linear curve has a relative distance dr of 0.222. APPLE-1001, 8:49-53.

89. The maximum divergence DIV_{max} of the distribution function $Fd1$ is calculated using the formula: $DIV_{max} \% = \frac{[dr(Pd) - dr(Pdl)]}{[dr(Pdl)]} * 100$, where $dr(Pd)$ is the relative distance from the center of the image to the point of maximum divergence Pd , and $dr(Pdl)$ is the relative distance from the center of the image to the linear distribution straight line, at the same field angle (here 20°). APPLE-1001, 8:54-65. Applying this formula, the maximum divergence at the field angle of 20° in Figure 7B is +125% (i.e., $\frac{[0.5 - 0.222]}{[0.222]} * 100$). APPLE-1001, 9:1-2.

90. Figure 9 (reproduced below) provides another example of a panoramic objective lens with an image distribution function that provides a compressed image zone (green below) between the center of the image (i.e., field angle of 0°) and the

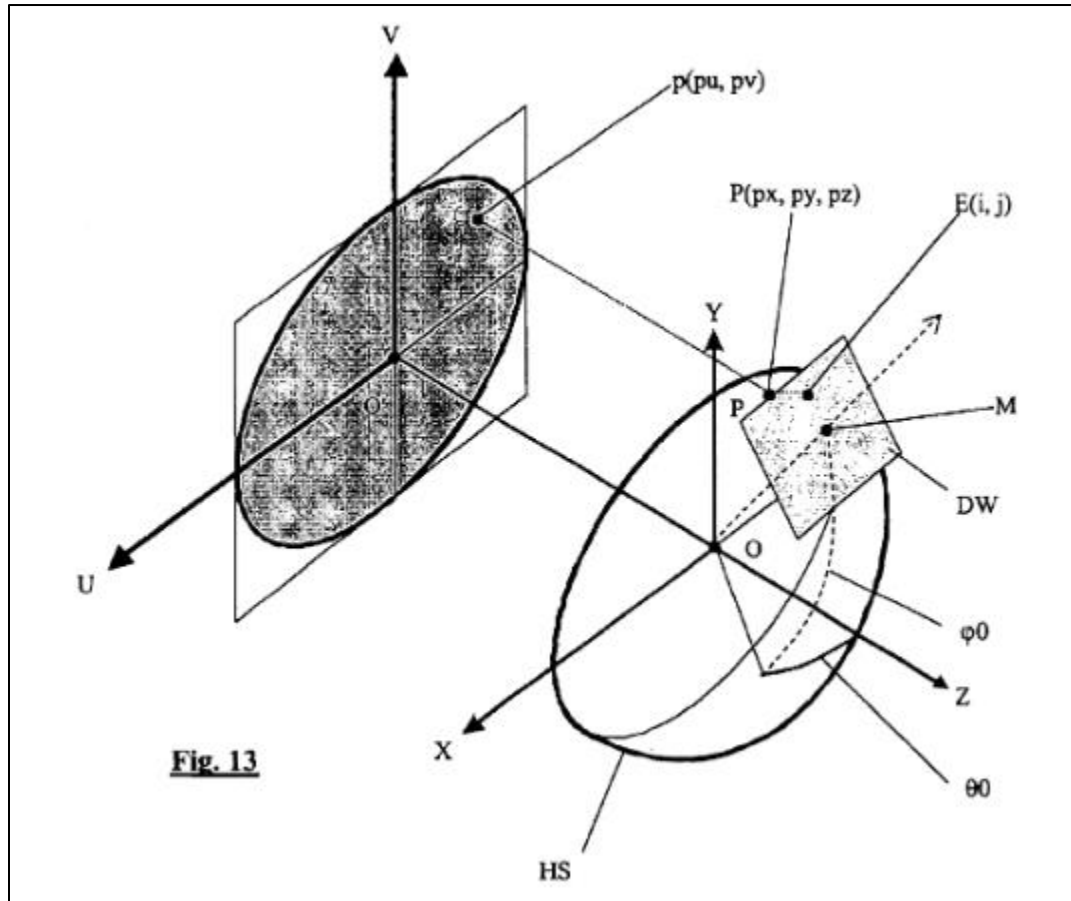
field angle of 30° , an expanded image zone (orange below) between the field angles 30° and 70° , and finally a compressed image zone (blue below) between the field angles of 70° and 90° . APPLE-1001, 9:58-64, Fig. 9.



91. As shown above, the compressed image zones (highlighted in blue and green on the chart) have gradients lower than the gradient of the linear distribution function, while the expanded image zone (highlighted in orange) has a gradient higher than the gradient of the linear distribution function.

92. The '990 Patent states that the non-linearity in the image can be corrected, e.g., using the non-linear distribution function of the objective lens, to display an image that is free from the optical distortion resulting from such non-linearity. APPLE-1001, Abstract, 10:6-17.

93. In one embodiment, and as shown in Figure 13, which is reproduced below, the '990 Patent's correction method involves a two-step technique: (1) projecting the image points of an image sector corresponding to a display window (referred to as $E(i, j)$), onto a sphere portion of a hemisphere of center O and of axes OX, OY, OZ , to obtain image points $P(px, py, pz)$; and (2) projecting the determined image points P onto an image disk (ID1) using the objective lens's non-linear distribution function. APPLE-1001, 12:59-14:35.



94. As shown above, the projection of the image points P (i.e., $P(px, py, pz)$) onto the image disk ID1 allows image points $p(pu, pv)$ to be obtained on the image

disk, in a coordinate system of center O' (corresponding to the center of the image disk) and of axes O'U and O'V. *See id.*

B. File History of the '990 Patent (APPLE-1002)

95. During original prosecution of the '990 Patent, Applicant cited Fisher (APPLE-1009), and foreign counterparts of Baker (APPLE-1006) and Nagaoka (APPLE-1010) (*i.e.*, EP 0 695 085 and EP 1 004 915, respectively). The Examiner issued a first-action allowance and provided the following reasons for allowance:

The prior art fails to teach a combination of all the claimed features as presented, for example, in independent claims 1 and 17, which include a panoramic objective lens having an image point distribution function that is not linear relative to the field angle of object points of the panorama, the distribution function having a maximum divergence of at least +/-10% compared to a linear distribution function, such that the panoramic image obtained has at least one substantially expanded zone and at least on[e] substantially compressed zone.

APPLE-1002, 232-233.

C. Reexamination Summary (APPLE-1011)

96. Patent Owner requested *ex parte* reexamination of claims 1-4, 6-7, 10-11, 15-20, 22-23, and 25 of the '990 Patent. APPLE-1011, 227-237. With the reexamination request, Patent Owner filed a preliminary amendment, in which it cancelled claims 1, 6-7, and 22, added new claims 27-48, and amended claims 2-4

and 15 (where claims 2-4 were amended to now depend from new claim 27). APPLE-1011, 247.

97. The Office granted Patent Owner's request for ex parte reexamination of the '990 Patent, finding that the request raised substantial new questions (SNQ) of patentability with respect to claims for which reexamination was requested. APPLE-1011, 52-63. Baker, Fisher, and Shiota were among the references that were applied during reexamination and which formed, at least in part, the basis for the SNQ finding. *Id.*

98. The Office subsequently issued a Notice of Intent to Issue Ex Parte Reexamination Certification (NIRC), finding claims 2-4 (as amended to depend from new claim 27), 10-11, 15-16, and new claims 27-47 allowable. APPLE-1011, 343-344.

99. In the corresponding reasons for patentability, the Office stated, in part, that new claims 2-4 and 27-47 include the feature of "displaying the obtained panoramic image by correcting the non-linearity of the initial image, performed by retrieving image points on the obtained image in a coordinate system of center O' using at least the non-linear distribution function and a size L of the obtained image," which is purportedly not disclosed by the cited art, which included Baker, Shiota, and Fisher (among other references). *Id.*

100. The reexamination certificate then issued. APPLE-1011, 355-356; APPLE-1001, *Ex Parte Reexamination Certificate*.

D. Interpretation of the '990 Patent Claims at Issue

101. I have been informed to apply (and I have applied) the constructions adopted by the Board in IPR2020-00195 for the following terms (listed in the table below) that also appear in the Challenged Claims.

Claim Term	Construction
“panoramic objective lens”	“a super-wide or ultra-wide objective lens”
“object points of the panorama”	“points of the object in the panorama being viewed by the lens”
“image point”	“a point of light projected by the lens onto an image plane, said light coming from the corresponding object point of a viewed object in the panorama”
“field angle of object points”	“the angles of incident light rays passing through the object points and through the center of the panorama photographed, relative to the optical

	axis of the objective lens”
“maximum divergence”	“Defined by the formula $DIV_{max} \% = \frac{dr(Pd) - dr(Pdl)}{dr(Pdl)} * 100$, where $dr(Pd)$ is the relative distance from the center of the image to the point of maximum divergence Pd, and $dr(Pdl)$ is the relative distance in relation to the center of the corresponding point on the linear image distribution line”
“expanded zone”	“the portion of the image point distribution function where the gradient is higher than the gradient of the linear distribution function”
“compressed zone”	“the portion of the image point distribution function where the gradient is lower than the gradient of the linear distribution function”

102. For all other claim terms, I understand that the terms that appear in the claims of the '990 Patent should be interpreted according to their plain and ordinary

meaning under the *Phillips* standard. In determining the ordinary and customary meaning, I understand that the words of a claim are first given their plain meaning that those words would have had to one of ordinary skill at the time of the alleged invention. I also understand that the structure of the claims, the specification and file history also may be used to better construe a claim insofar as the plain meaning of the claims cannot be understood. Moreover, I understand that even treatises and dictionaries may be used, albeit under limited circumstances, to determine the meaning attributed by one of ordinary skill to a claim term at the time of filing.

103. I have followed this approach in my analysis, and for all of the claim terms (other than those for which the Board has already adopted claim constructions), I have applied the plain and ordinary meaning of those terms. I followed this approach in my analysis. For these terms, based on the prior art's description of the claimed elements being similar to that of the '990 Patent specification, I understand that no formal claim constructions are necessary for these terms in this proceeding because claim terms only need to be construed to the extent necessary to resolve a controversy.

104. I also understand that the words of the claims should be interpreted as they would have been interpreted by one of ordinary skill at the time the invention was made (not today). For purposes of my analysis here, I have been informed to use (and have used) the May 11, 2001 priority date of the '990 Patent as the date of

invention (i.e., the Critical Date). Without exception, however, my analysis of the proper meaning of the recited claim elements (under the *Phillips* standard) in this declaration would be correct if the date of invention was earlier than 2001.

VIII. OVERVIEW OF THE CITED REFERENCES

105. The general descriptions that I have provided for the following references and combinations are incorporated into each subsection and mapping of the claims that includes citations to these references.

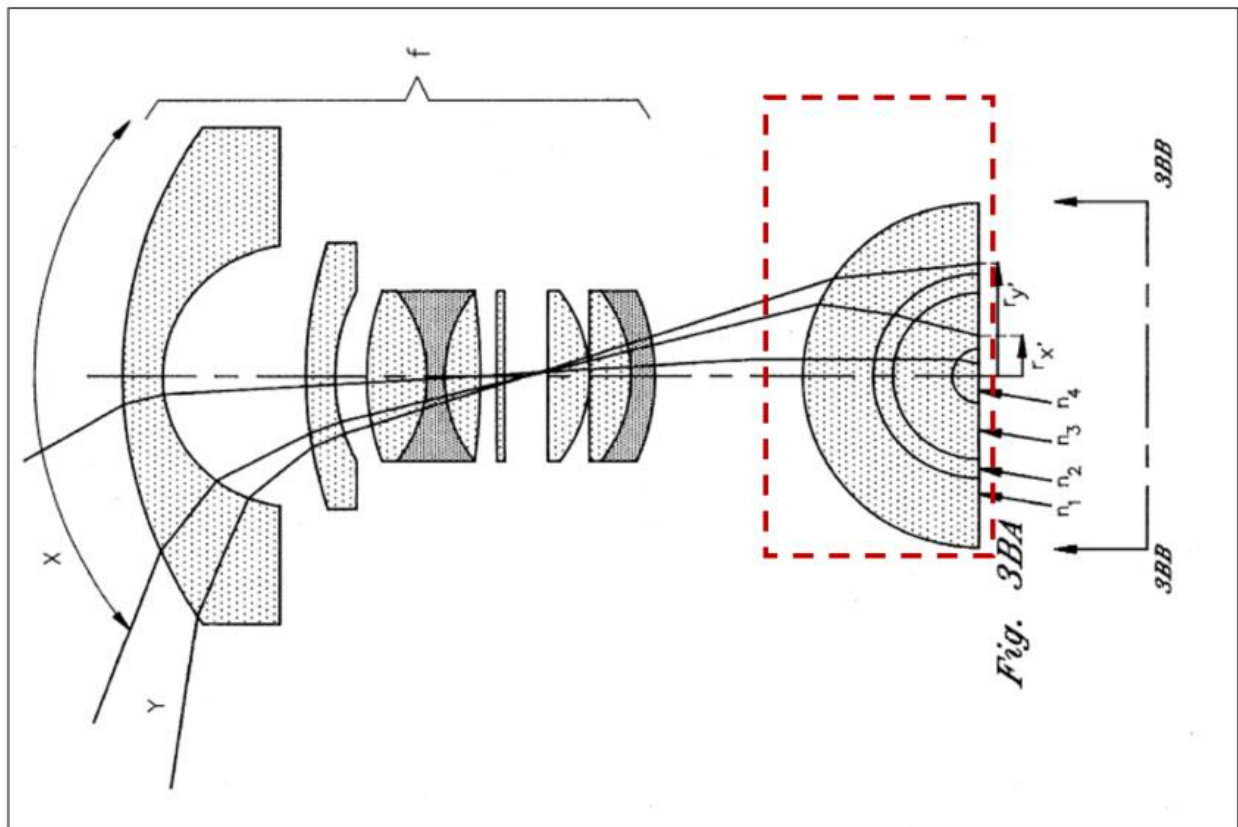
A. Baker (APPLE-1006)

106. Baker discloses a “video conferencing, voice-directional video imaging system for automatic electronic video image manipulation of a selected, directional signal of a hemispheric conference scene” APPLE-1006, 5:16-24.

107. Baker’s system includes an “imaging system” that includes a “camera having a capture lens” that captures a hemispherical or panoramic scene. *Id.*, 5:37-47. In particular, the capture lens in Baker’s system “emphasizes the peripheral content of a hemispherical field of view” (*id.*, 5:48-54) by “imaging the field of view to the image plane such that the ratio of the size of the smallest detail contained within the periphery of the scene to the size of the smallest resolving pixel of an image device is increased.” *Id.*, 5:57-62. Specifically, Baker explains that the “panoramic image” provided by its imager “is ideally suited for teleconferencing” where the “important image information” is located “along a 10 to 30 degree ...

segment of the horizon,” which represents a 60° to 80° segment of the field. APPLE-1006, 5:37-47, 1:52-58; *see id.*, 3-12-16 (“To obtain sufficient detail on the critical objects in the scene, the technique should differentiate between the relevant visual information along the horizon and the remaining visual information in the scene in order to provide greater resolution in areas of higher importance”).

108. An example of Baker’s capture lens as deployed in its imaging system is shown below:



APPLE-1006, FIGS. 3BA-3BB.

109. As shown, Baker’s lens includes a “multi-element refractive lens that is designed to capture a wide field of view” and a “hemispherical lens” (shown in

red annotation above) that “is made of gradient index material” such that “points impinging the image plane incur different factors of magnification depending on what index of refraction and what portion of the hemispherical curve or lenselets they pass through.” APPLE-1006, 11:52-65; *see id.*, 12:5-14 (explaining that, with the gradient index hemisphere, the index value decreases from the center such that $n_1 < n_2 < n_3 < n_4$).

110. Using Baker’s lens, as shown above, the peripheral portion of the scene is “map[ped] to a larger percentage of a given image detector area and, simultaneously, the mapped image of the central area of the scene ... [is] minimized by the lens so that it does not interfere with the peripheral content now covering a wider annulus in the image plane.” *Id.*, 5:55-6:1.

111. Per Baker, the lens can be used to increase resolution in the peripheral portion of an image compared to a typical fisheye lens: “if an ordinary fisheye lens focuses the lowest 15 degrees up from the horizon on ten percent of the imager at the imaging plane and the peripheral-enhancing lens focuses that same 15 degrees on fifty percent of the imager, there is a five-fold increase in resolution using the same imaging device” and “[d]epending on the application and exact formulation of the lens equations, there will be at least a five times increase in resolving power by this lens/imager combination.” *Id.*, 6:43-56; *see id.*, 11:48-51, 12:33-55, 8:32-40, 5:37-47, 1:52-58.

112. Baker acknowledges that the enhanced portion of the field of view depends on the particular application and the enhanced portions typically falls between the above-described examples (one where only 10° from the horizon is enhanced and another where 45° from the horizon is enhanced). APPLE-1006, 12:50-55.

113. Indeed, Baker contemplates one such application where the enhanced portion of the image falls between the above examples. Baker's lens projects an image on an image sensor (e.g., a CCD) of the camera and this image can be stored in memory or another storage device. APPLE-1006, 13:9-18, 14:9-17.

114. "When a portion of the scene is to be displayed," Baker's system retrieves the image information relating to the relevant portion of the scene from memory or another storage device. *Id.*, 6:5-24. Baker explains that the image captured using its lens is in a "warped form" in which the image "warp[ing]" is caused in part by the selective magnification along the peripheral field of view. APPLE-1006, 14:18-26. Baker's system compensates for this warping and displays a "corrected" version of the captured image with the "proper aspect of ratio for the human visual system (i.e., as a perspective corrected view)":

A transform processor subsystem electronically manipulates the scene for display as a perspective-correct image on a display device, such as a teleconference display screen or monitor, as if the particular portion of the scene had been viewed directly with

the video camera pointed in that direction. The transform processor subsystem compensates for the distortion or difference in magnification between the central and peripheral areas of the scene caused by the lens by applying appropriate correction criteria to bring the selected portion of the scene into standard viewing format. The transform processor subsystem can also more fully compensate for any aberrations of the enhanced peripheral image because of the image's improved resolution as it covers a larger portion of the image device (increased number of pixels used to detect and measure the smallest detail in the periphery image).

Id., 6:5-24, 14:42-15:59, 14:23-26 (describing recreation of a “proper display of the scene in two dimensions for perspective-correct viewing).

115. Thus, to perform this correction/transformation—i.e., “compensate[] for the distortion or difference in magnification between the central and peripheral areas of the scene caused by the lens”—Baker’s transform processor applies “appropriate correction criteria to bring the selected portion of the scene into standard viewing format.” APPLE-1006, 6:12-16; see *id.*, 6:16-24 (“transform processor subsystem can also more fully compensate for any aberrations of the enhanced peripheral image because of the image's improved resolution as it covers a larger portion of the image device (increased number of pixels used to detect and measure the smallest detail in the periphery image)”).

B. Shiota (APPLE-1012)

116. Like Baker, Shiota discloses an image transformation system for “transforming a fisheye image obtained by using a fisheye lens” into a “plane image for display.” APPLE-1012, Abstract.

117. Shiota explains that an “image produced by [a] fisheye lens is ... distorted compared to with an image obtained by using [a] standard lens and is very hard for the operator to watch it.” *Id.*, [0003]. Thus, Shiota’s system provides a two-step transformation process that transforms a “circular image obtained by using a fisheye lens into ... a plan[ar] image” (*id.*, [0004]), where the planar image is obtained by projecting points from the hemispherical objective lens surface onto a plane intersecting the lens surface at a point identifying the viewing direction from the origin of the camera. APPLE-1012, [0028]-[0032].

118. At the first step of Shiota’s transformation process, the projection of points P on the plane image (represented by u, v coordinates) are used to obtain the coordinates of the first projection points P’ (X_2 , Y_2 , Z_2) on a hemispherical face. APPLE-1012, [0028]-[0032]. This is similar to the ’990 Patent’s description of projecting image points onto a sphere portion of [a hemisphere] of center O and along the X, Y, Z axes. See APPLE-1001, 12:66-13:4.

119. At the second step of Shiota’s transformation process, the coordinates of the first projection points (i.e., P’ (X_2 , Y_2 , Z_2)) are multiplied by a correction

coefficient k_2 to generate the second projection coordinates (p_1, q_1). APPLE-1012, [0035]-[0041].

120. Shiota discloses computing the correction coefficient k_2 by dividing the lens' image distribution function, h , by the radius r , which represents the distance from the origin to the projected point. APPLE-1012, [0031]-[0035]; *see id.*, [0036] (explaining that height (h) from the origin on the fisheye image face (origin of the p, q coordinate system) to an image point w is expressed as a function of the field angle and the focal distance, f), [0037] (identifying image distribution function including an equidistant projection function ($h=f*\theta$) and stereoscopic projection ($h=2f*\tan(\theta/2)$)); *see* APPLE-1011, 117 (Patent Owner explaining that the function, $h=2f*\tan(\theta/2)$, as described in Shiota, is a non-linear distribution function that produces an image with an expanded portion).

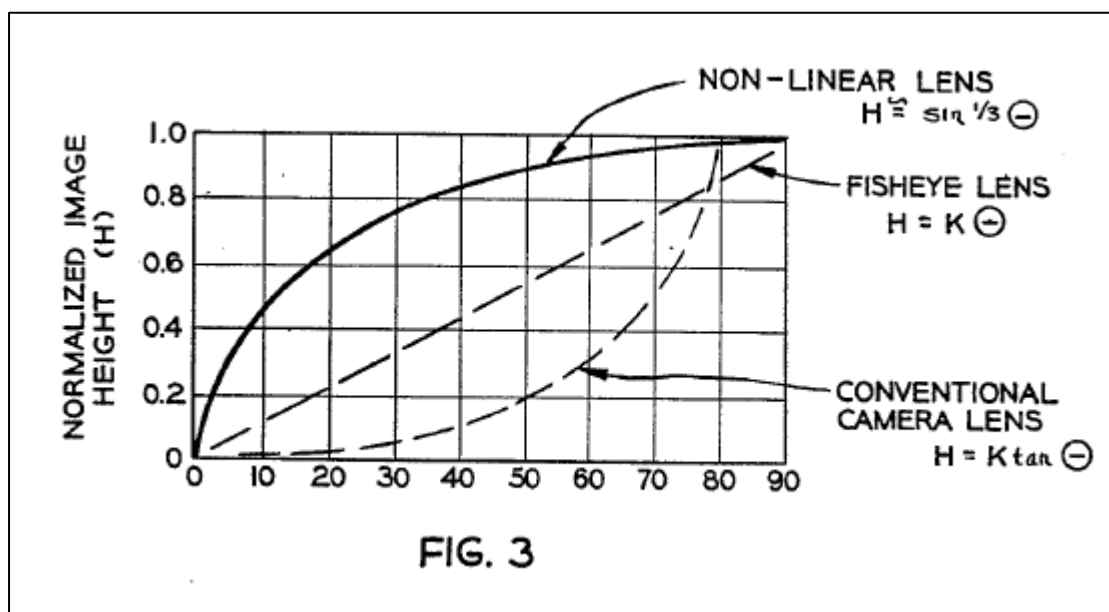
121. The correction coefficient k_2 is then used to obtain the corrected image points (second projection coordinates (p_1, q_1)) that are to be displayed, e.g., by multiplying this coefficient with each of the first projection coordinates X_2 and Y_2 . APPLE-1012, [0031]-[0035], [0042], [0046]; *see* APPLE-1011, 117.

C. Fisher (APPLE-1009)

122. Like Baker, Fisher discloses a fish-eye lens with non-linear image distribution—i.e., with distortion characteristics that result in certain portions of the image captured with such a lens being expanded while other portions of the image

being compressed. See APPLE-1009, Abstract, 2:5-10 (“non-linear lens possesses distortion characteristics which are such that objects along the optical axis of the lens occupy disproportionately large areas of the image cast by the lens, whereas objects near the periphery of the field of view occupy a disproportionately small area of the image.”).

123. FIG. 3, reproduced below, shows “the distortion characteristics” of Fisher’s non-linear lens “in terms of normalized image height and field of view” and compares these “distortion characteristics with the distortion characteristics of a linear fisheye lens and a conventional camera lens”:

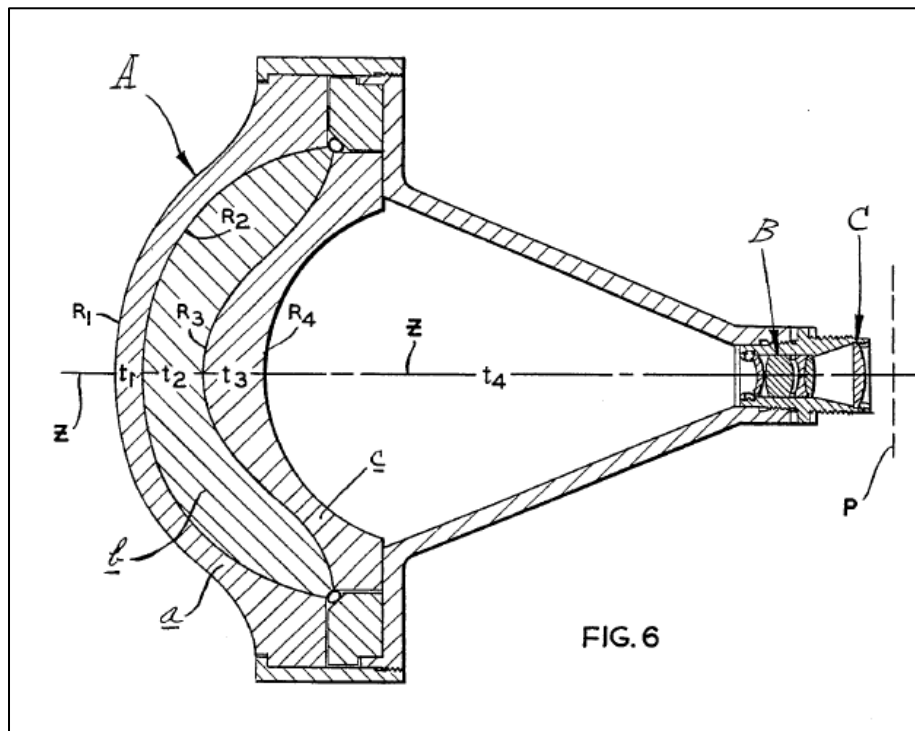


APPLE-1009, 2:38-43, FIG. 3.

124. As shown above, with a linear or fisheye lens, the image height is directly proportional to the field angle; whereas, Fisher’s “non-linear lens” use a

“variable function of the field angle” such that objects located in certain portions of the image (e.g., the center of the image in Fisher’s lens) occupy “a disproportionately large share of the image” compared with objects located in other portions of the image. APPLE-1009, 3:1-15.

125. An example of Fisher’s non-linear lens is provided below:



APPLE-1009, 2:56-57, FIG. 6, 5:44-45.

126. As shown, Fisher’s non-linear lens has three lens groupings A, B, and C. APPLE-1009, 5:44-50. The “first lens grouping A” is “a triplet and provides the mapping function, that is the unique distortion” defined by the non-linear distribution function shown in FIG. 3” (above). APPLE-1009, 5:44-60. The first

lens grouping has lenses with non-spherical (aspheric) lens surfaces. *See* APPLE-1009, 5:61-6:1.

127. Specifically, the first lens grouping A (shown above) includes three adjacent lens elements: an outside lens element *a*, an intermediate lens element *b*, and an inside lens element *c*, with no air gaps between these elements. *Id.* The “outside lens element *a* has a non-spherical surface R_1 exposed outwardly and a spherical surface R_2 ,” the intermediate lens element *b* has a spherical surface R_2 and an opposite surface R_3 that is non-spherical, and the inside lens element *c* has a non-spherical surface R_3 and an opposite surface R_4 that is spherical. *Id.* Thus, a POSITA would have understood that the first lens grouping A, with the non-spherical (aspherical) lens surfaces on the included lenses, achieve the non-linear image distribution described and shown above with reference to FIG. 3. *See id.*, 5:44-6:1.

IX. OVERVIEW OF UNPATENTABILITY GROUNDS

Ground	'990 Patent Claims	Basis
1	27, 2, 4, 29	§103: Baker in view of Shiota
2	29, 30	§103: Baker in view of Shiota and Fisher

X. GROUND 1: BAKER IN VIEW OF SHIOTA RENDERS OBVIOUS CLAIMS 27, 2, 4, AND 29

A. Combination of Baker and Shiota

128. A POSITA would have found it obvious to combine the teachings of Baker and Shiota, and would have been motivated to do so, for at least the reasons described below.

129. As described in §VIII.A (incorporated here), Baker discloses that its objective lens is used to capture an image in a “warped form” in which the image “warp[ing]” is caused in part by the “magnification” or resolution enhancement along the peripheral field of view. APPLE-1006, 14:18-26. Baker’s system “corrects” this warping and displays a “corrected” version of the captured image with the “proper aspect of ratio for the human visual system (i.e., as a perspective corrected view).” APPLE-1006, 14:23-26, 9:5-13.

130. To perform this correction/transformation and “recreate a proper display of the [captured] scene in two dimensions for perspective-correct viewing,” Baker’s system includes “processor logic in transform processor engine 22” (as shown in Baker’s FIG. 1). APPLE-1006, 14:42-47, FIG. 1; *see id.*, 14:47-54. The transform processor “compensates for the distortion or difference in magnification between the central and peripheral areas of the scene caused by the lens by applying appropriate correction criteria to bring the selected portion of the scene into standard viewing format.” APPLE-1006, 6:12-16; *see id.*, 6:16-24.

131. For this transformation, Baker contemplates remapping of two-dimensional images from a set of Cartesian coordinates (x,y) as defined within each image sector “unit” (A1, B1, etc.) onto a newly transformed set of coordinates (u,v). APPLE-1006, 14:55-15:6. According to Baker, this remapping is matched to the image’s distortion—i.e., to the varying enhancement/magnification resulting from Baker’s objective lens. See APPLE-1006, 15:14-19 (“The remapping of the pixel location is matched to the differential magnification of the particular periphery-enhancing lens that is used). From these disclosures, a POSITA would have understood that Baker’s system corrects or compensates for the distortion introduced into the image by its objective lens (which has a non-linear image distribution).

132. However, Baker does not expressly describe how such corrections are applied as part of its image transformation. Before the Critical Date, however, it was well known to compensate for a captured image’s distortion using the non-linear image distribution function of the lens used to capture the image. This is corroborated by, e.g.:

- APPLE-1013, 1-2 (describing correction of distorted images using a function representing the deformation/distortion in the image); and
- APPLE-1014, [0023]-[0026], [0030]-[0031] (disclosing a correction to an image captured using a fisheye lens, where the correction is performed using a non-linear distribution function, $h = 2f \cdot \tan(\theta/2)$).

133. Shiota similarly discloses such well-known compensation or correction of the distortion in an image captured by a fisheye lens using a non-linear distribution function. APPLE-1012, [0028]-[0042]; *see* §VIII.B (incorporated here). Indeed, even Patent Owner has acknowledged that Shiota’s teachings of compensating for the distortion in the image distribution function shows that Shiota discloses correcting the non-linearity of the initial image using a non-linear image distribution function. APPLE-1011, 117

134. Because (1) both Baker and Shiota disclose compensating for or correcting the distortion in an image captured by a fisheye lens, and (2) Shiota provides a well-known technique to implement such a compensation, e.g., by using the non-linear image distribution function of the lens, implementing Baker’s image transformation functionality using Shiota’s described technique of using the non-linear distribution function to perform the image transformation/compensation, would have amounted to the use of a known technique to improve similar devices in the same way, and combining prior art elements according to known methods to yield predictable results—display an image that “compensates for distortion or difference in magnification between the central and peripheral areas of the scene caused by the lens.” *Id.*

135. In fact, because Baker discloses “compensat[ing] for the distortion or difference in magnification between the central and peripheral areas of the scene

caused by the lens” by “matching the differential magnification of” the lens (APPLE-1006, 6:12-22, 15:16-19), a POSITA would have been motivated to use the same non-linear image distribution function that introduced this “differential magnification” to achieve the corresponding distortion/magnification correction. This is further corroborated by, e.g., APPLE-1013, 1-2, which describes correction of distorted images using a function representing the deformation/distortion in the image.

136. I note that Patent Owner has also previously acknowledged that a POSITA “would recognize the need to correct the image captured by Baker” and would have “had reason to consult Shiota for a method for dewarping the image captured by the panoramic lens of Baker” given that Shiota is “in the same field of endeavor” and teaches a method of transforming an image captured using a panoramic lens “into a plane image for display using [a] non-linear image distribution function.” APPLE-1011, 234.

137. For these reasons, a POSITA would have been motivated to implement Shiota’s specific image transformation functionality—namely, the use of the non-linear distribution function—as part of the image transformation functionality provided by Baker’s transform processing subsystem, to achieve Baker’s described “compensat[ion] for distortion or difference in magnification between the central and peripheral areas of the scene caused by the lens.” *Id.*

138. In the resulting combination, Baker’s non-linear image distribution function would be used—as contemplated by Shiota—to achieve Baker’s described “compensation for distortion or difference in magnification between the central and peripheral areas of the scene caused by the lens.” *Id.* Given the similar goals and overall functionality of the Shiota and Baker systems (e.g., displaying an image captured using a fish eye lens that compensates for the image’s distortion/non-linearity), a POSITA would have had a reasonable expectation of success in so combining these references, and would have reasonably expected to reap the benefits of non-linearity/distortion compensation techniques described in both Shiota and Baker, that result in correction of distortion in the image, which in turn results in an image with “the proper aspect ratio for the human visual system (i.e., as a perspective corrected view).” *Id.*

139. The resulting combination of Baker and Shiota renders obvious claims 27, 2, 4, 29, and 30, for the reasons described below.

B. Claim 27

140. Claim 27 of the ’990 Patent recites:

27. A method for displaying a digital panoramic image, the method comprising:

obtaining a digital panoramic image by projecting a panorama onto an image sensor using a panoramic objective lens, the panoramic objective lens having an image point distribution function that is not linear relative to a field angle of object points of the panorama, the distribution function having a maximum divergence of at least $\pm 10\%$ compared to a linear distribution function, such that the panoramic image obtained has at least one substantially expanded zone and at least one substantially compressed zone; and
displaying the obtained panoramic image by correcting the non-linearity of the initial image, performed by retriev-

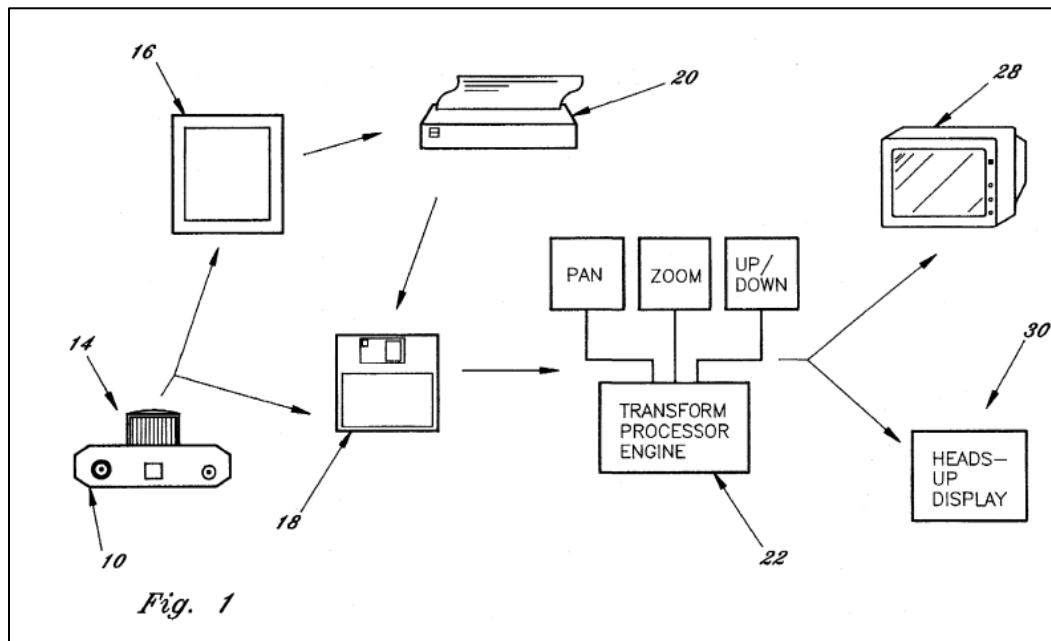
ing image points on the obtained image in a coordinate system of center O' using at least the non-linear distribution function and a size L of the obtained image.

141. As I explain in more detail below through my feature-by-feature analysis, the combination of Baker and Shiota renders obvious claim 27.

[27pre] A method for displaying a digital panoramic image, the method comprising:

142. If the preamble is limiting, Baker in view of Shiota renders obvious a method of displaying a digital panoramic image. As described below, the combination relies upon Baker's and Shiota's teachings of a visual imaging system that uses a lens (e.g., the lens shown in Baker's FIG. 3BA) to project a panorama onto an image sensor (e.g., CCD) that is digitally stored in the system's storage device and subsequently retrieved and transformed (e.g., to correct/compensate for the image distortion caused by the lens) for display on a display device.

143. In more detail, in the combination, Baker provides a “visual imaging system” that uses a “camera to capture the relevant visual information within a panoramic field of view existing along the horizon,” APPLE-1006, 6:29-32²; 8:58-62. An illustration of Baker’s visual imaging system, including the camera 10 and its lens 14 is shown below:



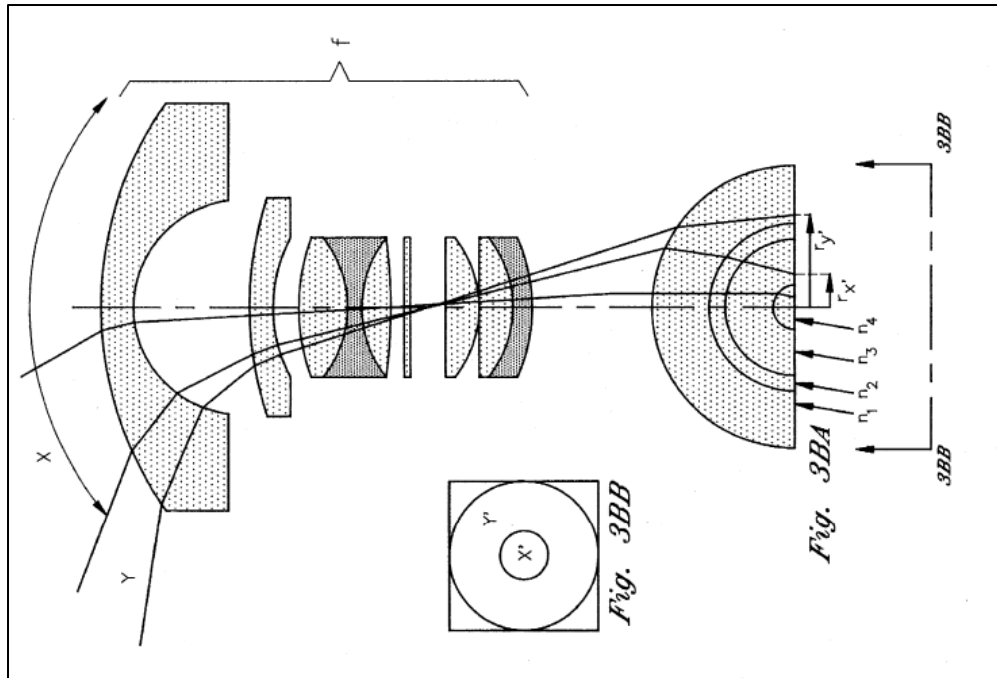
APPLE-1006, FIG. 1.

144. Baker describes that its visual imaging system can be used to “capture a panorama” in multiple applications, including in applications where an “outdoor scene” or a “room scene” is captured as well as in a teleconferencing application where the camera can be placed at a center of a conference table and can capture “a

² Emphasis added throughout unless otherwise noted.

panoramic view of the participants at the conference table or in a conference room.” APPLE-1006, 12:33-46, 10:28-36, 13:56-65 (“panoramic image provided by the imager is ideally suited for teleconferencing”).

145. Baker explains that, using its lens as shown in FIG. 3BA (reproduced below), the panoramic image is projected into the image plane where the image sensor/detector (e.g., a CCD) is positioned. APPLE-1006, 5:55-6:4 (“The lens provides an enhanced view of the valuable information in the scene’s periphery by imaging the field of view to the image plane such that the ratio of the size of the smallest detail contained within the periphery of the scene to the size of the smallest resolving pixel of an image device is increased. For this to be accomplished, the peripheral content must map to a larger percentage of a given image detector area and, simultaneously, the mapped image of the central area of the scene must be minimized by the lens so that it does not interfere with the peripheral content now covering a wider annulus in the image plane. Information in the image plane is then detected by the video camera.”).



APPLE-1006, FIGS. 3BA-3BB.

146. As shown above, Baker’s lens includes sequentially arranged lenses, including among other lenses a “hemispherical gradient index unit with a wide field multi-element lens.” APPLE-1006, 12:6-11. The hemispherical lens “is made of gradient index material such that points impinging the image plane incur different factors of magnification depending on what index of refraction and what portion of the hemispherical curve or lenslets they pass through.” APPLE-1006, 11:54-63.

147. Indeed, by using this hemispherical gradient index unit, “a fairly significant portion of the imaging surface [is] dedicated to the peripheral field, and consequently less of the surface [is] dedicated to the central field,” as illustrated in FIG. 3BB, which shows the field coverage that the lens “provides in the image plane

for detection by an imaging device or substrate.” APPLE-1006, 12:6-14, 12:23-32, 7:55-60.

148. In this manner, Baker explains that its imaging device, which can include “film emulsions or CCD,” when used in conjunction with Baker’s lens, results in the imager/imaging device “collect[ing] more information along the horizon than it will from the central area of the hemispheric scene.” APPLE-1006, 13:9-18.

149. Additionally, the “image received on the imager device is passed on to the system components for storage and/or transmission to a remote teleconferencing site.” APPLE-1006, 14:9-11. Baker explains that the image may be digitally stored in a storage device, such as, e.g., random access memories, a conventional diskette or hard file, or video recording tape. APPLE-1006, 14:12-18. Baker explains that the image is stored in a “warped” form, where the warping is caused not only by the wide angle nature of Baker’s lens “but also by the enhanced peripheral field of view of the lens.” APPLE-1006, 14:18-26.

150. The stored image can then be “transformed for display” (e.g., at the source location or at a remote teleconference location) to correct or dewarp the image. APPLE-1006, 14:42-47. For example, to “recreate a proper display of the scene in two dimensions for perspective-correct viewing,” Baker’s visual imaging system uses “processor logic in transform processor engine” (as shown in Baker’s FIG. 1),

which “compensates for the distortion or difference in magnification between the central and peripheral areas of the scene caused by the lens by applying appropriate correction criteria to bring the selected portion of the scene into standard viewing format.” APPLE-1006, 14:44-47, 6:7-21. The transform processor thus “corrects the” captured panoramic image “for display on a conventional display device 28 such as a video monitor or a video projection display system.” APPLE-1006, 9:8-13 (also enabling display of corrected image on a head-mounted display), FIG. 1.

151. Moreover, as described in §§VIII.B and X.A and with reference to the analysis present in [27e]-[27f] below, Shiota’s teachings are leveraged in the combination to provide specific techniques for compensating for the distortion in the image, e.g., based on a non-linear image distribution. APPLE-1012, [0022]-[0026], [0037]-[0042].

152. For at least the above reasons, Baker in view of Shiota renders obvious a method for displaying a digital panoramic image (to the extent the preamble is limiting). See APPLE-1006, Abstract, 1:9-13, 5:16-20, 5:37-6:36, 7:45-8:9, 8:17-35, 8:58-9:14, 10:61-11:6, 11:52-12:55, 13:9-32, 13:56-65, 14:9-17, 14:42-15:59, FIGS. 1, 1A, 5, 3AA-3AC, 3BA-3BB, 6A-6B; APPLE-1012, Abstract, [0001]-[0002], [0004], [0007]-[0010], [0021]-[0026], [0048]-[0050], claims 1, 5. The additional features of the method for displaying the digital panoramic image are further rendered obvious by the Baker-Shiota combination, as described with

reference to limitations [27a]-[27f] below (which are incorporated herein by reference).

[27a]: obtaining a digital panoramic image by projecting a panorama onto an image sensor using a panoramic objective lens,

153. Baker in view of Shiota renders obvious obtaining a digital panoramic image by projecting a panorama onto an image sensor (e.g., Baker's imager device, such as a CCD) using its panoramic objective lens (e.g., the lens as depicted in FIG. 3BA).

154. Miyamoto (APPLE-1007) in his seminal paper in 1964 stated that a "[l]ens which covers a hemispherical field ($2\omega=180^\circ$) is usually called a fish eye lens." APPLE-1007, 1. Panoramic lenses can be understood in some contexts to be lenses that image the 360° about the viewer. A fish eye lens (or hemispherical lens) when pointing up, captures the horizon much like a panoramic lens. *See id.* Both the '990 Patent and Baker (APPLE-1006) disclose lenses of this category of panoramic fish eye lenses.

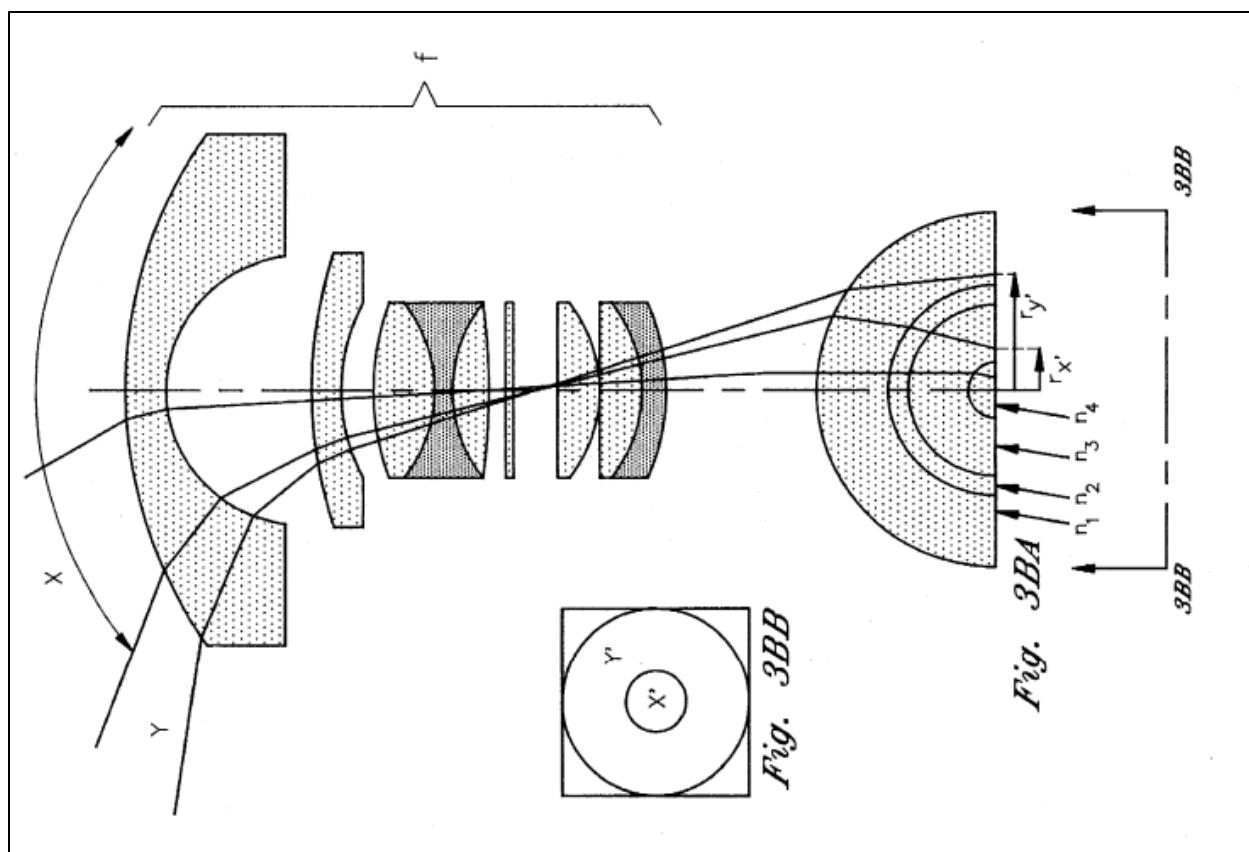
155. The '990 Patent's specification similarly explains that a panoramic objective lens captures a panoramic image and can include a fish eye lens (APPLE-1001, 1:17-20), which a POSITA would have understood as a lens which covers a hemispherical field.

156. Like the 990 Patent's teachings and the well known field of fisheye / panorama lenses, Baker discloses a panoramic objective lens in the form of a lens

that covers a hemispherical field and is used to capture a panoramic image. For example, Baker's "visual imaging system" uses "a single camera to capture the relevant visual information within a panoramic field of view existing along the horizon," APPLE-1006, 6:29-32³; 8:58-62 ("the visual imaging system ... includes a still image or moving picture camera 10, having a lens, ... designed to capture and enhance the peripheral content of a hemispheric scene"), 13:56-57 (providing a "panoramic image" that is "ideally suited for teleconferencing"), 16:19-23, Abstract (providing a system that captures a "panoramic ... scene" and includes a "camera and lens system that provides a panoramic display"). A POSITA would have understood that, because Baker's objective lens captures a panoramic or hemispheric scene, this lens is a super-wide or ultra-wide angle lens.

157. Baker's FIG. 3BA, reproduced below, shows an example lens used in Baker's visual imaging system that is used to capture a panoramic image:

³ Emphasis added throughout unless otherwise noted.



158. As shown in FIG. 3BA (above), and as described with reference to [27pre] (which is incorporated by reference here), Baker's objective lens includes sequentially arranged lenses, including among other lenses a "hemispherical gradient index unit with a wide field multi-element lens," the use of which results in "the portion of the camera dedicated to the periphery [being] increased, thereby increasing the relative resolution of information detectable by the imaging device sensing elements." APPLE-1006, 12:6-11, 12:23-32.

159. Moreover, as described with reference to [27pre], Baker's lens projects a panorama onto an image sensor located in the image plane of the objective lens. For example, Baker's lens "imag[es] the field of view" representing a scene to "the

image plane” APPLE-1006, 5:57-62. In particular, the objective lens is used to image a “panoramic” or “hemispheric” “field of view,” with a particular emphasis on the peripheral content in the image. APPLE-1006, 6:29-35, 8:62-65; *see id.*, 2:35-39. From these disclosures, a POSITA would have understood that Baker’s objective lens projects a panorama into an image plane of the objective lens. *See also* APPLE-1001, 1:17-20 (similarly describing capturing of hemispheric field of view using the panoramic objective lens).

160. Baker additionally provides a digital sensor (e.g., a CCD) that is positioned within the image plane of Baker’s lens and thus, Baker’s lens projects the panorama onto a digital image sensor (e.g., a CCD) located in the image plane of its objective lens. APPLE-1006, 13:9-18, 14:8-17, 5:55-6:4, 7:55-60.

161. Additionally, Baker discloses that that scene/visual information obtained by its objective lens and captured on an image sensor (e.g., a CCD device) “can be stored onto an assortment of media, e.g., ... electronic storage 18, or other conventional storage means.” APPLE-1006, 13:9-18. 8:62-65; 2:35-39; 10:55-57; 14:32-36. Baker thus discloses digital storage of the image captured on its imager device, e.g., within a “storage device” such as “random access memories, a conventional diskette or hard file.” APPLE-1006, 14:9-17. Thus, in view of these disclosures, a POSITA would have understood that Baker’s objective lens obtains a digital panoramic image.

162. For at least the above reasons, the Baker-Shiota combination renders obvious [27a]. *See* APPLE-1006, Abstract, 1:10-14, 6:29-34, 7:12-25, 10:22-12:22, 12:33-55, 13:9-65, 14:9-36, FIGS. 1, 5, 6A-6B, claim 1, FIG. 1, 5, 6A-6B; APPLE-1012, [0002]-[0007], [0021]-[0026], [0048]-[0050].

[27b]: the panoramic objective lens having an image point distribution function that is not linear relative to a field angle of object points of the panorama,

163. Baker in view of Shiota renders obvious the panoramic objective lens (e.g., lens shown in FIG. 3BA) has an image point distribution function that is not linear relative to a field angle of object points of the panoramic image.

164. Specifically, Baker's objective lens (including its series of multiple optical elements), as shown in FIG. 3BA, is "designed to capture and enhance the peripheral content of a hemispheric scene." APPLE-1006, 8:60-62. "To maximize data collection and resolution for analysis and/or display of the relevant visual information located in this portion of the hemispheric scene," Baker contemplates "maximiz[ing] the dedication of the available image detection area to this peripheral field portion." APPLE-1006, 8:32-36.

165. As to the example objective lens shown in FIG. 3BA, Baker explains that, by using a "hemispherical gradient index unit with wide field multi-element lens," the "portion of the camera dedicated to the periphery is increased, thereby

increasing the relative resolution of information detected by the imaging device[’s] sensing elements.” APPLE-1006, 12:6-14.

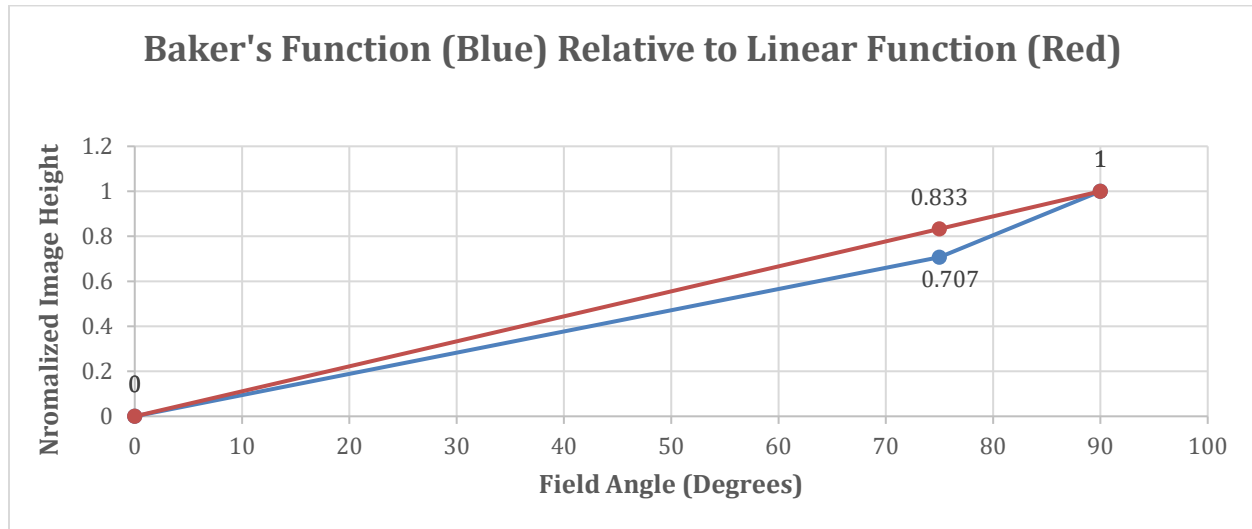
166. In one application of its objective lens, Baker explains that, compared to “an ordinary fish eye lens” that “focuses the lowest 15 degrees up from the horizon on ten percent of the imager at the imaging plane,” the objective lens, e.g., as shown in FIG. 3BA, “focuses that same 15 degrees on fifty percent of the imager” at the imaging plane. APPLE-1006, 6:48-56. Per Baker, this results in a “five-fold increase in resolution” and “at least five times increase in resolving power by this lens/imager combination.” *Id.*

167. The following plot shows an image distribution function that corresponds to Baker’s objective lens as described above—where the last 15° segment of the horizon fills the top 50% of the image height. A POSITA would have understood that 0° of the horizon represents a field angle of 90°, and thus, the reference to the last 15° segment of the horizon represents a field angle of 75° to 90°.

168. Using a normalized image height of 1 at a field angle of 90°, a POSITA would have determined that the area of the circular image with height h at 75° occupies 50% of the area of the entire circular image. This relationship can be represented as: area of circular image at height h (at 75°) = $\pi \cdot h^2 = \pi \cdot r^2 \cdot 0.5$, where $r=1$). Thus, when solving for h in the above equation, which would be the square

root of $(1^2 \cdot .5)$, h at 75° is 0.707. In comparison, the linear curve at 75° has a corresponding image height of .8333

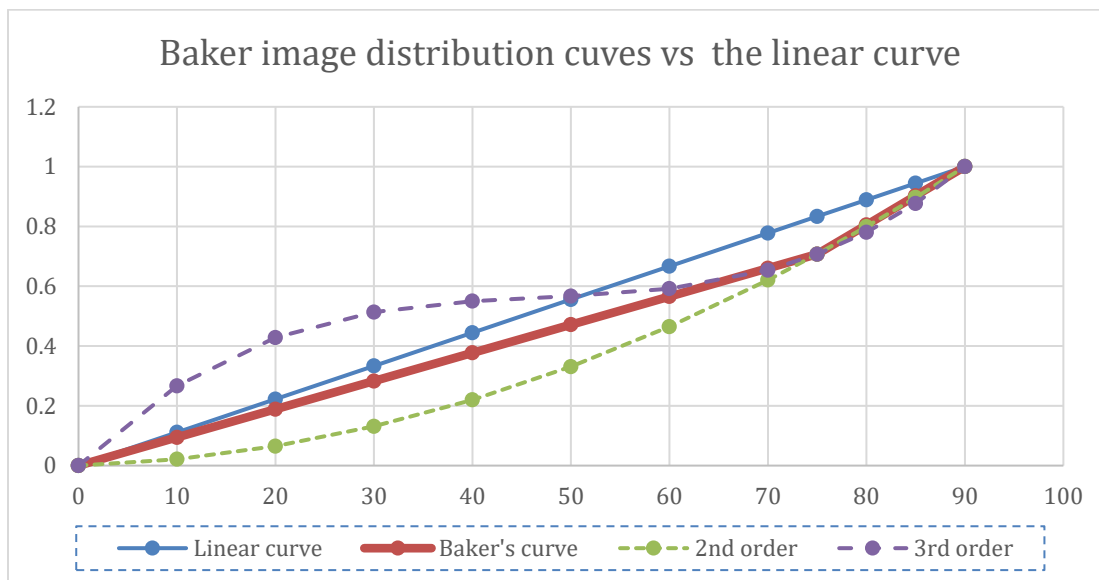
169. Baker's image distribution function can be represented using the following plot showing the normalized image height at various field angles:



170. In the above graph, a red line has been added to present a linear function that has a constant gradient that results in a linear growth/increase in field angle and the corresponding distance of an image point relative to the center of the image.

171. A comparison of the blue line (representing Baker's function) to the red line (representing a linear function) shows that Baker's function has varying gradient at different field angles. For example, relative to the linear distribution function, a Baker's function has lower gradient for the field angle between 0° and 75° and a higher gradient for the field angles between 75° and 90° . This shows that Baker's

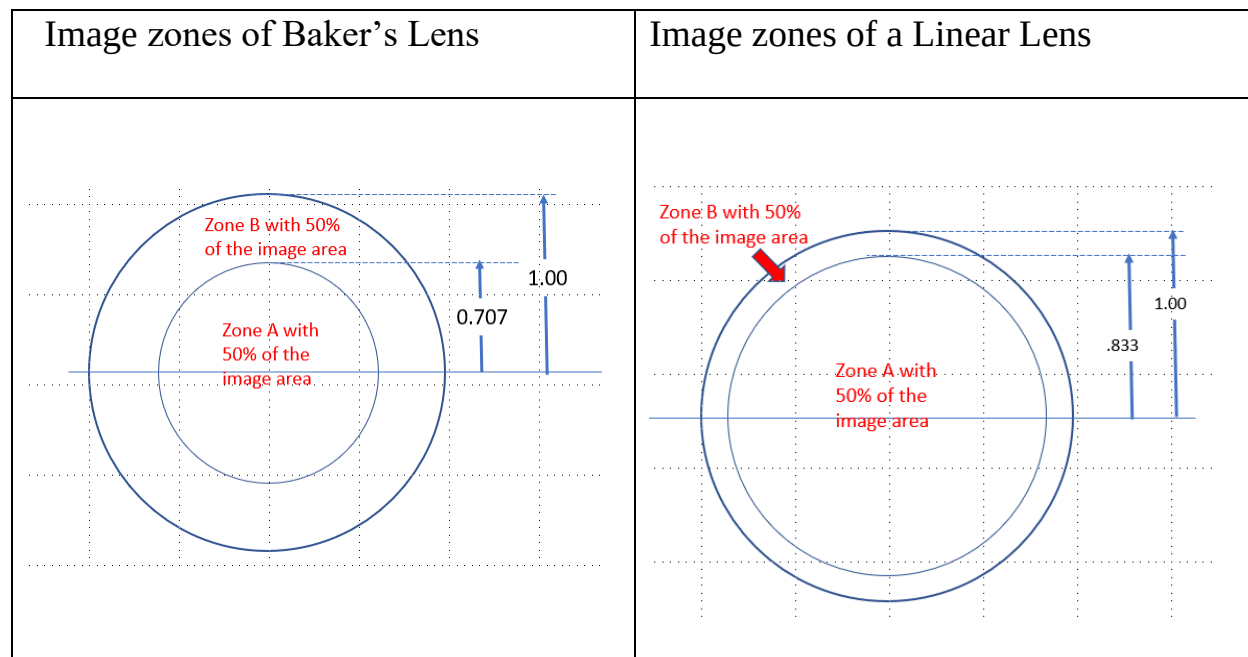
objective lens has an image distribution function that is not linear relative to the field angle (of the object points of the panorama).



172. The Baker curve was shown above as two linear segments. Using the same two data points at 75° and 90°, a POSITA could also use other curves such as a second order polynomial shown in green or a third order polynomial shown in cyan all having 0.707 image height at 75° and all exhibiting different magnification or gradient zones

173. This non-linearity can be further illustrated with reference to an image sensor circle diagram, akin to what is disclosed and shown in the '990 Patent (see APPLE-1001, Fig. 4A, 2:14-29). Assuming a normalized image height of 1 at a field angle of 90°, a POSITA would have observed that Baker's fisheye lens in the above scenario would define two image zones (Zone A and Zone B), with Zone A

appearing more compressed and Zone B appearing more compressed relative to a lens with a linear image distribution function:



APPLE-1006, FIGS. 2B, 3B; *see id.*, 13:29-65.

174. For at least the above reasons, a POSITA would have understood or found obvious that Baker's objective lens has an image point distribution function that is not linear relative to the field angle of object points of the panorama. Therefore, the Baker-Shiota combination renders obvious [27b]. *See* APPLE-1006, Abstract, 4:24-29, 5:37-6:4, 6:29-56, 8:16-55, 9:62-10:5, 10:22-11:6, 11:42-51, 11:52-12:55, 14:18-26, 15:13-19, claims 1-4, FIGS. 1, 3AA-3AC, 3BA-3BB, 5.

[27c] the distribution function having a maximum divergence of at least +/-10% compared to a linear distribution function,

175. Baker in view of Shiota renders obvious that the panoramic objective lens (e.g., Baker's lens as shown in FIG. 3BA) has an image point distribution

function with a maximum divergence of at least +/-10% compared to a linear distribution function.

176. The '990 patent's specification provides the following description regarding the computation of the maximum divergence relative to a linear distribution function:

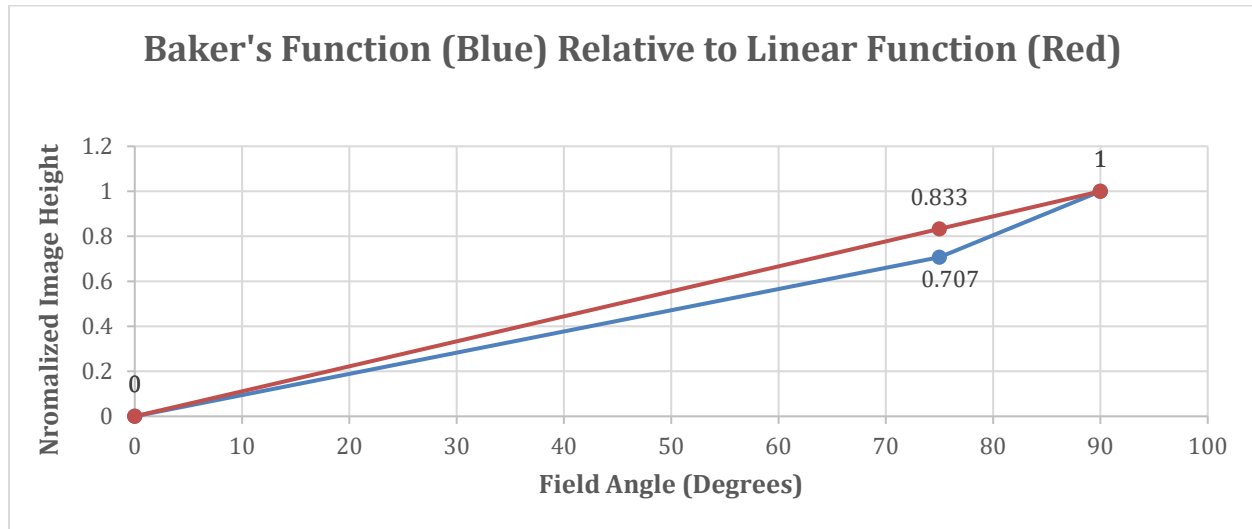
As demonstrated in this example, the curve Fd1 has a point of maximum divergence Pd at the angle $\alpha=20^\circ$. "Point of maximum divergence" refers to the image point Pd(α) at which the greatest gap in relative distance dr in relation to a corresponding point Pd1(α) on the linear distribution straight line Ka can be observed. In this example, the point Pd($\alpha=20^\circ$) has a relative distance dr equal to 0.5 relative to the center of the image while the corresponding point Pd1($\alpha=20^\circ$) on the linear curve Fdc has a relative distance dr of 0.222. The maximum divergence DIVmax of the distribution function Fd1 according to the present invention can be calculated by a formula of the type:

$$DIVmax \% = \frac{[dr(Pd) - dr(Pd1)]}{[dr(Pd1)]} * 100$$

APPLE-1001, 8:44-60.

177. Using this maximum divergence formula to the image distribution functions described with reference to [27b] (which are incorporated herein by reference), a POSITA would have understood or found obvious that Baker's image distribution function has a maximum divergence of at least $\pm 10\%$ compared to a linear distribution function.

178. For example, the following plot shows one example image distribution function that corresponds to Baker's objective lens as described with reference to [27b]—where the last 15° up from the horizon (where the horizon is at 90°) fills the top 50% of the image height:



179. In this example, a POSITA would have understood that the gap between the linear distribution function (red) and Baker's image distribution function (blue) is greatest at the field angle of 75°.

180. At that angle, the relative distance of an image point on Baker's function ($dr(Pd(75))$) is 0.707 and the relative distance of a corresponding point on the linear distribution function ($dr(Pd1(75))$) is 0.833. When applying the maximum divergence formula recited in the '990 patent ($DIV_{max} \% = \frac{dr(Pd) - dr(Pd1)}{dr(Pd1)} * 100$), the resulting maximum divergence amounts to approximately about -15% (i.e., $[0.707 - 0.833] / 0.833 * 100$).

181. For at least the above reasons, the Baker-Shiota combination renders obvious [27c]. See APPLE-1006, Abstract, 4:24-29, 5:37-6:4, 6:29-56, 8:16-55, 9:62-10:5, 10:22-11:6, 11:42-51, 11:52-12:55, 14:18-26, 15:13-19, claims 1-4, FIGS. 1, 3AA-3AC, 3BA-3BB, 5.

[27d]: such that the panoramic image obtained has at least one substantially expanded zone and at least one substantially compressed zone, and

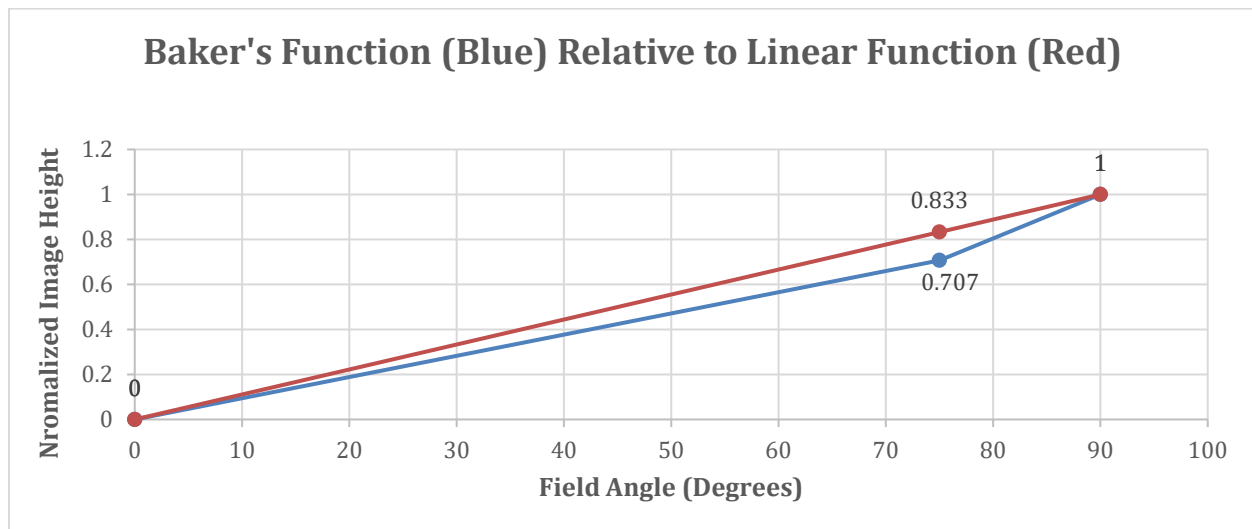
182. Baker in view of Shiota renders obvious that the panoramic objective lens (e.g., Baker's lens as shown in FIG. 3BA) projects a panoramic image that has at least one substantially expanded zone and at least one substantially compressed zone(s).

183. As described with reference to [27a]-[27b] (which are incorporated by reference here), Baker's objective lens obtains a panoramic image.

184. Baker's objective lens also projects a panoramic image in which the obtained panoramic image has one substantially expanded zone and one substantially compressed zone. Specifically, Baker discloses that the panoramic image obtained by its objective lens "has a fairly significant portion of the imaging surface dedicated to the peripheral field, and consequently less of the surface dedicated to the central field," such that the lens "fill[s] the greater available area of an imager device with the peripheral areas than the central areas of the captured scene." APPLE-1006, 12:29-32, 10:46-60; see *id.*, 5:57-61 (describing the objective

lens providing an “enhanced view of the valuable information in the scene’s periphery such that the “peripheral content ... map[s] to a larger percentage of a given image detector area and, simultaneously, the mapped image of the central area ... [is] minimized”), 6:43-56.

185. This is illustrated using the image distribution function described and depicted with reference to [27b]-[27c] (which are incorporated by reference here), where at least one zone of the image (e.g., a zone ranging from 75° to 90° of the field) occupies 50% of the image height and has greater resolution relative to at least one other zone (e.g., a zone ranging from 0° to 75°) that occupies occupying less of the image height and has lesser resolution.

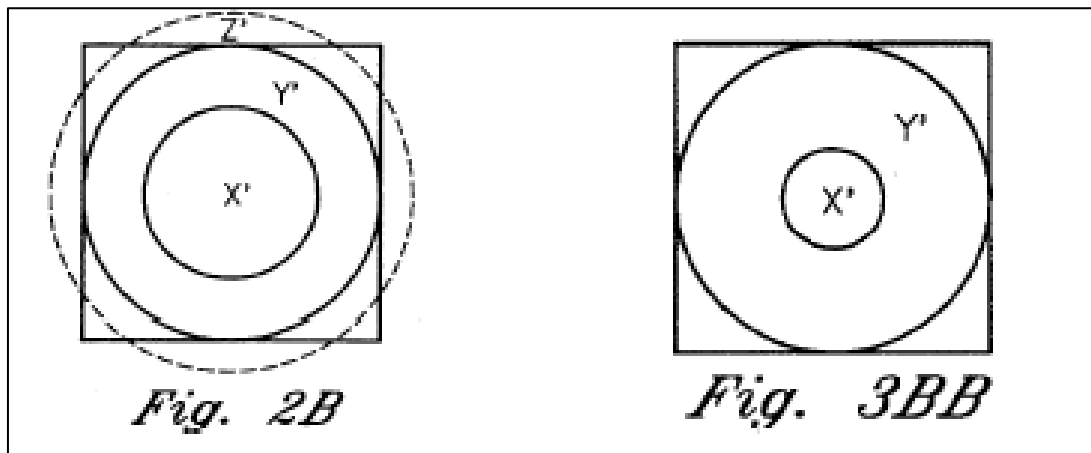


186. As shown above, the gradient of the above image distribution function in Baker (blue) is less than that of the linear distribution function (red) for the zone ranging from 0° to 75° , and thus, this zone represents a compressed zone. In

particular, for this 0° to 75° segment of the field, gradient of Baker's function is 0.009 ($0.707/75$), which is less than the linear function's gradient of 0.011 ($1/90$).

187. The gradient of Baker's image distribution function (blue) is higher than that of the linear distribution function (red) for the zone ranging from 75° to 90° , and thus, this zone represents an expanded zone. Specifically, for the 75-90 degree segment of the field, gradient of Baker's function is 0.0195 ($((1-0.707)/(90-75))$), which is higher than the linear function's gradient of 0.011 ($1/90$)).

188. This is also illustrated when comparing Baker's figures: FIG. 2B, which relates to an objective lens (as shown in FIG. 2A) with a linear image distribution function, and FIG. 3BB, which provides an objective lens (as shown in FIG. 3BA) with a non-linear image distribution function (as described above with reference to [27b] and [27c], which are incorporated here by reference):



APPLE-1006, FIGS. 2B, 3BB.

189. A comparison of the image in Fig. 2B to the image in Fig. 3BB (image obtained using the lens in FIG. 3BA with a non-linear image distribution) shows that zone X' has been substantially compressed and zone Y' has been substantially expanded when using Baker's objective lens shown in FIG. 3BA.

190. For at least the above reasons, the Baker-Shiota combination renders obvious [27d]. See APPLE-1006, Abstract, 5:37-6:4, 6:29-56, 8:17-55, 10:37-12:55, 13:29-65, 14:18-26, 15:14-19, FIG. 3BA-3BB, 2A-2B, 5, claims 1-4.

[27e]: displaying the obtained panoramic image by correcting the non-linearity of the initial image,

191. As described below, and as acknowledged by Patent Owner during its self-initiated reexamination of the '990 Patent, Baker in view of Shiota renders obvious displaying the obtained panoramic image by correcting the non-linearity of the initial image.

192. The combination relies upon Baker's teachings of displaying a transformed image on a display device by "compensat[ing] for the distortion" in the image "caused by" its lens (e.g., the lens shown in FIG. 3BA). APPLE-1006, 6:5-24, 9:5-13; see APPLE-1001, 7:24-28, 10:60-11:8. Specifically, Baker describes that an image captured by its camera (and the associated panoramic objective lens) can be "transformed for display" at a "source location or a remote teleconference location." APPLE-1006, 14:42-47. Baker explains that the image captured using its lens is in a "warped form" in which the image "warp[ing]" is caused in part by

the selective magnification along the peripheral field of view. APPLE-1006, 14:18-26. Baker's system compensates for this warping and displays a "corrected" version of the captured image with the "proper aspect of ratio for the human visual system (i.e., as a perspective corrected view)." APPLE-1006, 14:23-26.

193. To perform this correction/transformation and "recreate a proper display of the [captured] scene in two dimensions for perspective-correct viewing," Baker's system includes "processor logic in transform processor engine 22" (as shown in Baker's FIG. 1). APPLE-1006, 14:42-47; *see id.*, 14:47-54 ("The transform processors may be made of collections of small-scale, medium-scale, large-scale, or very-large-scale integrated (VLSI) circuits, examples of which are image re-sampling sequencers, commercially available from Raytheon Semiconductors (formerly TRW LSI Products, Inc., LaJolla, Calif.), which are marketed under the mark/designation TMC2301 and TMC2302").

194. The transform processor "compensates for the distortion or difference in magnification between the central and peripheral areas of the scene caused by the lens" by applying "appropriate correction criteria" to bring the selected portion of the scene into standard viewing format." APPLE-1006, 6:12-16; *see id.*, 6:16-24 ("transform processor subsystem can also more fully compensate for any aberrations of the enhanced peripheral image because of the image's improved resolution as it

covers a larger portion of the image device (increased number of pixels used to detect and measure the smallest detail in the periphery image)").

195. The combination would have also relied upon Shiota's teachings, which Patent Owner acknowledges as disclosing "correct[ion] [of] the non-linearity of the initial image" APPLE-1011, 117. For example, as described with reference to §§VIII.B and X.A (incorporated here by reference), Shiota describes a two-step image transformation process for an image captured by a fisheye lens, as part of which, Shiota describes the use of a non-linear image distribution function to compute a correction coefficient that is then used to obtain the corrected image points to be displayed. APPLE-1012, [0031]-[0035], [0024], [0037]-[0042].

196. Because the correction coefficient "is computed using the non-linear distribution function," Patent Owner has stated that Shiota discloses "correcting the non-linearity of the initial image, performed ... by means of the non-linear distribution function." *See id.*; APPLE-1011, 117.

197. Moreover, as discussed in §§VIII.B and X.A (incorporated here by reference), a POSITA would have been motivated to implement Shiota's specific image transformation teachings, which include using a correction coefficient computed based on a non-linear image distribution to perform the image transformation, within Baker's system, which already contemplates transformation of a distorted image captured using Baker's objective lens. *See* §§VIII.B and X.A

(incorporated here by reference). Again, Patent Owner has stated that a POSITA would have been motivated to so combine these references to render obvious correction for the non-linearity of the initial image, as obtained by the combination's objective lens. APPLE-1011, 234, 117.

198. For at least the above reasons, the Baker-Shiota combination renders obvious [27e]. See APPLE-1006, Abstract, 5:31-37, 6:5-35, 7:6-11, 8:32-55, 9:5-13, 14:41-16:47, FIGS, 1, 6A-6B, claims 1, 12-14; APPLE-1012, Abstract, [0001], [0004]-[0005], [0014]-[0017], [0021]-[0026], [0029]-[0042], [0044], [0048]-[0050], claim 1.

[27f]: performed by retrieving image points on the obtained image in a coordinate system of center O' using at least the non-linear distribution function and a size L of the obtained image.

199. Baker in view of Shiota renders obvious correcting the non-linearity of the image by retrieving image points on the obtained image in a coordinate system of center O' using at least the non-linear distribution function and a size L of the obtained image.

200. Baker discloses that its transform processor "compensates for the distortion or difference in magnification between the central and peripheral areas of the scene caused by the lens" by applying "appropriate correction criteria" to bring the selected portion of the scene into standard viewing format." APPLE-1006, 6:12-

16; *see id.*, 6:16-24. This is described above in detail with respect to [27e] (which is incorporated by reference here).

201. For reasons described in §§VIII.B and X.A and in [27e] (incorporated here by reference), a POSITA would have found it obvious to implement Shiota's image transformation techniques in combination with Baker, to transform and display a non-linear panoramic image captured with Baker's objective lens in a "proper aspect ratio" to provide a "perspective corrected view," as contemplated by Baker. APPLE-1006, 14:18-26.

202. Specifically, the Baker-Shiota combination would have relied upon Shiota's teachings that describe image correction by applying a correction coefficient (k_2)—which is determined based on a non-linear image distribution function—to the captured image to obtain transformed image points that compensate for the distortion in the captured image. APPLE-1012, [0022]-[0024]. Specifically, the equation for determining the correction coefficient is $k_2 = h/r$, where h represents the lens image distribution function and r is the distance from the origin of an X, Y, Z coordinate system to the projected point on the image plane. APPLE-1012, [0037]-[0042].

203. Again, Patent Owner has acknowledged that these disclosures in Shiota teach correcting the non-linearity of the initial image using a non-linear distribution function. APPLE-1011, 234, 117.

204. In the Baker-Shiota combination, and for the reasons described in §§VIII.B and X.A, the combination's image transformation functionality would similarly rely upon the image distribution function used by Baker's lens (which, as described with reference to claim 27, is a non-linear image distribution function) to determine a correction coefficient that is used to compensate for the non-linearity (i.e., magnification/distortion) introduced by the lens (as disclosed in Shiota). The resulting compensation or image transformation would thereby determine/retrieve transformed image points of the obtained image (e.g., (p, q) coordinates are recited in Shiota) using Baker's non-linear distribution function.

205. The combination would have also rely upon Shiota's teaching of using the actual size of the image in performing the above-described image transformation. For its described image transformation operations, Shiota assumes a normalized radius of 1 of the image circle at a field angle of 90° (from the front of the lens). APPLE-1012, [0023]. However, Shiota acknowledges that the image circle diameter (i.e., the size of the image) "differs according to at least the size of the image pickup device" and that "at the time of actual[] use, magnification adjustment is performed." *Id.* A POSITA would have thus understood that this reference to "magnification adjustment" 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. *See also* APPLE-1012, [0025]-[0026] (explaining that

necessary parameters for the image transformation operations include, e.g., the magnification of the image), [0024] (using “the scale factor (zoom ratio) as the size of the plane image” to perform the described image transformation).

206. Thus, a POSITA would have understood or found obvious that the image transformation described in Shiota, when applied to an actual application accounts for the size of the actual image for the underlying image transformation. Moreover, given that the size of the image pickup device (and by extension the size of the image) varies depending on the implementation, a POSITA would have found it obvious to use the actual size of the image—as applicable in Baker’s system—as part of the image transformation to generate a properly compensated/transformed image for display.

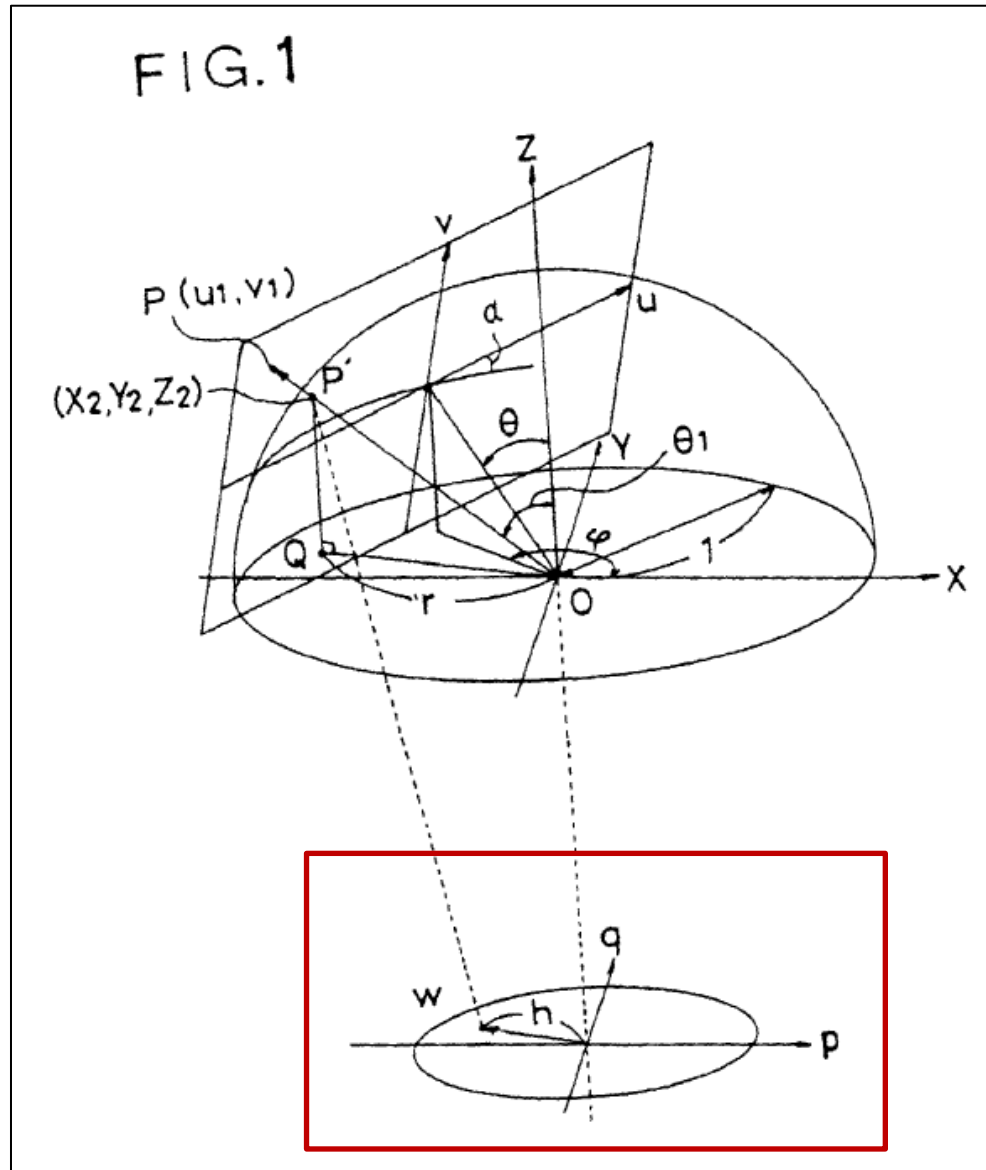
207. Additionally, a POSITA would have understood or found obvious that the size of the image pickup device could be represented using any appropriate units, e.g., pixels, inches, millimeters, etc. Indeed, Baker discloses that its image transformation process includes a “pixel remapping” process (APPLE-1006, 14:64-15:19), and Shiota additionally describes its image transformation process accounts for pixel-based measurements as part of the image transformation process (APPLE-1012, [0022]-[0023], [0025], [0049]). Accordingly, a POSITA would have found it obvious for the size of the image pickup device (and by extension, the size of the image captured by this device) is represented in units of pixels.

208. A POSITA would have also understood or found obvious that, in the Baker-Shiota combination, the transformed image points/coordinates are retrieved image points in a coordinate system with center O' , consistent with how this feature is described in the '990 Patent. Specifically, in the '990 Patent's specification, the image transformation includes the following steps: (1) the image points of the display window $E(i,j)$ are projected onto a sphere portion HS of center O to obtain points $P(px, py, pz)$, and (2) these points P are then projected onto the image disk using the non-linear distribution function to obtain points $p(pu,pv)$ in a coordinate system of center O' (where O' corresponds to the center of the image disk). See APPLE-1001, 12:66-13:24, FIG. 13.

209. Similarly, in Shiota's two-step image transformation process: (1) the points on a plane image corresponding to coordinates of a display monitor are projected on a hemispherical surface to obtains point P' (APPLE-1012, [0022], [0024], [0028]) and (2) the point P' is then used to obtain/retrieve second projection coordinates (p, q coordinates) on the image pickup face (which corresponds to the image disk in '990 Patent) by using a non-linear image distribution function (APPLE-1012, [0033], [0035]-[0037], [0040]-[0041]).

210. Thus, the p, q are coordinates on the image pickup face (or image disk as referenced in the '990 Patent). And, as shown in Shiota's FIG. 1 (reproduced

below), the p, q coordinate system has a center that corresponds to the center of the image disk/pickup surface.



APPLE-1012, FIG. 1 (annotated); *see also id.*, [0022], [0025], [0048] (disclosing that a “plane image to be obtained is shown by an (u, v) coordinate system” and is centered at the origin, and the transformed coordinates p, q on the image pickup face corresponding the coordinates (u, v) on the display screen).

211. Thus, in the Baker-Shiota combination and based on the above disclosures, a POSITA would have understood or found obvious that the retrieved image points (which are obtained using the size L of the image and the non-linear image distribution function) are points in a coordinate system with center O'.

212. For at least these reasons, a POSITA would have found it obvious that the Baker-Shiota combination corrects the non-linearity of the initial image by retrieving image points on the obtained image in a coordinate system of center O' using at least the non-linear distribution function (e.g., Baker's non-linear distribution function) and a size L of the obtained image. *See* APPLE-1006, Abstract, 6:5-23, 13;15-28, 14:41-16:46, claims 12-14; APPLE-1012, Abstract, [0001], [0004]-[0005], [0014]-[0017], [0021]-[0026], [0029]-[0042], [0044], [0048]-[0050], claim 1.

213. Therefore, the Baker-Shiota combination renders obvious [27f].

C. Claim 2

214. Claim 2 of the '990 Patent recites:

2. The method according to claim **[1]** 27, wherein the objective lens has a non-linear distribution function that is symmetrical relative to the optical axis of the objective lens, the position of an image point relative to the center of the image varying according to the field angle of the corresponding object point.

215. As I explain in more detail below through my feature-by-feature analysis, the combination of Baker and Shiota renders obvious claim 2.

[2pre] The method according to claim 27:

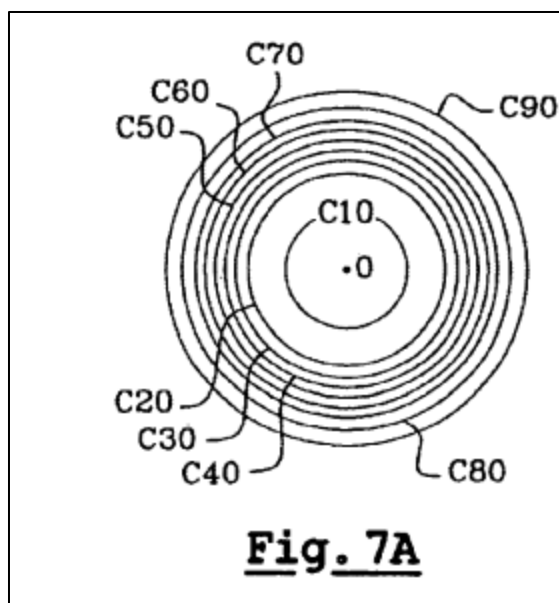
216. As described with reference to claim 27, and in particular, [27pre] to [27f], Baker in view of Shiota renders obvious the method of claim 27.

[2a] wherein the objective lens has a non-linear distribution function that is symmetrical relative to the optical axis of the objective lens, the position of an image point relative to the center of the image varying according to the field angle of the corresponding object point;

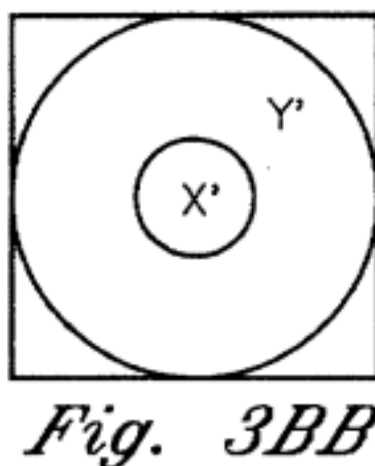
217. As described with reference to [27a]-[27b] (which are incorporated here by reference), Baker's objective lens has a non-linear image distribution function.

218. This non-linear distribution function is symmetrical relative to the optical axis of the objective lens, such that the position of an image point relative to the center of the image varies according to the field angle of the corresponding object point.

219. The '990 Patent's specification explains that a "non-linear panoramic objective lens with axial symmetry relative to optical axis" is one "in which the position of an image point only varies with the field angle relative to this axis of the corresponding object point, "which gives a distribution of points in concentric circles" as shown in FIG. 7A of the '990 Patent that are reproduced below:



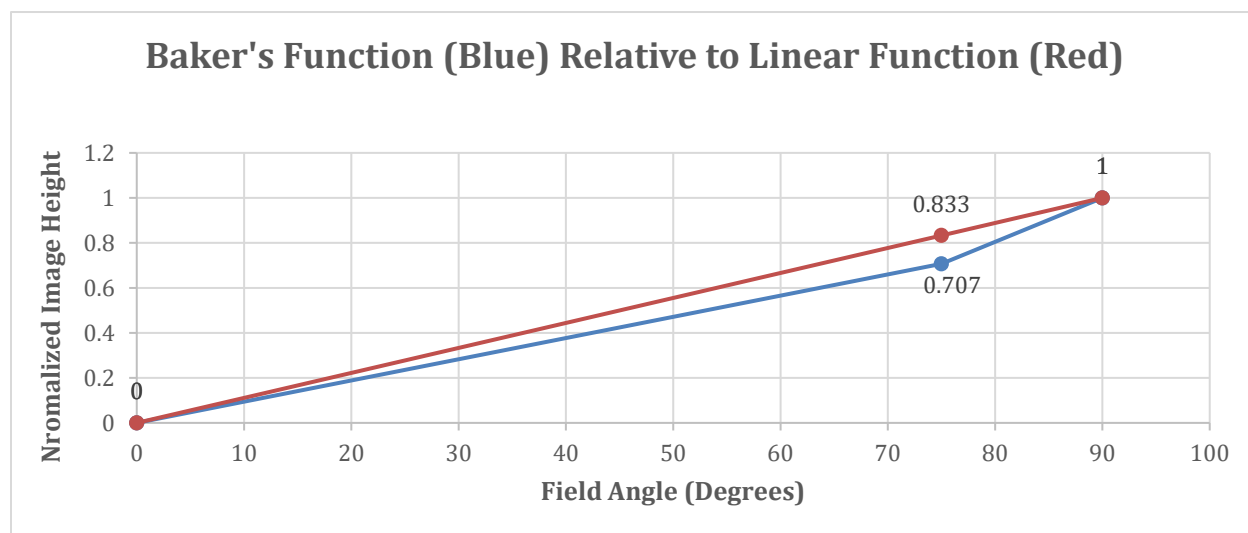
220. Similarly, Baker’s objective lens with its non-linear distribution function provides a distribution of points in concentric circles, as shown in FIG. 3BB, which is reproduced below (see APPLE-1006, FIG. 3BB, 13:29-65):



221. Indeed, in the '990 Patent’s reexamination, Patent Owner acknowledged that, for “symmetric distribution functions” the “image points would

be distributed in concentric circles,” and that Baker’s FIG. 3BB provides such a symmetric distribution function by “show[ing] concentric circular distribution of image points.” See APPLE-1011, 251-252.

222. Moreover, as depicted in FIG. 3BB above as well as in the plots generated to represent the non-linear distribution function of Baker’s objective lens, the position of an image point varies according to the field angle of the corresponding object point:



223. In the above plot, the image points are represented on the y-axis and are shown as varying according to the field angles that are represented on the x-axis.

224. In addition, the above disclosures in Baker and in view of Patent Owner’s statements regarding the same, a POSITA would have understood that Baker’s objective lens has a non-linear distribution function that “is symmetrical relative to the optical axis of the objective lens” with “the position of an image point

relative to the center of the image varying according to the field angle of the corresponding object point.”

225. Therefore, Baker in view of Shiota renders claim 2 obvious. *See also* APPLE-1011, 137 (Patent Owner acknowledging that Baker’s objective lens has a non-linear distribution function that is symmetrical relative to the optical axis of the objective lens, the position of an image point relative to the center of the image varying according to the field angle of the corresponding object point); APPLE-1006, 7:51-65, 12:15-55, 13:29-55, FIGS. 3BA-3BB, 2A-2B, 5.

D. Claim 4

226. Claim 4 of the ’990 Patent recites:

4. The method according to claim [1] 27, wherein the objective lens expands the edges of the image and compresses the center of the image.
--

227. As I explain in more detail below through my feature-by-feature analysis, the combination of Baker and Shiota renders obvious claim 4.

[4pre]: The method according to claim 27:

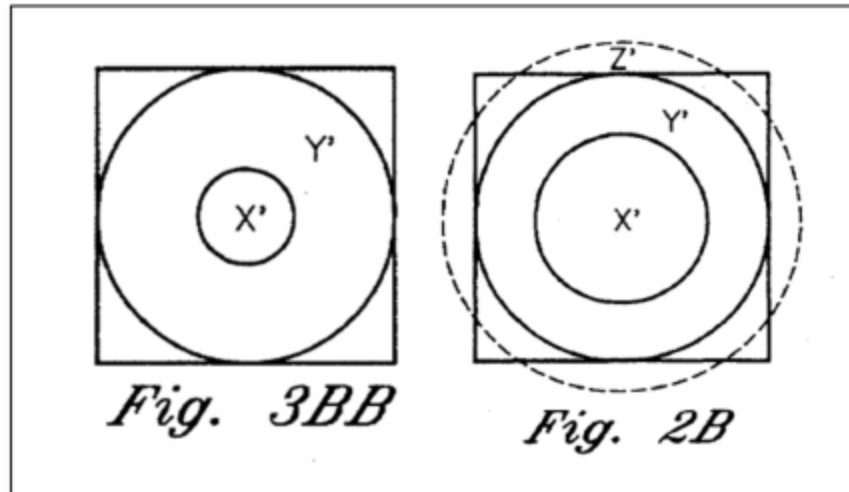
228. As described with reference to claim 27, and in particular, [27pre] to [27f], Baker in view of Shiota renders obvious the method of claim 27.

[4a]: wherein the objective lens expands the edges of the image and compresses the center of the image.

229. As described with reference to [27d] (which is incorporated here by reference), in the Baker-Shiota combination, Baker provides an objective lens that emphasizes or expands the periphery or edges of the image and compresses the center of the image.

230. For example, Baker discloses that its objective lens “fill[s] the greater available area of an imager device with the peripheral areas rather than the central areas of the captured scene” such that “a fairly significant portion of the imaging surface is dedicated to the peripheral field, and consequently less of the surface dedicated to the central field.” APPLE-1006, 10:57-60, 12:29-32.

231. This is further illustrated with reference to Baker’s FIG. 3BB, which is reproduced below and which similarly shows the expansion of the periphery or edges of the image and compression of the center of the image (especially when compared to zones X’ and Y’ in a linear objective lens shown in FIG. 2).



232. Therefore, Baker in view of Shiota renders obvious an objective lens that expands the edges of the image and compresses the center of the image. See APPLE-1011, 137 (Patent Owner acknowledging that Baker's objective lens expands the edges of the image and compresses the center of the image); APPLE-1006, Abstract, 4:24-29, 5:37-6:4, 6:29-56, 8:16-55, 9:62-10:5, 10:22-11:6, 11:42-51, 11:52-12:55, 14:18-26, 15:13-19, claims 1-4, FIGS. 1, 3AA-3AC, 3BA-3BB, 5.

E. Claim 29

233. Claim 29 of the '990 Patent recites:

29. The method according to claim 27, wherein the objective lens comprises a set of lenses forming an apodizer.

234. As I explain in more detail below through my feature-by-feature analysis, the combination of Baker and Shiota renders obvious claim 29.

[29pre]: The method according to claim 27:

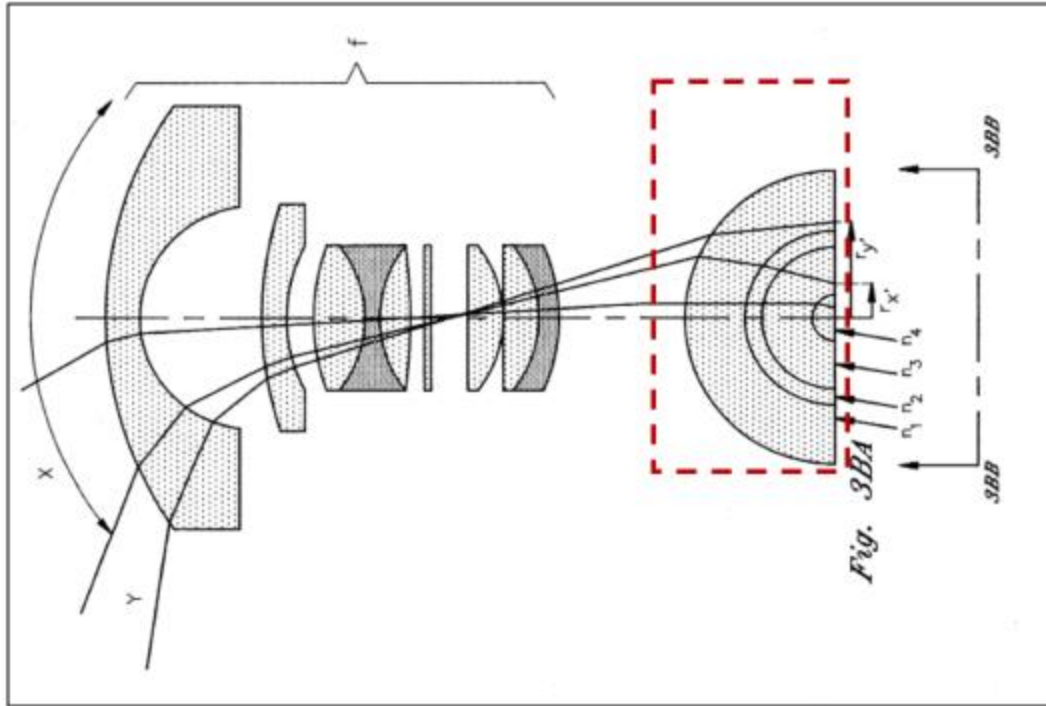
235. As described with reference to claim 27, and in particular, [27pre] to [27f], Baker in view of Shiota renders obvious the method of claim 27.

[29a] wherein the objective lens comprises a set of lenses forming an apodizer.

236. Baker discloses that its objective lens comprises a set of lenses forming an apodizer, consistent with how that term is used in the '990 Patent.

237. The '990 Patent's specification states that "the idea of the present invention is to use an apodizer" and that "the principles of the apodizer is used to control the angular distribution of a panoramic objective lens and to obtain the non-linearity sought." APPLE-1001, 16:1-4.

238. Similar to description of "apodizer" in the '990 Patent's specification, Baker's objective lens (reproduced below) includes an apodizer in the form of its "hemispherical lens" or "combination of lenslets" that are "of gradient index material":



APPLE-1006, FIG. 3BA, 11:1-6.

239. The use of this hemispherical lens element or combination of lenslets “with a wide angle multi-element lens” controls the angular distribution of Baker’s objective lens and obtains non-linearity by increasing “the portion of the camera dedicated to the periphery” and “thereby increasing the relative resolution of information detectable by the imaging device sensing elements.” APPLE-1006, 11:1-4, 12:6-14; *see id.*, 11:52-63 (“In this case, the hemispherical lens is made of gradient index material such that points impinging the image plane ***incur different factors of magnification depending on what index of refraction and what portion of the hemispherical curve or lenslets they pass through.***”).

240. Therefore, Baker in view of Shiota renders obvious an objective lens that includes a set of lenses forming an apodizer (e.g., a hemispherical lens element or combination of lenslets made of gradient index material). *See* APPLE-1011, 137 (Patent Owner acknowledging that Baker's hemispherical lens elements in FIG. 3BA constitutes an apodizer, as that term is used in the '990 patent's specification); APPLE-1006, 10:61-11:6, 11:41-45, 11:48-12:55, claim 3.

XI. GROUND 2: BAKER IN VIEW OF SHIOTA AND FISHER RENDER OBVIOUS CLAIMS 29 AND 30

241. I incorporate the entirety of my element-by-element analysis above with respect to Section X here. Below, Baker and Shiota are applied in a similar manner to that discussed above in Section X. Indeed, all of the analysis and citations with respect to Baker and Shiota presented in Section X apply equally to Section XI. Below, additional support for obviousness of certain elements and claims is provided based on the additional teachings of Fisher, as implemented in combination with the collective teachings of Baker and Shiota.

A. Combination of Baker, Shiota, and Fisher

242. As described with reference to §X.A (incorporated here by reference), a POSITA would have found it obvious to implement Shiota's image transformation techniques to compensate for the distortion introduced in the image by Baker's objective lens and provide a corrected/compensated image for display.

243. A POSITA would have also found it obvious to combine Fisher's teachings with those of Baker and Shiotu, and would have been motivated to do so, for at least the following reasons.

244. Baker discloses that its objective lens achieves the selective magnification/distortion by using a "hemispherical lens or a combination of lenslets" that is/are "made of gradient index material" such that "points impinging the image plane incur different factors of magnification depending on" the index of refraction used and the portion of the hemispherical curve or lenslets they pass through." APPLE-1006, 11:53-63, 12:7-14. As such, Baker's objective lens magnifies or increases resolution dedicated to the peripheral field of view of Baker's lens, while minimizing the central area of the scene. *See, e.g.*, APPLE-1006, 10:37-41, 5:55-6:1.

245. A POSITA would have thus understood that Baker's objective lens achieves the non-linearity in the captured image (e.g., its selective magnification/expansion and minimization/compression of portions of the captured image) using its hemispherical lens or a combination of lenslets that are made of gradient index material.

246. Before the Critical Date, and as I explained in Section VI.D above (incorporated by reference here), it was well known to use aspheric optical elements as part of panoramic objective lenses to control angular distribution of the lens,

thereby achieving a non-linear image distribution. This is further corroborated by, e.g.:

- APPLE-1015, Abstract, 4:8-19 (providing a super wide angle lens with one or more lens elements having aspheric surfaces);
- APPLE-1016, 2, 4 (using aspheric elements for distortion control; stating, e.g., “[i]f instead a spherical mirror an aspherical one is used, it is possible to eliminate angular distortion and to obtain constant angular magnification over the whole 180 FOV”).

247. Consistent with this common and well-established knowledge of using aspheric lenses to implement panoramic objective lenses having non-linear image distributions, Fisher discloses an objective lens that has three sets of lenses, with a first set of lenses including two aspheric lenses and achieving the non-linear image distribution shown with respect to Fisher’s FIG. 3 reproduced above. APPLE-1009, 2:56-57, 5:44-61 (explaining that the first lens grouping A has aspheric lenses and provides a “mapping function” with the unique non-linear distortion/magnification achieved by its lens), FIGS. 3, 6; *see also* §VIII.C (incorporated here by reference).

248. Indeed, before the Critical Date, there were two commonly used techniques for designing panoramic or fish eye lenses that control the lenses’ angular distribution to achieve a non-linear image distribution: (1) implementing a gradient index optical element as part of the objective lens, as described in Baker, or (2) implementing one or more aspheric optical elements as part of the objective lens.

For example, gradient index (GRIN) optical elements—such as those disclosed in Baker—were considered equivalent to aspheric elements given that they achieve similar distortion or non-linear image distribution in the objective lens. This is further corroborated by, e.g.:

- APPLE-1017, 2 (“contributions of an axial gradient index (GRIN) to the third order aberrations of an optical system are equivalent to those of aspheric surfaces”);
- APPLE-1018, 2 (“An axial GRIN profile in combination with a spherical surface is virtually equivalent to an aspheric surface.”).

249. Thus, a POSITA would have recognized that implementing one or more aspherical optical elements in place of Baker’s hemispherical gradient index element would have amounted to a simple substitution of one well known element/technique for another, to obtain the same predictable result of controlling angular distribution in an objective lens to achieve a non-linear image distribution, as already contemplated by both Baker and Fisher.

250. At least the above reasons would have motivated a POSITA to implement Baker’s panoramic objective lens with one or more aspherical elements (e.g., aspherical lenses as disclosed in Fisher) instead of or in place of Baker’s disclosed gradient index-based hemispherical lens element, to achieve the same or similar non-linear image distribution achieved by Baker’s objective lens when using the hemispherical gradient-index lens element.

251. Indeed, a POSITA would have recognized that placing aspheric elements in the same location of Baker's objective lens as the gradient index element would achieve a similar the effect of controlling magnification/distortion in the image. See APPLE-1020, 10, 13 (contemplating positioning of equivalent elements—gradient index element and aspheric lens—away from the aperture, to “control distortion or other field aberrations”). In fact, a POSITA would have recognized that Baker's gradient index element is positioned farthest away from the aperture stop (the point where the ray bundles coincides on the optical axis).

252. Similarly, a POSITA would have found it obvious and would have readily provided one or more aspheric elements that achieve the same distortion profile around the same position of Baker's objective lens to achieve a similar distortion effect.

253. Additionally, although Fisher describes the use of its aspheric lenses in an objective lens that achieves a non-linear image distribution where the center of the image is expanded and the periphery is compressed, a POSITA would have known to utilize aspheric elements that achieve the same effect as Baker's gradient index element—where the image's center is compressed and the image's periphery is expanded. Indeed, the above-cited evidence demonstrates that one or more aspherical lenses could have the same effect as Baker's gradient index element, and thus, a POSITA would have sought out and implemented aspherical surfaces that

achieve the same effect or image distribution as in Baker's system when using the gradient index element. *See, e.g. and generally*, APPLE-1017, 2; APPLE-1018, 2, APPLE-1018, 2. Thus, a POSITA would have had a reasonable expectation of success in implementing aspheric lenses (as contemplated by Fisher and numerous other references in the relevant field) as part of Baker's objective lens, to achieve the same non-linear image distribution contemplated by Baker, where the image's center is compressed and the image's periphery is expanded.

B. Claims 29 and 30

254. Claim 29 of the '990 Patent recites:

29. The method according to claim 27, wherein the objective lens comprises a set of lenses forming an apodizer.

30. The method according to claim 29, wherein the set of lenses forming an apodizer comprises at least one aspherical lens.

255. As I explain in more detail below through my feature-by-feature analysis, the combination of Baker, Shiota, and Fisher renders obvious claims 29 and 30.

[29pre]/[30pre]: The method according to claim 27,

256. Baker in view of Shiota and Fisher renders obvious the method of claim 27 for the same reasons described with reference to [27pre] to [27f], which are incorporated here by reference.

[29a]: wherein the objective lens comprises a set of lenses forming an apodizer / [30a] wherein the set of lenses forming an apodizer comprises at least one aspherical lens.

257. Baker in view of Shiota and Fisher provides an objective lens with a set of lenses forming an apodizer. The '990 Patent's specification states that "the idea of the present invention is to use an apodizer" and that "the principles of the apodizer is used to control the angular distribution of a panoramic objective lens and to obtain the non-linearity sought." APPLE-1001, 16:1-4.

258. Similar to this description of "apodizer" in the '990 Patent's specification, and as described with reference to §XI.A (incorporated here by reference), a POSITA would have found it obvious to implement the Baker-Shiota-Fisher combination such that it leverages Fisher's teachings of implementing one or more aspheric lenses as part of the combination's panoramic objective lens to control the objective lens' angular distribution and thereby achieve the same non-linear image distribution, as already contemplated by Baker.

259. Therefore, Baker in view of Shiota and Fisher renders obvious an objective lens that includes a set of lenses forming an apodizer that includes at least one aspherical lens. See APPLE-1006, 10:61-11:6, 11:41-45, 11:48-12:55, claim 3; APPLE-1009, Abstract, FIGS. 3, 4-6, 2:56-3:42, 5:44-7:11, claim 6.

XII. ADDITIONAL REMARKS

I currently hold the opinions expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

I hereby declare that all statements made are of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare 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 the Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this proceeding.

Dated: 1/17/23

By: 
David Kessler, Ph.D.