

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.
Petitioner

v.

IMMERVISION, INC.,
Patent Owner

Case IPR2023-00472
Patent No. 10,795,120

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. 10,795,120 (“the ’120 Patent”). Specifically, I have been asked to consider the validity of claims 1-7 of the ’120 Patent (“Challenged Claims”) in view of prior art, anticipation and obviousness considerations, and the understanding of a person of ordinary skill in the art at the time of the invention (“POSITA”) as it relates to the ’120 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 my *curriculum vitae* (EX1021). For ease of reference, I have highlighted certain information below.

7. I am a senior optical physicist and optical designer with extensive experience in research and development of advanced optical systems. I have over forty years of academic and industry experience in optics. I am proficient in aberrations theory, physical optics, optical systems architecture and design, and major optical CADs (e.g., Zemax's OpticStudio).

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; designing CCD scanners; designing 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); working on the first digital cinema projectors; and designing 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. My full portfolio and my current projects are on my web site at www.KesslerOptics.com.

11. While at Kodak, I taught advanced optical design over two academic years as a visiting professor at Tel-Aviv University. I also conducted four optical design courses for corporate optical design teams in Israel. More recently, I have

conducted a number of advanced optical design courses for corporate optical design teams.

12. 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 “Meaningful image quality criteria in optical design” (which are the criteria to be chosen for usage in the merit function while optimizing lenses and other optical systems).

13. 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.

14. I am a fellow of the SPIE and the International Society of Optical Engineering, and I am a member of organizations such as OPTICA and The Society for Information Display (SID).

III. LEVEL OF ORDINARY SKILL IN THE ART

15. In my opinion, a person of ordinary skill in the art (“POSITA”) relating to, and at the time of, the ’120 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.

16. 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 with, hired, 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

17. In reaching the conclusions described in this declaration, I have relied on the documents and materials cited herein as well as those identified in this declaration, including the '120 Patent, the prosecution history of the '120 Patent, and prior art references cited herein. These materials comprise 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.

18. 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 asserted priority date of the claimed subject matter in the '120 Patent, which I have been informed by counsel is December 23, 2015.

- EX1001: U.S. Patent No. 10,795,120
- EX1002: File History for U.S. Patent No. 10,795,120
- EX1004: S. Thibault, J. Parent, H. Zhang, and P. Roulet, Design, fabrication and test of miniature plastic panomorph lenses with 180° field of view, Proceedings of SPIE, 2014 (“Thibault”)
- EX1005: U.S. Patent Pub. No. 2010/0194853 to Matsusaka et al. (“Matsusaka”)
- EX1006: Korean Patent No. 100677055B1 to Kim
- EX1007: Certified translation of Korean Patent No. 100677055B1 to Kim (“Kim”)
- EX1009: Declaration of Patrick Franzen
- EX1010: U.S. Patent No. 9,091,843 to Hudyma *et al.*
- EX1011: Rebiai et al., “Image Distortion from Zoom Lenses: Modeling and Digital Correction,” 1992 IBC International Broadcasting Convention (July 1992) (“Rebiai”)
- EX1012: “Fish Eye Lens” by K Miyamoto (Feb. 19, 1964) (“Miyamoto”)
- EX1013: Zeljko Andreic, “A simple 180° field-of-view F-theta all-sky camera,” SPIE Proc. 1500 (Oct. 1, 1991) (“Andreic”)
- EX1014: 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”)

- EX1015: Susan Houde-Walter, “Recent Progress In Gradient-Index Optics,” SPIE Proc. 0935 (Apr. 8, 1988) (“Houde-Walter”)
- EX1016: 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”)
- EX1017: U.S. Patent No. 5,686,957 to Baker (“Baker”)
- EX1018: Zemax Output for Matsusaka’s Example 19
- EX1019: Zemax Output for Kim’s First Embodiment

V. LEGAL STANDARDS

19. I am not a lawyer and do not provide any legal opinions, but I have been advised that certain legal standards are to be applied by technical experts in forming opinions regarding meaning and validity of patent claims. I have applied the legal standards described below, which were provided to me by counsel for Petitioner.

20. It is my understanding that assessing the validity of a U.S. patent based on a prior art analysis requires two steps. First, one must construe the terms of the patent claims to understand what meaning a POSITA would have given the terms. In the absence of any specific constructions, claim terms are construed in accordance with their plain and ordinary meaning. Second, after the claim terms have been construed, one may then assess validity by comparing a patent claim to the “prior art.” I understand that the teaching of the prior art is viewed through the eyes of a

POSITA at the time the invention was made. My analysis as to what constitutes a relevant POSITA is set forth above.

A. Legal Standards for Prior Art

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

22. As I referenced earlier, the '120 Patent claims priority to a provisional application that was filed on December 23, 2015 ("Critical Date"). In this case, I understand that a U.S. or foreign patent qualifies as prior art if the date of issuance of the U.S. or foreign patent is prior to the Critical Date. I further understand that a printed publication, such as an article published in a magazine or trade publication, qualifies as prior art if the date of publication, or the date the printed publication was otherwise made available to the public, is prior to the Critical Date.

23. I understand that a U.S. or foreign patent qualifies as prior art if the date of issuance of the U.S. or foreign patent is more than one year before the Critical Date. I further understand that a printed publication, such as an article published in a magazine or trade publication, constitutes prior art if the publication, or public availability otherwise, occurs more than one year before the Critical Date.

24. I understand that a U.S. patent or published U.S. application that names another inventor qualifies as prior art if the application for that patent was effectively filed in the United States before the Critical Date.

25. 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.

26. 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 Obviousness

27. 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.

28. 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 '120 Patent would have been obvious, I considered whether the prior art and other evidence submitted in this proceeding support 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.

29. 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.

30. 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(s) 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.

31. 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.

32. 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.”

33. 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.

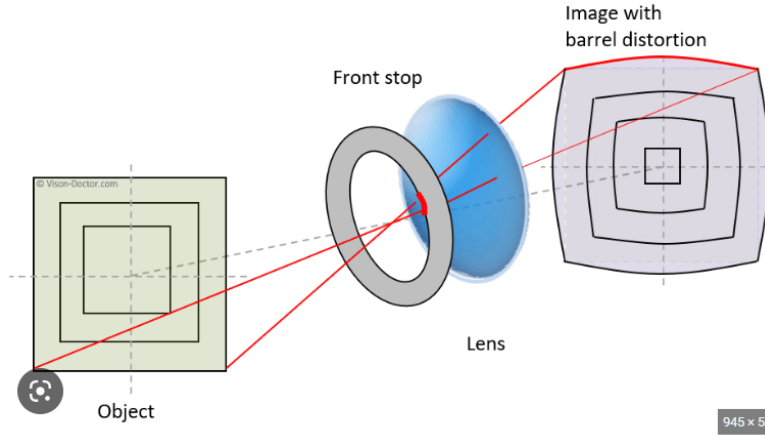
34. I understand that, to establish a secondary consideration, the evidence must demonstrate a nexus between that secondary consideration and the claimed invention.

VI. TECHNOLOGICAL OVERVIEW

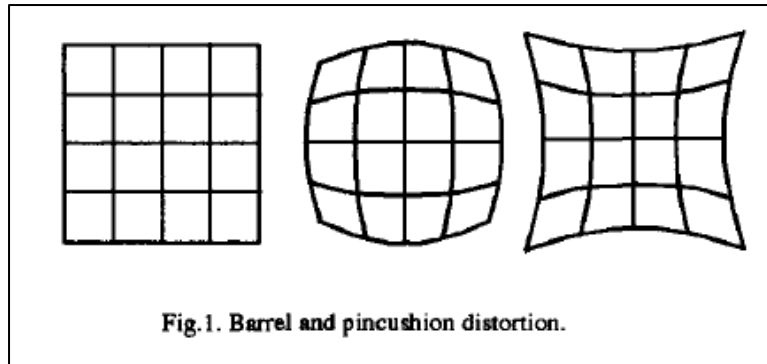
A. Rectilinear imaging

35. 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 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)).

36. In addition to getting the small focused spot/point at the image plane, an optical designer 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. Distortion is the deviation of the spot at the image plane from the position it should be at. This is illustrated below:



37. 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.



EX1011, 1 (showing no distortion in first image from left; showing barrel and pincushion distortion in second and third images from left).

38. In other words, before 2001, 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 $\mathbf{r}_i$ of the spot as a function of the field angle θ is given by:

$$\mathbf{r}_i(\theta) = f^* \tan(\theta) \quad (1)$$

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.

39. 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 $\mathbf{r}(\theta)$. The default definition of distortion $D_{ist}(\theta)$ in optics is the difference of the actual position $\mathbf{r}(\theta)$ of the image at the image sensor relative to the ideal position $\mathbf{r}_i(\theta)$, which can be represented using the following equation:

$$D_{ist}(\theta) = 100 * \frac{\mathbf{r}(\theta) - \mathbf{r}_i(\theta)}{\mathbf{r}_i(\theta)} \quad (2)$$

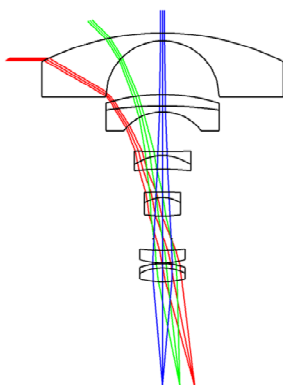
40. Since $\mathbf{r}_i(\theta)$ is known from equation (1), it means that “Distortion” and “Image Distribution Function” are both describing the same information as to the location of the image point as a function of the field angle.

41. 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 were using the $f*\tan(\theta)$ 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 and fisheye lenses

42. Panoramic imaging started shortly after the invention of photography in 1839. The desire to show overviews of cities and landscapes prompted photographers to create panoramas. These cameras 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.

43. 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* EX1012.



44. 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, but the lens didn't rise to prominence until the 1960s when the fisheye lens was finally mass-produced.

45. Fisheye lenses cannot be rectilinear. They have very large distortion against the $f \cdot \tan(\theta)$ curve needed for rectilinear imaging. This distortion effectively stems from flattening the hemisphere. *See* EX1012, 1. Fisheye lenses thus use a different reference function, which is represented using the following:

$$\mathbf{r}_i(\theta) = f \cdot \theta \quad (3)$$

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).

46. 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.

47. 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.

48. 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. EX1012. Miyamoto identified and discussed 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.

49. Miyamoto provided graphically the image distribution curves for these four projections:

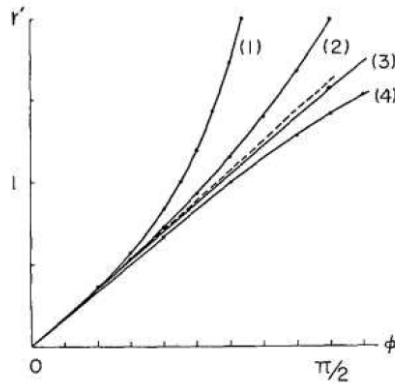


Fig. 1: Curves of different projections. (1) Ordinary projection, (2) stereographic projection, (3) equidistance projection, (4) equisolid angle projection

50. 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.” EX1012, 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. *Id.*, 1-2.

51. 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 (U.S. Patent No. 3,953,111), Nagaoka (U.S. Patent No. 6,128,145), among many other references from this period.

52. 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 will be motivated to choose a particular image distribution and design the lens to have a certain type of deviation, namely distortion, of his/her choice. In particular, if the designer seeks to increase the resolution by expanding a certain segment of the field of view—the designer could readily look for a published image distribution curve, a combination of them, or come up with his/her own trigonometric function of the field or a polynomial one, suitable for the particular application.

53. Looking at Miyamoto's projections (shown above), a POSITA would have understood that curves 1, 2, and 4 have divergence from a linear function 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

54. It was common for optical designers before and after 2015 to use optical design software (optical CADs) like Code V, Accos, Zemax, etc. All optical CADs feature operands for constructing the merit function, which inform the program the performance the lens is required to have (my own 1981 dissertation subject is 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.

55. A POSITA in and around 2015 would have known how to design for almost any functional form presented to him/her for the particular application. The

designer would have done so 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 calculate the desired image points using the chosen image distribution function/mapping.

56. 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.

57. 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

58. Until about the mid-1980s, lenses were based on standard lens elements that have spherical surfaces (i.e., spherical lenses). 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. Aspheric surfaces started to become practical at about the mid-1980s.

59. In general, the more a designer asks the CAD program to do—like a more complex image distribution function of higher resolution or higher fields—the more variables the designer has to provide to the CAD program. 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). EX1013, EX1014, EX1015, EX1016, EX1017. Such a GRIN element could generally be made with an unisotropic index of refraction such as in:

$$n(r) = n_0 + n_2r^2 + n_4r^4 + n_6r^6 + \dots \quad (5)$$

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

60. As of today, the aspherics approach “won” over the GRIN solution and has been used extensively pre-2000. Currently, the majority of lenses used in mobile phones are high order aspherics, each with a large number of coefficients.

E. Post-Capture Image Processing

61. 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). 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.

VII. OVERVIEW OF THE '120 PATENT

A. Brief Description of the '120 Patent

62. At a high level, the '120 Patent is directed to “optical lenses and more particularly to miniature lenses having a wide-angle field of view.” EX1001, 1:20-22. The '120 Patent explains that “[f]or most applications requiring wide-angle imaging, larger lens constructions having a miniaturization ratio (i.e., a total track

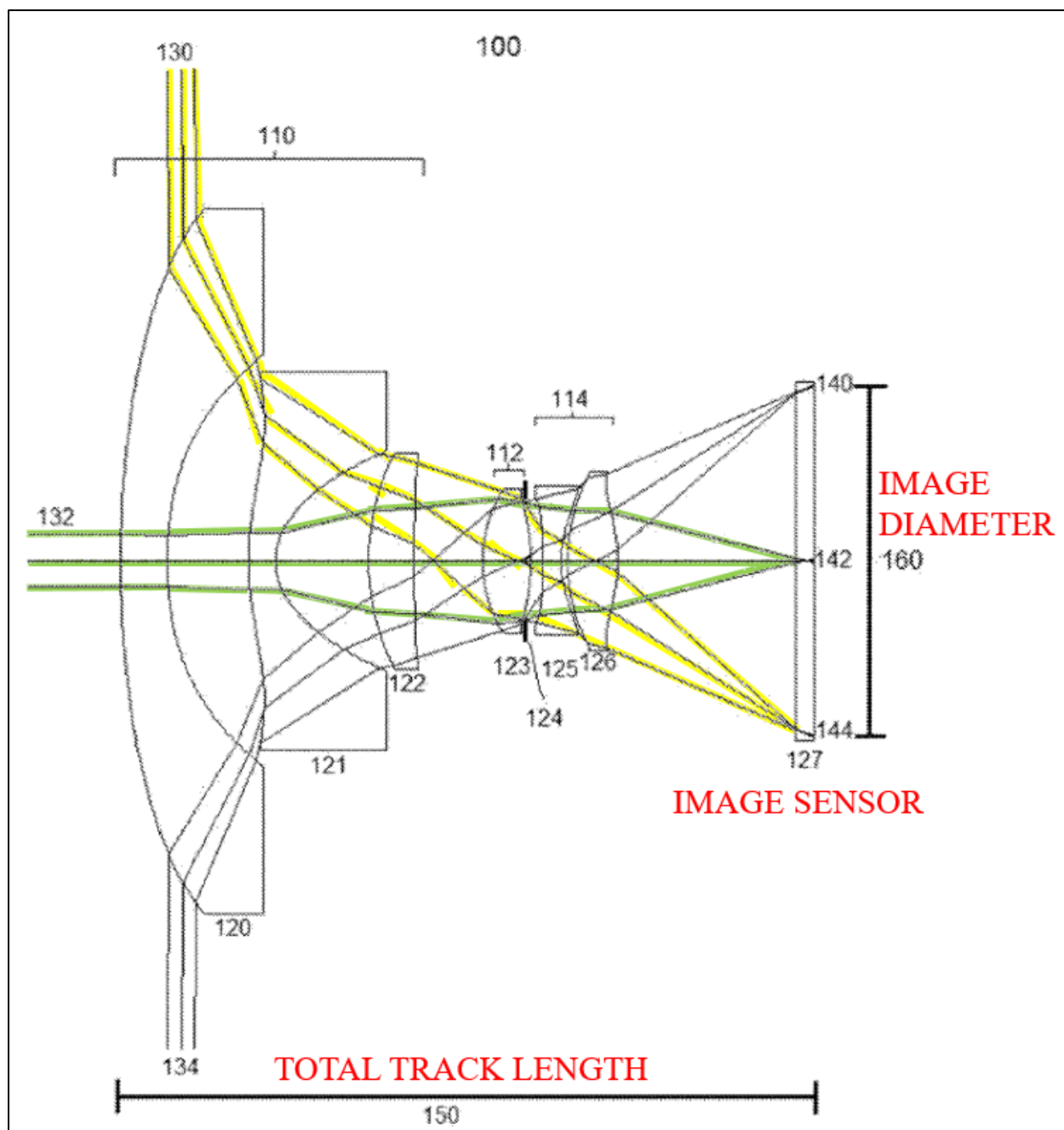
length over an image circle diameter) greater than 3.0 are often used.” *Id.*, 1:23-26.

With various consumer devices, such as mobile devices, however, “the trend is that the lens thicknesses are becoming thinner while the sensor sizes are becoming larger,” so “a new kind of wide-angle lenses with a miniaturization ratio less than 3.0 are required.” *Id.*, 1:26-30.

63. Responsive to this purported need, the ’120 Patent describes “miniature wide-angle imaging lenses having a miniaturization ratio (i.e., total track length from the center of the first surface to the focal plane over the image circle diameter) less than 3.0 while maintaining a good balance between image quality parameters, including MTF [modulation transfer function], relative illumination, and resolution.” *Id.*, 2:6-13.

64. With reference to Figure 1 (reproduced below), the ’120 Patent shows an “optical layout for a design having six optical elements in an asymmetric configuration.” *Id.*, 3:41-45. The miniature wide-angle lens 100 comprises three groups 110, 112, and 114. *Id.*, 3:45-46. The first group 110 includes lenses 120, 121, and 122 and has a negative total optical power. *Id.*, 3:46-49. The second group 112 includes an aperture stop 124 and a single positive lens 123 and has a positive optical power. *Id.*, 3:49-51. The third group has a negative total power and includes two optical elements 125 and 126. *Id.*, 3:51-54.

65. When light enters the lens 100, it hits a first surface of element 120 between an upper angle 130 and a lower angle 134, with a total field of view of 180°, “but any total field of view over 100° can be considered as a wide-angle lens according to the present invention.” *Id.*, 3:55-61. Light passes through elements 120, 121, 122, single lens 123, aperture stop 124, and elements 125 and 126 before reaching an IR filter and image sensor 127. For instance, a light beam from direction 130 (highlighted yellow) travels through the lens 100 and reaches the sensor 127 at position 144, while a light beam from direction 132 (highlighted green) travels through the lens 100 and reaches the sensor 127 at position 142. *Id.*, 3:66-4:3.



EX1001, FIG. 1 (highlighted; annotated).

66. For each light beam, a chief-ray is “defined as the middle ray of the three rays drawn because it passes through the center of the aperture stop 124.” EX1001, 4:3-5. The “angle of the cone of light formed by the chief-rays reaching

the sensor plane at positions 140 and 144 is over 40° to minimize the dimensions of the lens 100.” *Id.*, 4:6-9. The lens of Figure 1 has a total track length 150 as measured “from the first surface on the object side of the lens 120 to the image sensor,” forming an image with a diameter 160, which is “a distance on the sensor 127 between the position 140 and the position 144 where the light beams from the lower and the upper fields 130, 134 reach the sensor 127.” *Id.*, 4:14-20. The miniaturization ratio of the lens is obtained “by dividing the total track length 150 over the footprint diameter 160 and is less than 3.0 for any miniature lens according to the present invention and could even be less than 2.0 for an extreme miniature lens.” *Id.*, 4:20-24.

67. Figures 2 and 3 show other optical layouts having seven and eight optical elements, respectively. *Id.*, 4:25-5:56. Figure 4 (reproduced below) shows a relative illumination curve 400 for a miniature wide-angle lens according to the ’120 Patent’s disclosure. *Id.*, 5:57-59. The ’120 Patent explains that the “overall shape having a value around 100% at 0° shown at center 410 and under 80% at the maximum field angle shown at position 420 is present in all families of miniature wide-angle lenses according to the present invention.” *Id.*, 5:59-65.

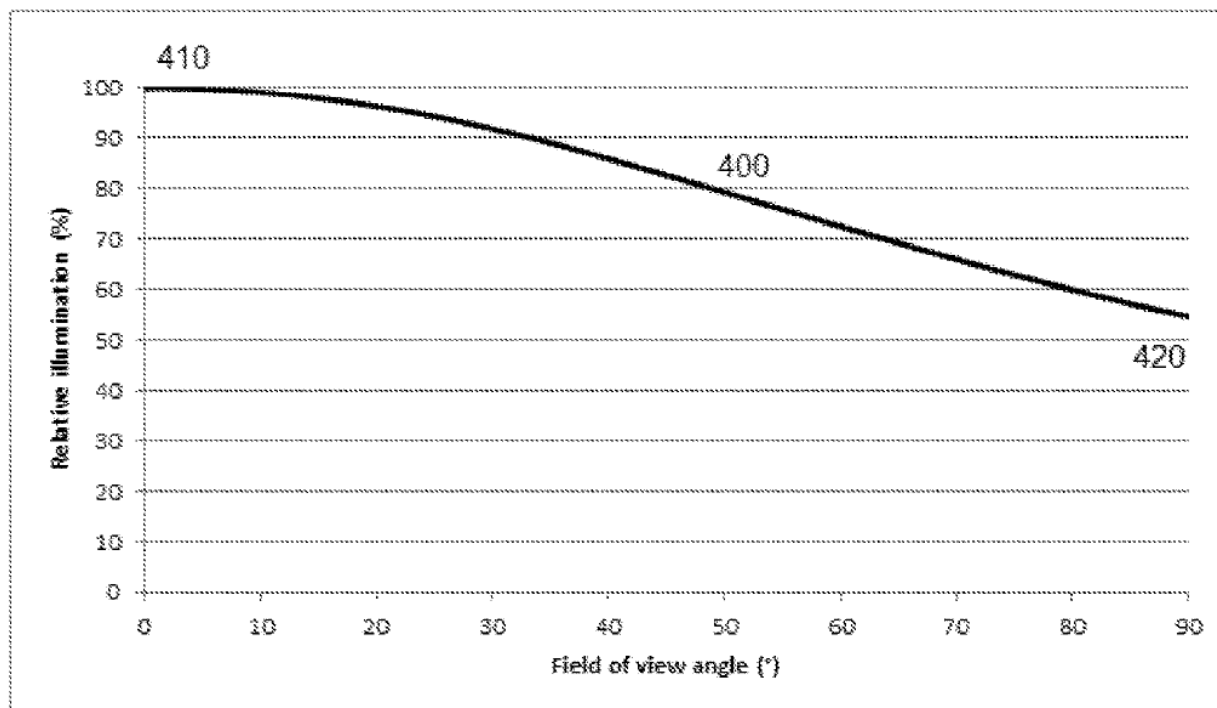


Figure 4

EX1001, FIG. 4

68. Figure 5 (reproduced below) shows a sagittal MTF curve 500 and tangential MTF curve 505 for a miniature wide-angle lens according to the '120 Patent's disclosure. *Id.*, 5:66-6:1. The '120 Patent explains that the overall shape shown in Figure 5 “having a higher value at 0° shown at center 510 than at the edge shown at position 520 is present in all families of miniature wide-angle lenses according to the present invention.” *Id.*, 6:1-8.

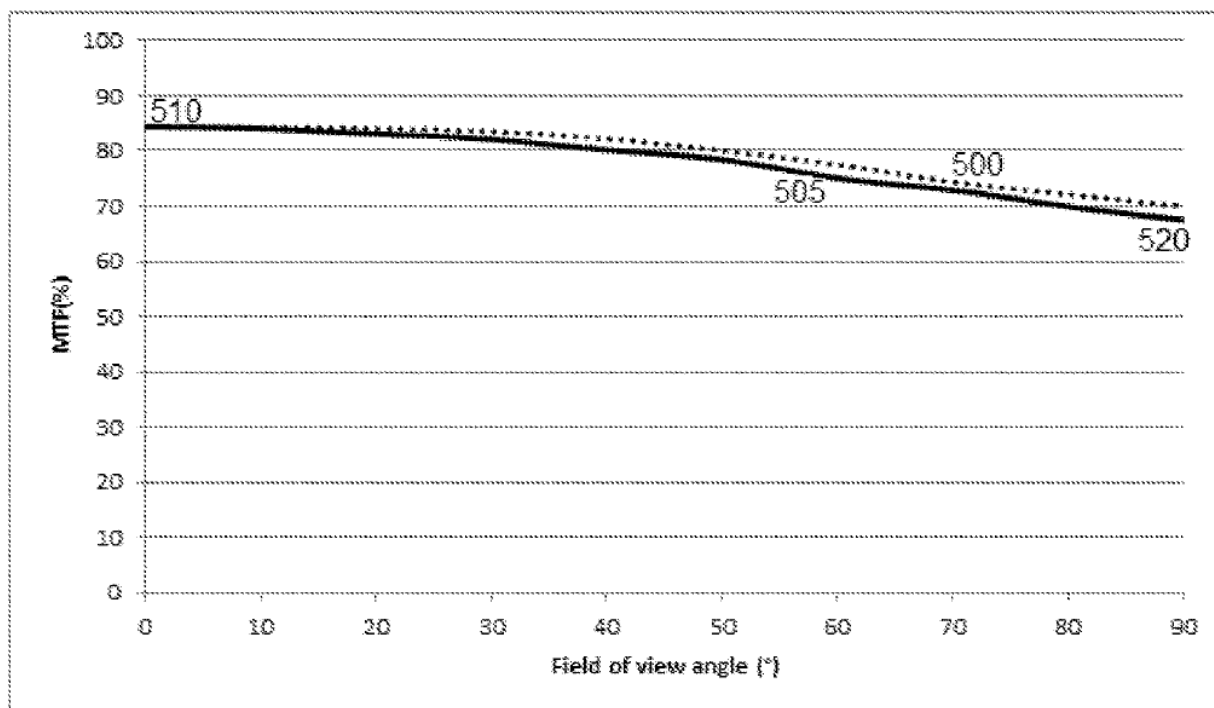


Figure 5

EX1001, FIG. 5

69. Figure 6 (reproduced below) shows a “targeted resolution curve 600 for a miniature wide-angle lens according to embodiments of the present invention where the targeted resolution is non-linear and a higher number of pixels per degree is intentionally present in a part of the image.” *Id.*, 6:9-13. In some instances, “the shape of the targeted resolution is intentionally designed to compensate for the drop of relative illumination seen in FIG. 4,” and in some instances, “the shape of the targeted resolution is intentionally designed to compensate for the drop of MTF seen in FIG. 5.” *Id.*, 6:13-19. In high resolution zones, more sensor pixels are used to image a given angle of the object space, which “compensates for the lower image

quality in this zone either due to the lower relative illumination or the lower MTF.”

Id., 6:19-24. The '120 Patent states that this approach “create[s] a resulting image with constant image quality across the whole field of view.” *Id.*, 6:24-27.

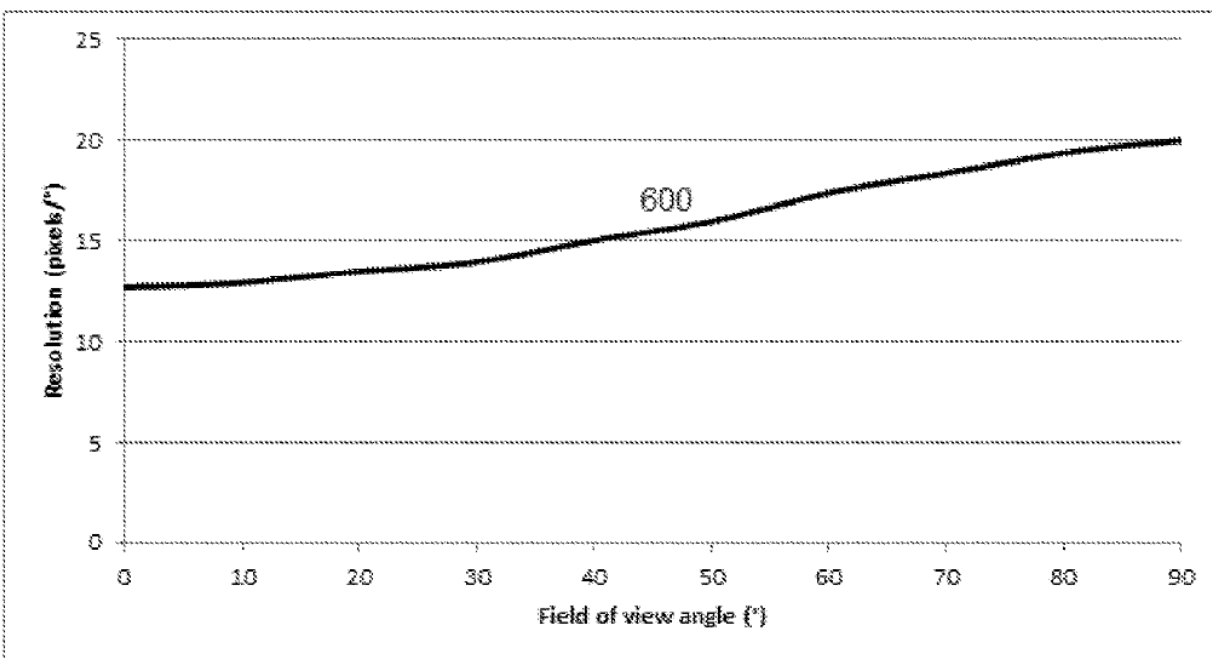


Figure 6

EX1001, FIG. 6

70. Figure 7 shows another non-linear targeted resolution curve 700, which has “an upward curve between the center resolution value 710 and a maximum 712 (number of pixels/degree), followed by a downward curve between the maximum 712 and a region near the edge of the field of view around position 714.” *Id.*, 6:28-35. The “downward curve between maximum value 712 and position 714 allows the lens system to have a higher relative illumination value toward the edge of the field of view by having a lower object to image magnification ratio in that region

and hence redirecting the same quantity of light from an object to a smaller region in the image with more illumination.” *Id.*, 6:35-41. Figure 7 also shows a “change of direction at the edge of the field of view 716,” which “allows for a closer value of resolution in the pixels/degree in the center 710 and at the edge 716, creating the best balance of MTF between the center 710 and the edge 716.” *Id.*, 6:42-50.

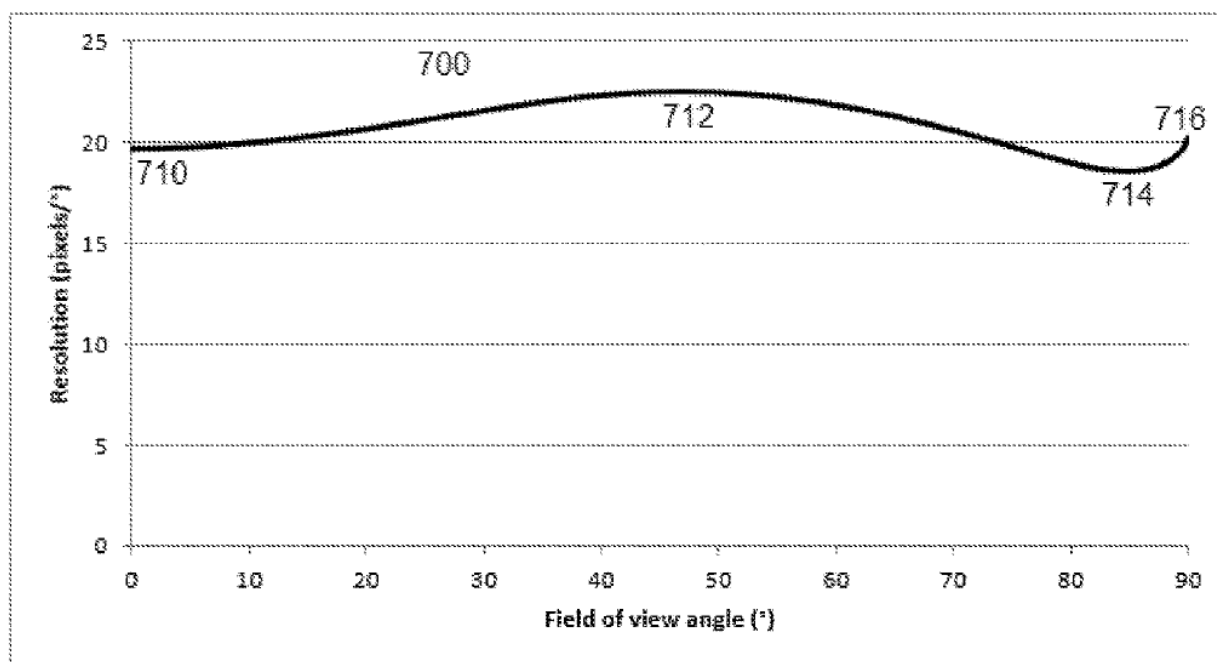


Figure 7

EX1001, FIG. 7

71. According to the '120 Patent, the downward curve between positions 712 and 714 allow for higher relative illumination, and the change of direction between positions 714 and 716 provides “the best image quality on the lens and camera system.” *Id.*, 6:51-55.

72. Despite its discussion in the '120 Patent as a purportedly “new kind of wide-angle lens[],” the miniature lenses discussed in the '120 Patent were not new. *Id.*, 1:29-30. Notably, as discussed in more detail below, some of the inventors of the '120 Patent published a paper (Thibault) directed to this same concept before the Critical Date of the '120 Patent.

B. File History of the '120 Patent

73. The '120 Patent issued on October 6, 2020, from U.S. Patent Application No. 16/432,180 (“the '180 application”), filed June 5, 2019, and claims priority to U.S. provisional application No. 62/298,795, filed February 23, 2016, and U.S. provisional application No. 62/387,409, filed December 23, 2015. EX1001, 1.

74. The '120 Patent prosecution history is relatively short. The '180 application was filed with eight claims. In a non-final Office action, the examiner rejected all claims based on U.S. Pub. No. 2012/0314296 to Shabtay. EX1002, 32-38. In a subsequent response, the applicant amended independent claim 1 to add “an opening angle of light entering the optical apparatus being over 100°,” which was recited in dependent claim 4. *Id.*, 24-30. With the amendment, the applicant argued that Shabtay’s disclosure of a lens with a field of view in the range of 30°-45° and as large as 54° does not qualify as “wide angle” or “come anywhere close to the 100° or greater field of view provided in claim 1.” *Id.*, 28-29. The Office responded with a Notice of Allowance that allowed the pending seven claims. *Id.*, 13.

75. While the applicant successfully argued that the Shabtay reference did not teach a “wide angle” lens with an opening angle of at least 100°, the Office did not rely on any other prior art to teach this feature. Notably, a number of prior art references, including the ones relied on in this petition, teach this and the other features recited in the claims of the ’120 Patent, as I discuss in greater detail below.

C. Interpretation of the ’120 Patent Claims at Issue

76. I provide my opinion regarding the interpretation of particular “use” language recited in independent claim 1 below. For all other claim terms, I understand that the terms that appear in the claims of the ’120 Patent should be interpreted according to their ordinary and customary meaning in light of the specification (EX1001) and prosecution file history (EX1002). 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.

77. I have followed this approach in my analysis, and for all of the claim terms other than those noted below, 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 '120 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.

78. 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 used the December 23, 2015 purported priority date of the '120 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 in this declaration would be correct if the date of invention was earlier or later than 2015.

1. Use and Intention Language of Claim 1

79. Independent claim 1 of the '120 Patent includes a limitation that I do not believe specifies structure for or adds structure to the claimed miniature wide-angle optical apparatus. Specifically, the claim recites “the lower or higher object to image magnification ***being used to*** compensate, at least in part, for a lower image quality due to at least one of a drop of relative illumination or a drop of MTF in a

zone of the image.” EX1001, 7:23-8:2¹. I believe this language is an intended use that the '120 Patent does not teach implicates the structure of the claimed optical apparatus.

80. Rather, the '120 Patent describes that the claimed “compensation” is a necessary byproduct of the optical apparatus including the claimed “zone . . . with a lower or higher object to image magnification compared to linear targeted resolution.” Specifically, the '120 Patent describes that, “[i]n wide-angle lenses the relative illumination is usually maximum in the center and drops continuously toward the edge of the field of view.” EX1001, 1:56-58. Similarly, the modulation transfer function (MTF) also drops “from the center to the edge of the field of view.” EX1001, 1:63-2:3. Examples of these drops are illustrated in FIGS. 4 and 5. EX1001, 5:57-6:8. The '120 Patent describes that either increasing or decreasing the image magnification (*i.e.*, pixels per degree) in regions of the image away from the center compensates for these natural drops in relative illumination and/or MTF. *See* EX1001, 6:9-50. For example, with respect to FIG. 6, the '120 Patent explains that increasing resolution in a region away from the center of the image “compensates for the lower image quality in this zone either due to the lower relative illumination or the lower MTF.” EX1001, 6:21-24. On the other hand, with respect

¹ Emphasis added throughout unless otherwise noted.

to FIG. 7, the '120 Patent explains that decreasing resolution further from the center of the image “allows the lens system to have a higher relative illumination value toward the edge of the field of view by having a lower object to image magnification ratio in that region and hence redirecting the same quantity of light from an object to a smaller region in the image with more illumination.” EX1001, 6:35-41.

81. Accordingly, by implementing the otherwise claimed “zone in an image captured by the miniature wide-angle optical apparatus with a lower or higher object to image magnification compared to linear targeted resolution,” the '120 Patent teaches that the optical apparatus compensates, at least in part, for a lower image quality due to at least one of a drop of relative illumination or a drop of MTF in a zone of the image. For purposes of this declaration, I have not undertaken any analysis to confirm that the above descriptions provided in the '120 Patent are technically accurate. Rather, I have simply accepted these statements as true in order to consider whether the prior art teaches or suggests these concepts and the limitations set forth in the claims.

VIII. OVERVIEW OF THE CITED REFERENCES

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

83. I understand that Thibault was publicly available as of the Critical Date as evidenced by the Declaration of Patrick Franzen. *See* EX1009. As a fellow of SPIE, I am very familiar with the organization, and I have presented papers at a number of their conferences, which were subsequently published in The Proceedings of SPIE and in the SPIE Digital Library. SPIE and the SPIE Digital Library would have been well known to the POSITA at the Critical Date, as it was and continues to be a prominent organization within the technology of optic design, and its various publications are widely disseminated and consulted by members of the optic design community.

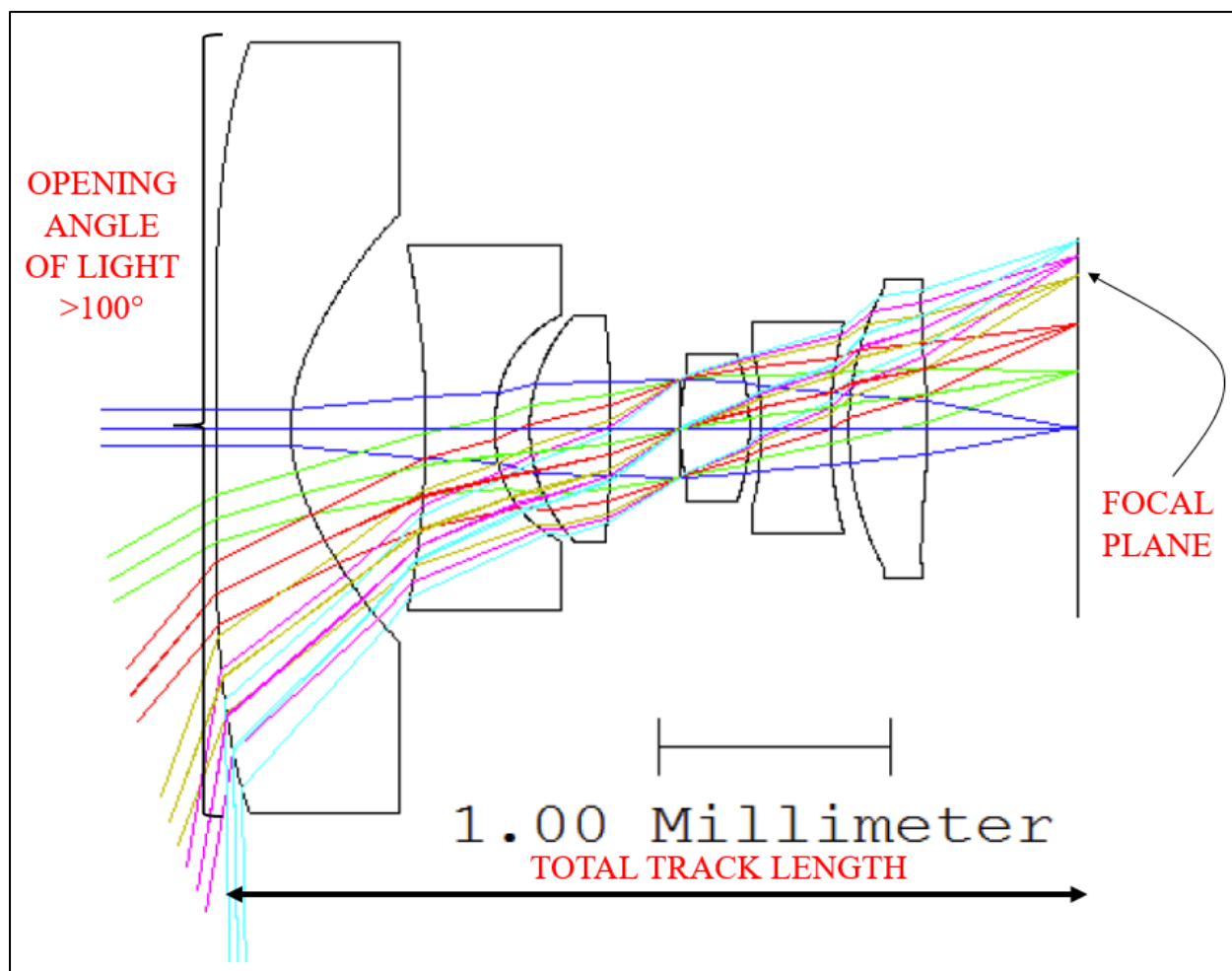
A. Thibault (EX1004)

84. Thibault is a paper titled “Design, fabrication and test of miniature plastic panomorph lenses with 180° field of view” authored by four of the six inventors listed on the ’120 Patent. EX1004, 1. Like the ’120 Patent, Thibault describes miniature wide-angle lenses. *Id.*, Abstract. Thibault further recognizes “the challenges of designing and manufacturing miniature panomorph lenses suitable for state of the art megapixels sensor.” *Id.*, 2.

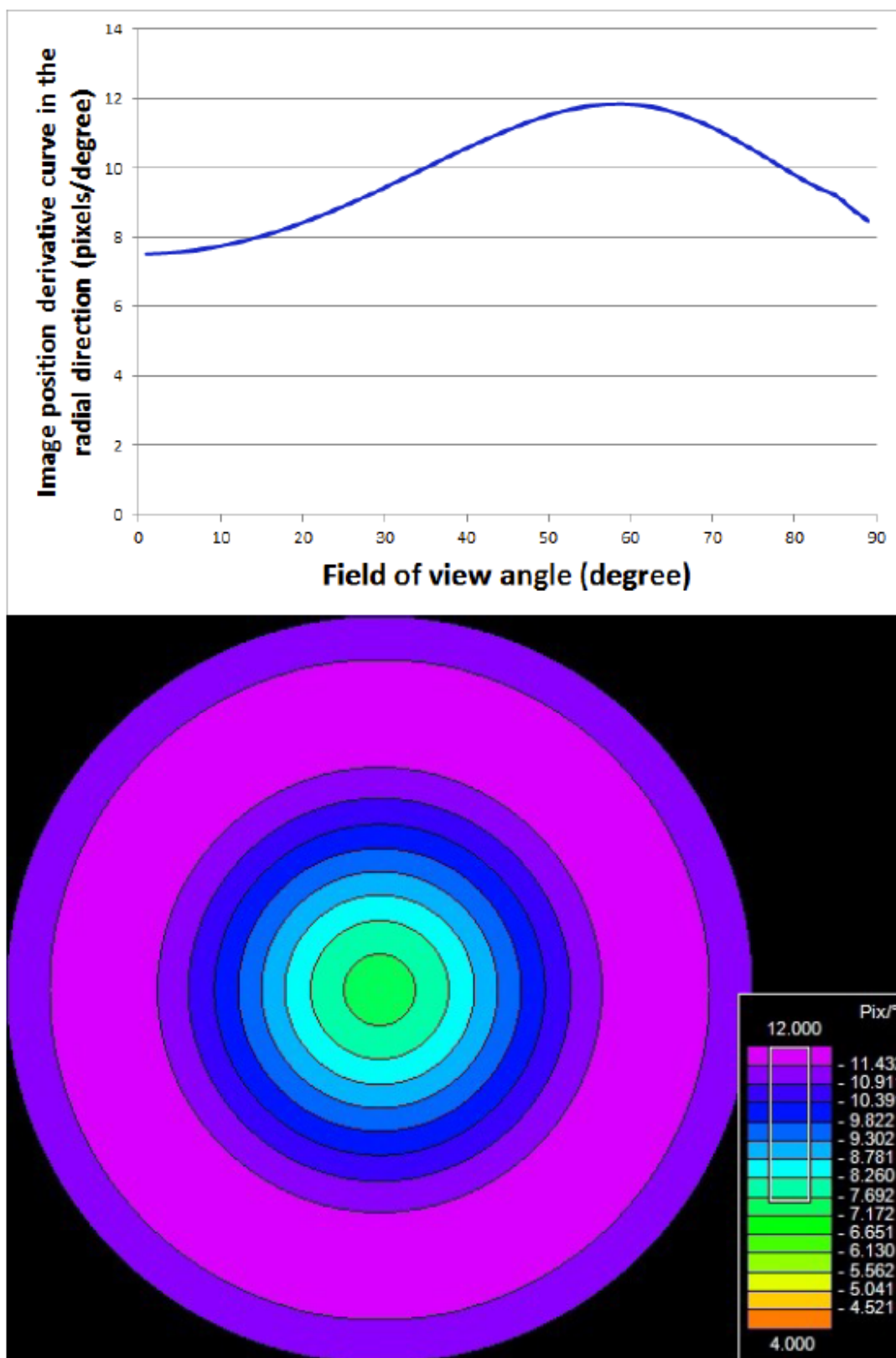
85. Thibault explains that panomorph lenses are wide-angle lenses with a field of view over 120° that use “particular elements to increase the number of pixels in an area of interest.” *Id.*, 2. The “particular elements” used to increase the number of pixels are “an anamorphic ratio to match the sensor optical format” and

“controlled distortion to selectively stretch or compress the number of pixels in areas of interest in the field of view.” *Id.*

86. Figure 5 (reproduced below) shows a miniature panomorph lens “designed at the end of 2013 for mobile device applications” with a requirement of a smaller TTL and diameter. *Id.*, 6. The resulting lens has a TTL of 3.80 mm with a 0.2 mm cover glass and six elements. *Id.* The “f/2.8 lens has a 1:1 anamorphic ratio and use[s] targeted distortion to increase the number of pixels in the zone of interest for mobile video chat applications,” shown in Figure 6 (reproduced below). *Id.* “The panomorph footprint is 2.01 x 2.01 mm and is designed for the full 360° image to fit the height on a 5.04 MPx 4.3 sensor with 2592 x 1944 pixels of 1.12 μm.” *Id.*



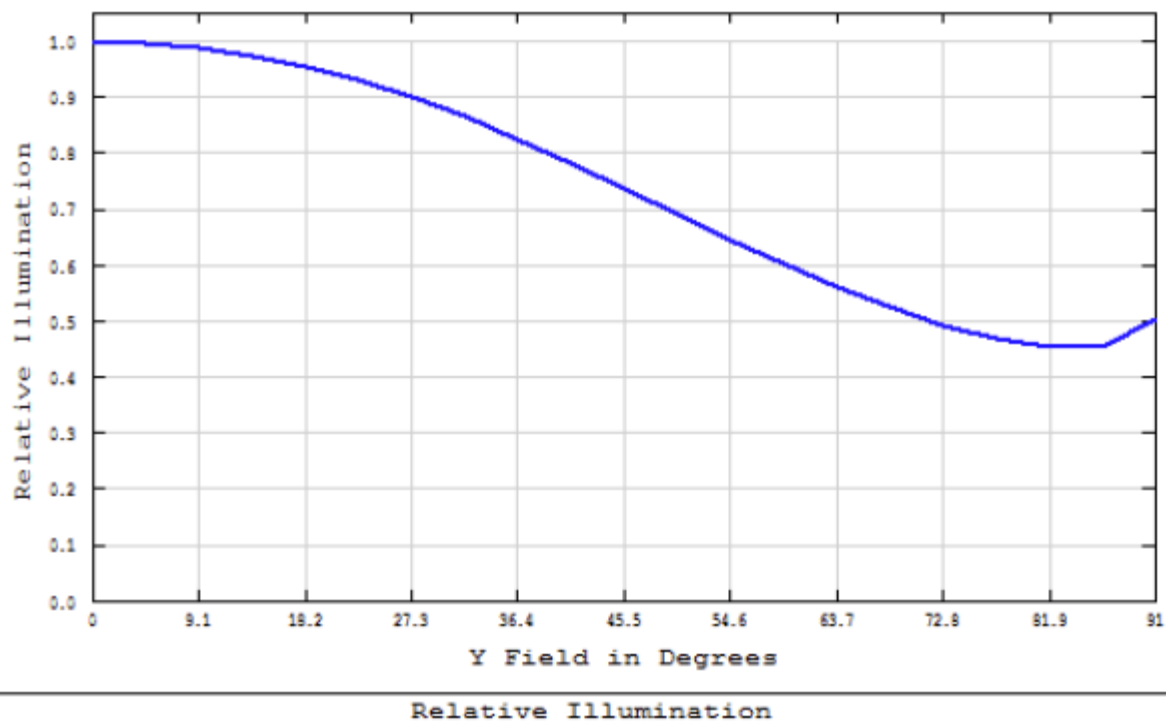
EX1004, FIG. 5 (annotated)



EX1004, FIG. 6

87. The top graph of Figure 6 shows the image position derivative curve in the radial direction (pixels/degree), and the bottom image shows the surfacic resolution² over the full circular panomorph image. *Id.*, 7. In Figure 6, the zone shown in magenta has the highest number of pixels per degree associated with it. Collectively, Figure 6 shows an increase in the number of pixels in various zones of the resulting image. *Id.* Figure 7 (reproduced below) shows the relative illumination of the panomorph lenses with a TTL of 3.80 mm. *Id.*

² In this context, the “surfacic resolution” is referring to the number of pixels that are associated with a given degree of the surface area of the lens, such that light that passes through that portion of the lens will have a particular “resolution” (i.e., number of pixels of the image sensor capturing it).



EX1004, FIG. 7

88. Thibault further discusses using de-warping to “exploit the increase of resolution in a region of interest created by the panomorph lens design while removing the distortion to provide human brain friendly views tailored for specific applications or use cases.” *Id.*, 10. In consumer electronic and mobile devices, these techniques are often used for 360° live video chat or selfies. *Id.* In the case of selfies, “de-warping is also used to correct the viewpoint to a vertical orientation based on orientation information extracted directly from the device.” *Id.*

B. Matsusaka (EX1005)

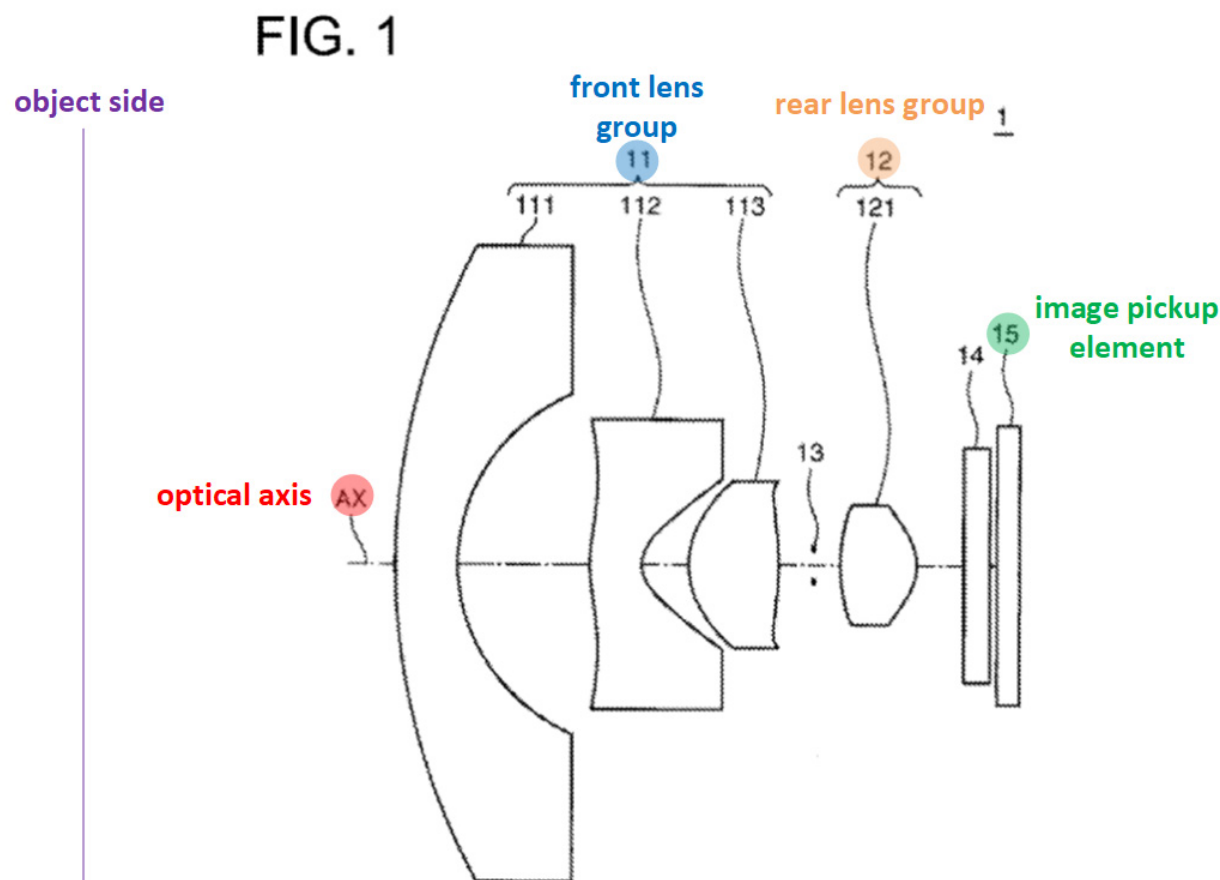
89. Matsusaka is a U.S. patent publication titled “Wide-angle optical system, image pickup lens device, monitor camera, and digital apparatus.” EX1005,

1. Like the '120 Patent, Matsusaka is directed to a “wide-angle optical system that is compact and copes with a wide angle of view, and in particular, relates to a wide-angle optical system that is suitable to a super wide-angle optical system that copes with a super wide angle and has a total angle of view of 90° or more.” *Id.*, ¶0002.

90. Matsusaka describes that there was a known recognition for the usefulness, across a variety of uses cases, of “wide-angle optical systems having a large angle of view for taking images (wide angle of view).” EX1005, ¶¶0003-0004. There existed prior art wide-angle optical systems that (1) prevented “shading that is a problem caused when the optical system has a super wide angle and is formed of a small number of lenses,” and (2) controlled “fluctuations of an image forming position under various temperature environments by employing glass members arranged at proper positions.” EX1005, ¶¶0005-0008. However, Matsusaka recognized that these prior art wide-angle optical systems failed to correct “chromatic aberrations which are caused because of downsizing of the optical system,” and resulted in lower “contrast over the entire image area.” EX1005, ¶0008. Thus, Matsusaka sought to “provide a wide-angle optical system which is compact and has more excellent optical propert[ies],” as compared to the prior art wide-angle optical systems and their observed failures. *Id.*

91. Matsusaka describes a general wide-angle optical system 1 with respect to FIG. 1. EX1005, ¶¶0144-0145. Matsusaka teaches certain structural

specifications for the wide-angle optical system 1 and a series of thirteen (13) conditions that the wide-angle optical system 1 should meet in order to exhibit the improved optical properties that Matsusaka sought. *See generally*, EX1005, ¶¶0144-0208.



EX1005, FIG. 1 (annotated)

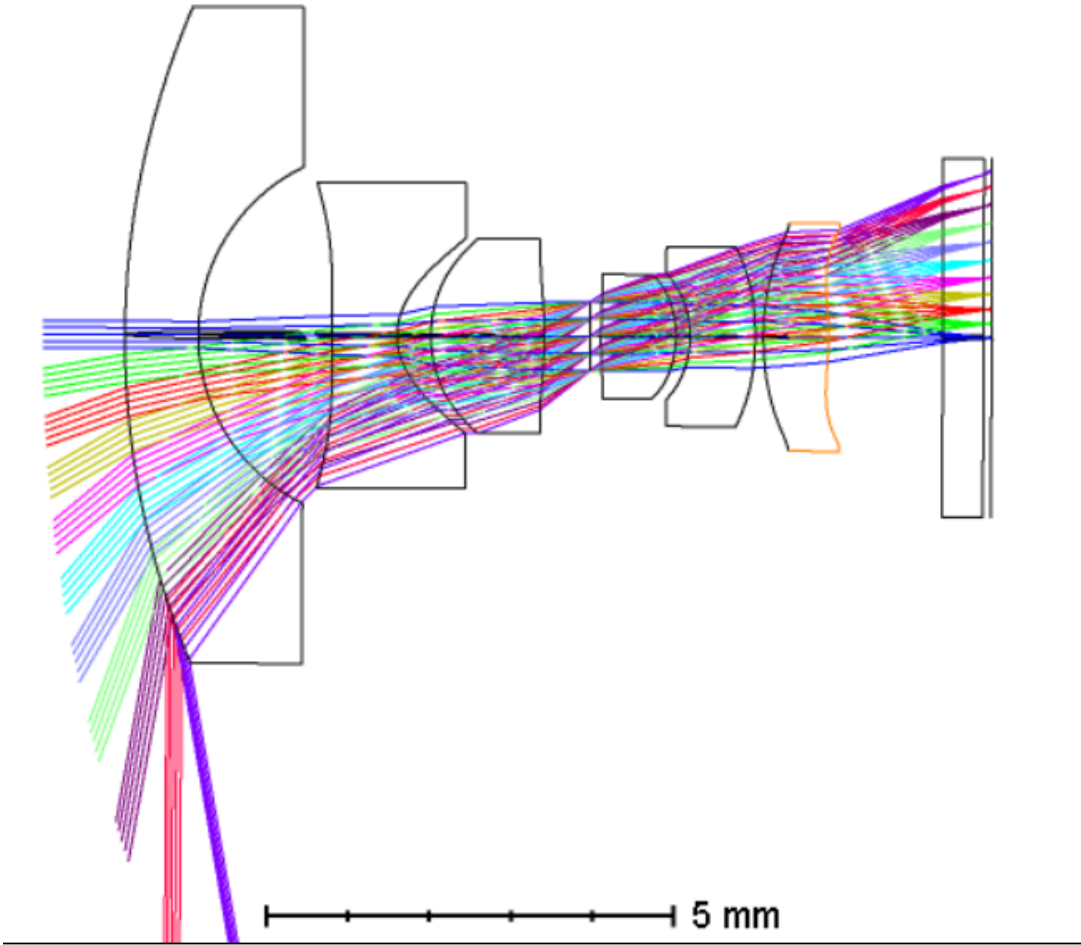
92. Matsusaka goes on, in FIGS. 5-50B and their associated descriptions, to provide twenty three (23) examples of “[s]pecific constructions of wide-angle optical system 1 shown in FIG. 1” that each “satisfy the required conditions relating to the present invention,” and therefore “have more excellent optical properties,

achieve to be compact sufficiently for being mounted on digital apparatus, especially for being mounted on an onboard monitor camera or on a mobile terminal, and are capable of achieving cost reduction.” EX1005, ¶¶0234, 0449-0450.

93. A number of the lenses taught by Matsusaka prove that claims 1 and 3-6 of the '120 Patent are anticipated and/or obvious, including, *e.g.*, Examples 6, 8, 18, 19, 20, 22, and 23. However, for simplicity, my analysis focuses primarily on Example 19, which is illustrated in and described with respect to FIGS. 23, 43A, and 43B.

94. Using the construction data provided by Matsusaka for Example 19, I was able to model the lens in a program called Zemax to evaluate various of its properties. As I explained above in my Technological Overview, Zemax is an optical design software program, and has been commercially available since at least 1990. Those of ordinary and above-ordinary skill in the art of optical system design would have been familiar with Zemax or equivalent optical design software. These programs allow those of skill in the art to evaluate properties of an optical system.

95. By entering the values provided in the table “Numerical Example 19” in paragraph 0411, I was able to create the following model, the detailed specifications for which I have provided as EX1018:



Zemax Model of Matsusaka’s Optical System 1S of Example 19

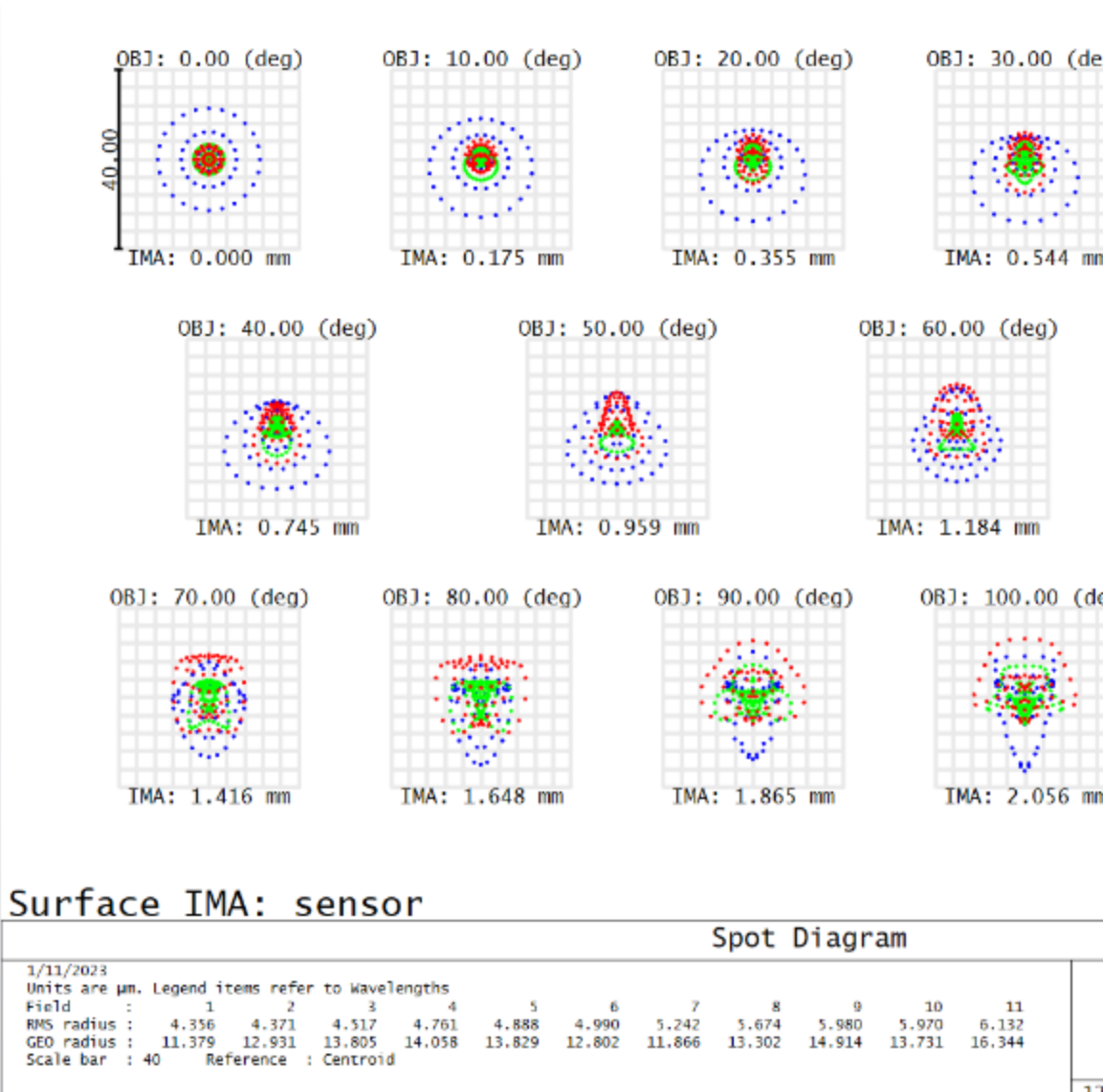
96. The below prescription list of this Zemax model matches the values provided in the table “Numerical Example 19” in paragraph 0411:

SURFACE DATA SUMMARY:									
Surf	Type	Radius	Thickness	Glass	Clear Diam	Chip Zone	Mech Diam	Conic	Comment
OBJ	STANDARD	Infinity	Infinity		0	0	0	0	
1	STANDARD	20	1		16.1518	0	16.1518	0	
2	STANDARD	10.286	0.9	1.834810, 42.720000	7.551308	0	7.551308	0	1st element
3	STANDARD	2.3	1.638		4.03672	0	7.551308	0	
4	EVENASPH	38.903	0.8	1.530480, 55.720000	3.472907	0	3.472907	292.36	2nd element
5	EVENASPH	0.812	0.416		2.277847	0	3.472907	-1	
6	EVENASPH	1.623	1.392	1.632000, 23.410000	2.288192	0	2.288192	0	3rd element
7	EVENASPH	-4.562	0.561		2	0	2.288192	0	
STO	STANDARD	Infinity	0.132		0.8423115	0	0.8423115	0	STOP
9	EVENASPH	6.361	0.921	1.530480, 55.720000	1.033538	0	1.486923	0	4th element
10	EVENASPH	-1.232	0.171		1.486923	0	1.486923	0	
11	EVENASPH	-1.225	0.8	1.632000, 23.410000	1.51001	0	2.2	0	5th element
12	EVENASPH	-3.876	0.1		2.2	0	2.2	0	
13	EVENASPH	3.352	0.8	1.530480, 55.720000	2.8	0	2.8	0	7th element
14	EVENASPH	-3.49	1.4		2.515663	0	2.8	-0.54212	
15	STANDARD	Infinity	0.5	1.516800, 64.200000	3.6	0	3.660258	0	filter
16	STANDARD	Infinity	0.1		3.660258	0	3.660258	0	
IMA	STANDARD	Infinity			4	0	4	0	sensor

97. Similarly, the below aspheric coefficients of the Zemax model matches the values provided in the table “Numerical Example 19” in paragraph 0411:

	ENASPH	Surface 4	Surface 5	Surface 6	surface 7		surface 9	surface 10	surface 11	surface 12
Coefficient	r ²	0	0	0	0		0	0	0	0
Coefficient	r ⁴	-0.03137	0.01758	0.038489	0.049059		0.02	0.088	0.063	-0.10227
Coefficient	r ⁶	0.002231	-0.017	0.007793	0.02021		-0.18626	-0.27312	-0.15499	0.033583
Coefficient	r ⁸	0.000527	-0.00374	-0.00769	-0.00082		-0.40585	-0.24511	-0.2872	0.026008
Coefficient	r ¹⁰	-1.59E-05	-0.00567	-0.00283	-0.01092		0.40853	0.295	0.425	-0.0149
Coefficient	r ¹²	-1.18E-05	0.002767	0	0		0	0	0	0
Coefficient	r ¹⁴	0	0	0	0		0	0	0	0
Coefficient	r ¹⁶	0	0	0	0		0	0	0	0

98. Another indication that the Zemax model is correct is that the performance of the model in terms of RMS spot sizes, for example, is very good and under 6 microns for all field angles and well corrected for color as shown below:



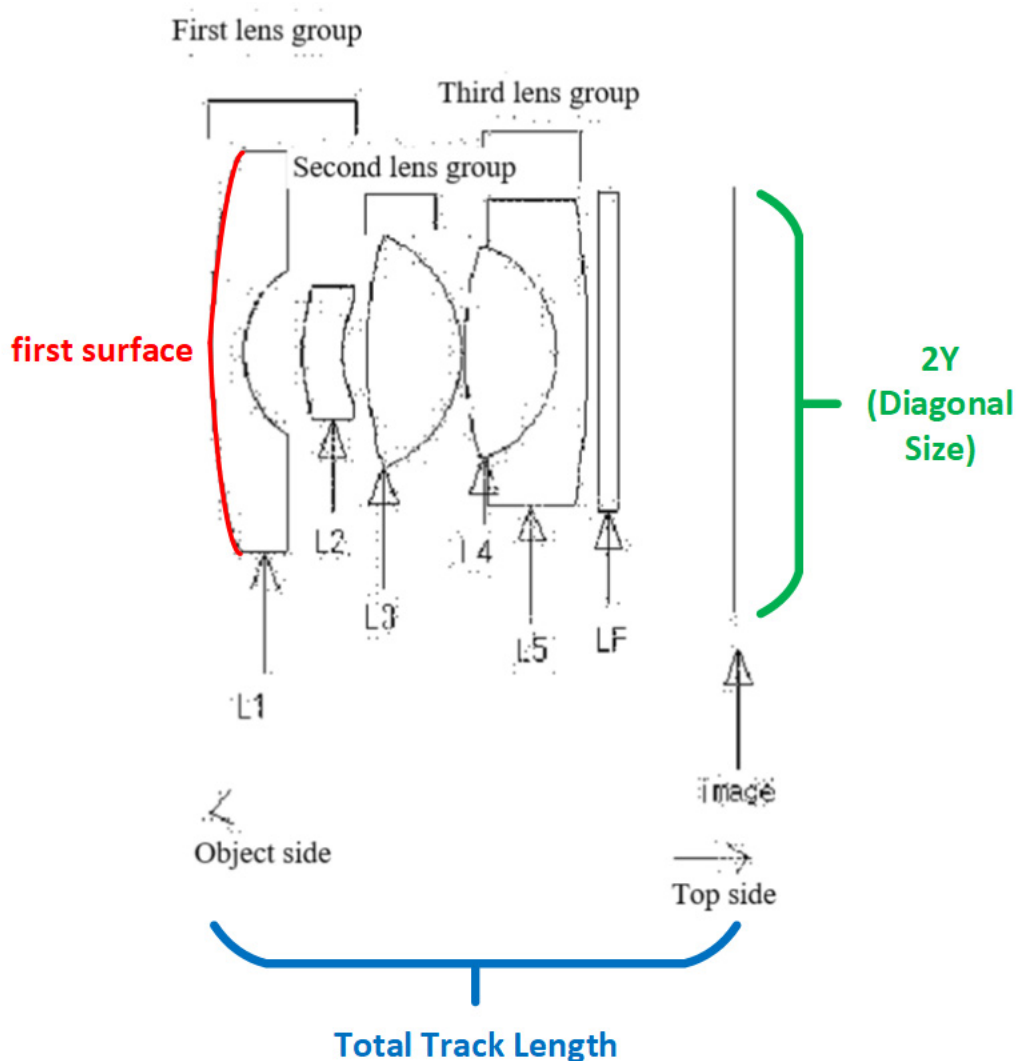
99. A POSITA would have been able to create this Zemax model using similar techniques, and would also be able to recreate and evaluate my model based on the data provided in EX1018.

C. Kim (EX1006, EX1007)

100. Kim is a Korean patent titled “Compact Superwide Angle Optical System.” EX1007, 1. Like the ’120 Patent, Kim is directed to a “compact superwide angle optical system.” EX1007, 1, Summary.

101. With reference to Diagram 1A (reproduced below), Kim discloses a “lens optical system” with a first lens group having lenses L1 and L2, a second lens group having lens L3, and a third lens group having lenses L4 and L5. *Id.*, 4-5, Diagram 1A. A filter, LF, is included after the fifth lens L5. *Id.*, 8, Diagram 1A. The optical system includes an image plane, labeled “image.” *Id.*, 5, Diagram 1A.

Diagram 1a



EX1007, Diagram 1A (annotated)

102. The lens of Diagram 1A has the specifications shown in Table 1 (below) under the “Embodiment 1” column. *Id.*, 6 (Table 1). The diagonal size (twice the image height Y) and total track length TTL are annotated in Diagram 1A above. Kim explains that the examples shown in Table 1 “assume a lens system in which the image height Y value is 1 (in other words, the image diagonal size is 2).”

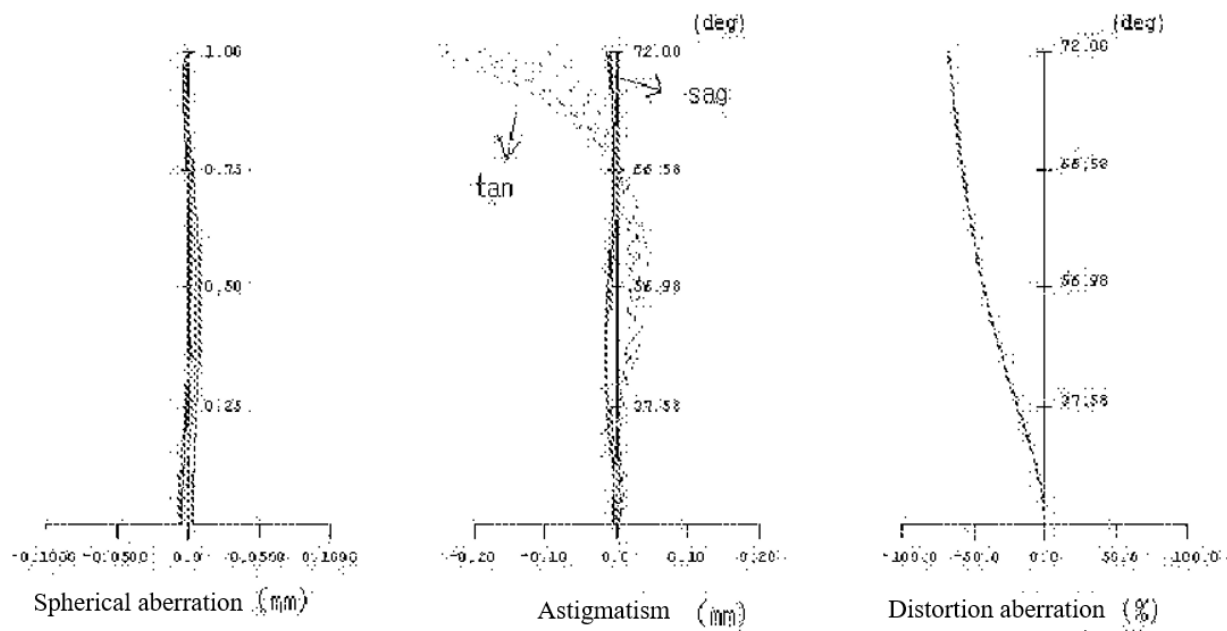
Id., 6. “TTL/2Y is the total length of the lens divided by the diagonal size of the image, and represents information on the total length of the lens,” where “TTL is the distance from the first surface of the lens to the image sensor, and 2Y is the diagonal size of the image sensor.” *Id.* Kim further states that “the values of TTL/2Y related to the size of the optical system are all less than 2, and therefore, according to the embodiment of the invention, it can be shown that the optical electric field can be configured to be less than twice the diagonal size of the image sensor.” *Id.*

	Embodiment 1	Embodiment 2	Embodiment 3
FNO	1.7916	1.7916	1.8200
Angle of view	144	148	154
TTL/2Y	1.9189	1.9750	1.9415
Image height - Y	1	1	1
Total length of the lens	0.97760	0.97730	0.96280
ϕ_{12}/ϕ_t - Conditional Expression 1	0.62729	0.70657	0.61669
ϕ_3/ϕ_t - Conditional Expression 2	0.22170	0.15353	0.20317
$V4/V5$ - Conditional Expression 3	2.18726	2.18726	2.18726

EX1007, 6 (Table 1) (highlighted)

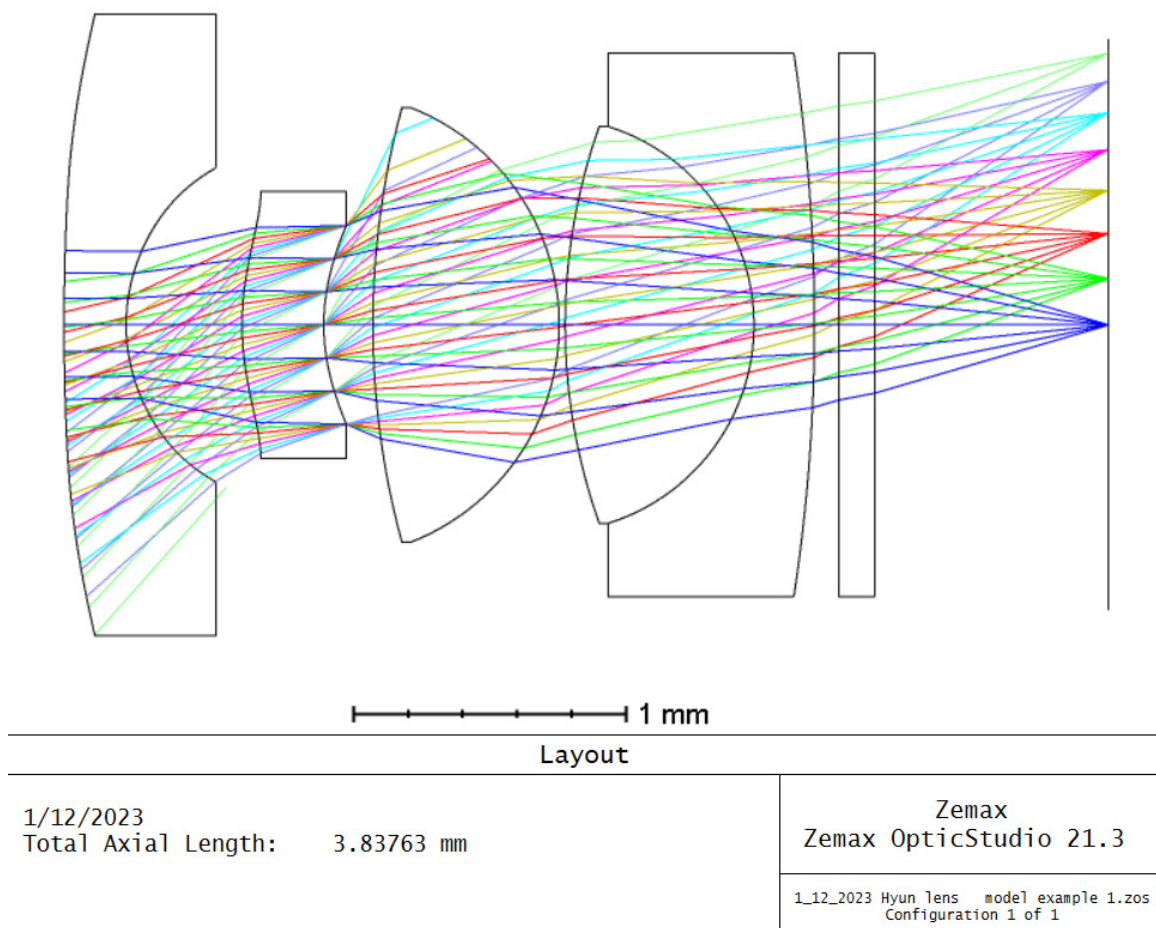
103. Diagram 1B (reproduced below) shows various graphs relating to the lens system shown in Diagram 1A. EX1007, 7, FIG. 1B.

Diagram 1b



EX1007, FIG. 1B

104. There are three lenses taught by Kim that prove that claims 1, 4, 5, and 7 of the '120 Patent are anticipated and/or obvious. However, for simplicity, my analysis focuses primarily on the first embodiment, the detailed characteristics of which are included on page 6. EX1007, 6. As with Matsusaka, I modeled the lens based on these characteristics in a program called Zemax to evaluate various of its properties. I have provided the specifications for this model as EX1019.



Zemax Model of Kim's First Embodiment

105. I was able to verify this model using a similar method as described above with respect to Matsusaka. A POSITA would have been able to perform the same analysis, and would be able to verify my model based on the data contained in EX1019.

IX. OVERVIEW OF UNPATENTABILITY GROUNDS

Ground	Claim(s)	Prior Art Basis
1	1-7	§§102/103 – Thibault
2	1, 3-6	§§102/103 – Matsusaka
3	1 4, 5, 7	§§102/103 – Kim

X. GROUND 1: THIBAUT ANTICIPATES OR RENDERS OBVIOUS CLAIMS 1-7

A. Claim 1

106. Claim 1 of the '120 Patent recites:

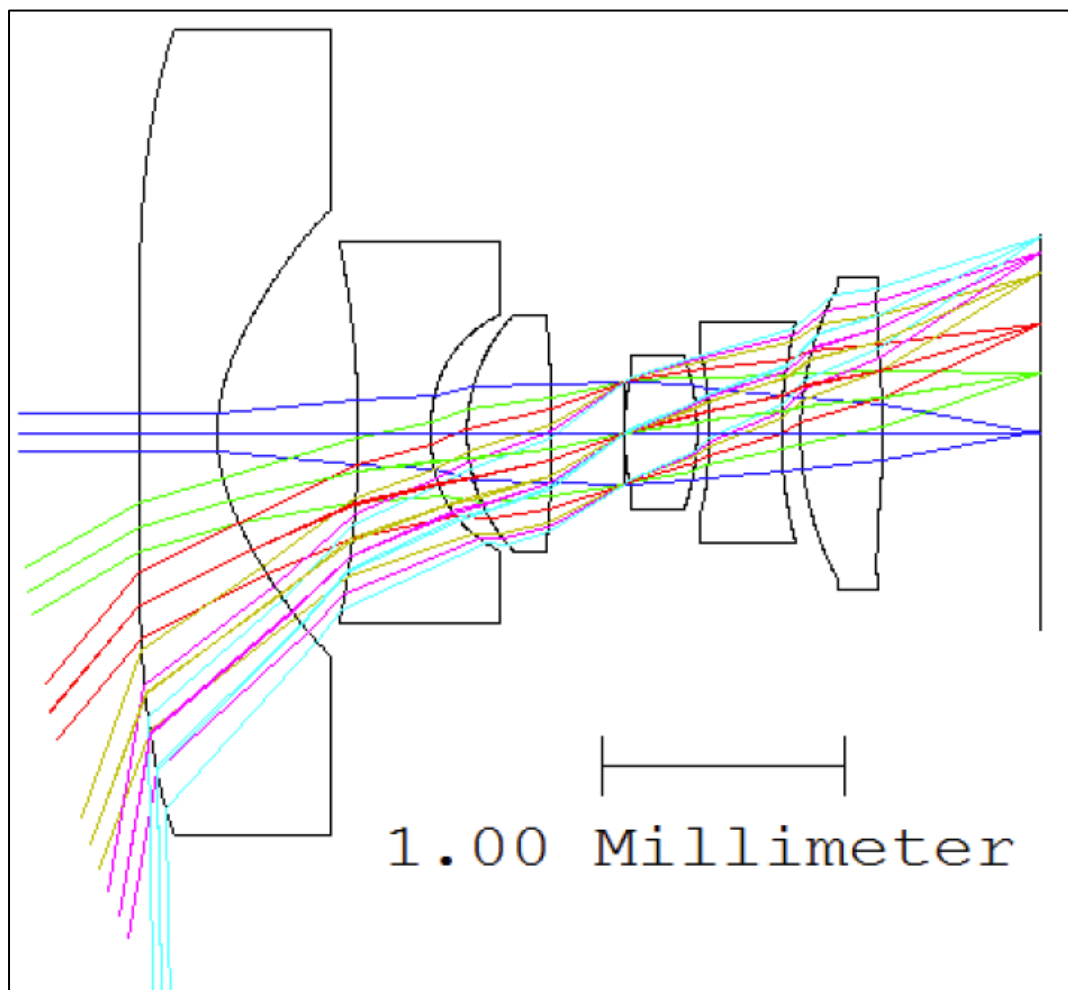
1. A miniature wide-angle optical apparatus comprising:
a light-receiving first surface;
a focal plane;
a total track length measured from a center of the first surface to the focal plane;
a miniaturization ratio with a value less than 3.0, the miniaturization ratio being a ratio of the total track length divided by an image circle diameter; and
a non-linear targeted resolution to intentionally create a zone in an image captured by the miniature wide-angle optical apparatus with a lower or higher object to image magnification compared to linear targeted resolution, the lower or higher object to image magnification being used to compensate, at least in part, for a lower image quality due to at least one of a drop of relative illumination or a drop of MTF in a zone of the image,
an opening angle of light entering the optical apparatus being over 100°.

107. As I explain in more detail below through my feature-by-feature analysis, Thibault discloses or renders obvious claim 1.

1. [1pre] A miniature wide-angle optical apparatus comprising:

108. In Figure 5 (reproduced below), Thibault discloses a “*miniature* panomorph lens,” where Thibault describes a “panomorph lens” as being “modern

patented since 2001 ... wide-angle lenses with a field of view of 120°, usually 180° and beyond, using particular elements to increase the number of pixels in an area of interest.” EX1004, 2, 6. Thibault describes itself as “introduc[ing] the two *smallest* panomorph *wide-angle lenses* with fields of view of 180°.” EX1004, 10.

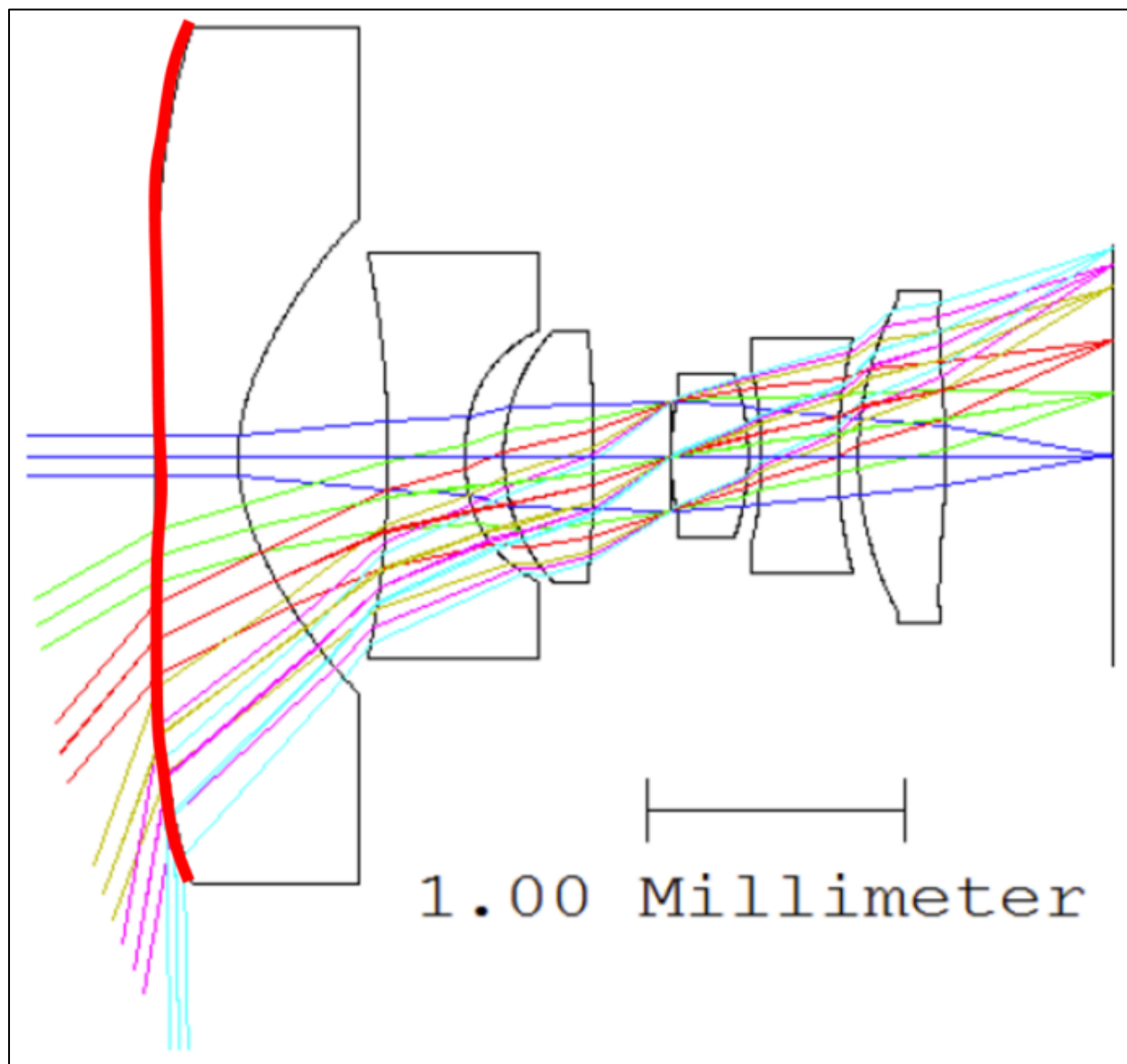


EX1004, FIG. 5

2. [1a] a light-receiving first surface;

109. Thibault discloses this element. EX1004, 6, FIG. 5. “As shown at figure 5, the layout still consist of 6 plastic elements, the shorter TTL being obtained

by further compressing every air spaces and lens thickness to their manufacturing limits and placing the IR filter on the sensor cover glass.” EX1004, 6. The first element (from the left, object-side) includes a light-receiving surface (highlighted red), where various rays of light are shown as multi-colored lines. EX1004, FIG. 5.



EX1004, FIG. 5 (highlighted)

110. While Thibault does not explicitly describe the multicolored lines passing through the panomorph lens of FIG. 5 as “light,” a POSITA would have understood the multi-colored lines as representing rays of light that enter the lens at the light-receiving first surface highlighted red below.

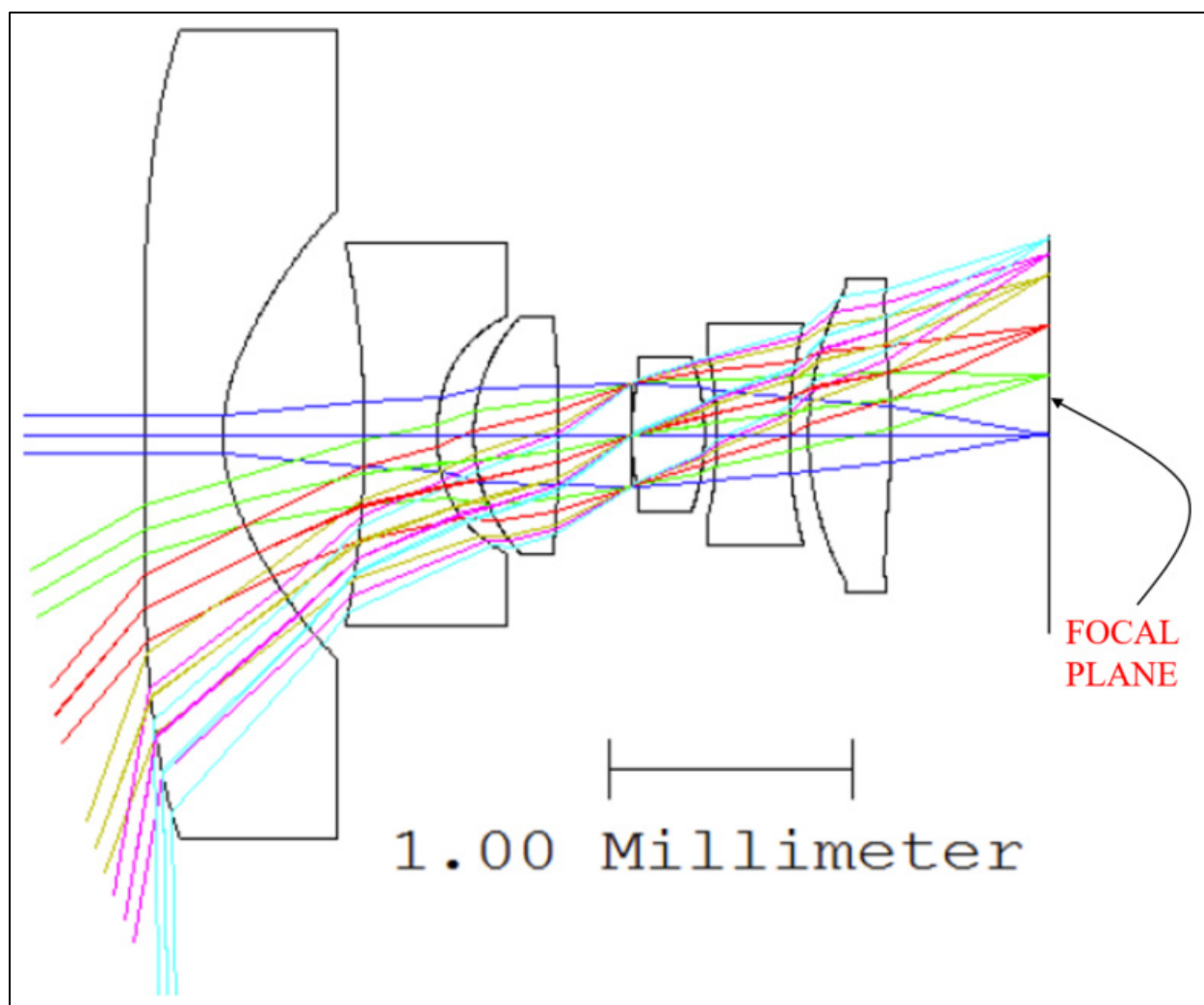
111. Thibault teaches that FIG. 5 does not show “the 0.20 mm cover glass of the sensor which is included in the TTL measurement of 3.80 mm.” EX1004, 6. A POSITA would have understood that the “0.20 mm cover glass” is an optional optical element positioned on the object-side of the panomorph lens that helps protect the system. EX1004, 3 (“the front lens vortex can be leveled with the mechanical surrounding or the lens can be behind a thin cover-glass”). The “0.20 mm cover glass” would have been positioned on the object-side of the lens assembly illustrated in FIG. 5 (*i.e.*, to the left of the above red highlighting). *Id.* The “0.20 mm cover glass” described by Thibault is necessarily an optical element because it would have to pass light through to the remainder of the panomorph lens assembly for the assembly to operate.

112. Thus, in those implementations that include the “0.20 mm cover glass,” the object-side of the cover glass would have been the claimed “light-receiving first surface.” On the other hand, where the “0.20 mm cover glass” is omitted (or located somewhere else within the system), the above red highlighted object-side of the first

element of the panomorph lens would have been the claimed “light-receiving first surface.”

3. [1b] a focal plane;

113. Thibault discloses this element. EX1004, FIG. 5. In particular, Figure 5 of Thibault shows a lens design where various rays of light are shown as multi-colored lines. EX1004, FIG. 5. The convergence of light rays at the line at right, annotated “FOCAL PLANE,” indicates that the lens has a focal plane at the annotated location.

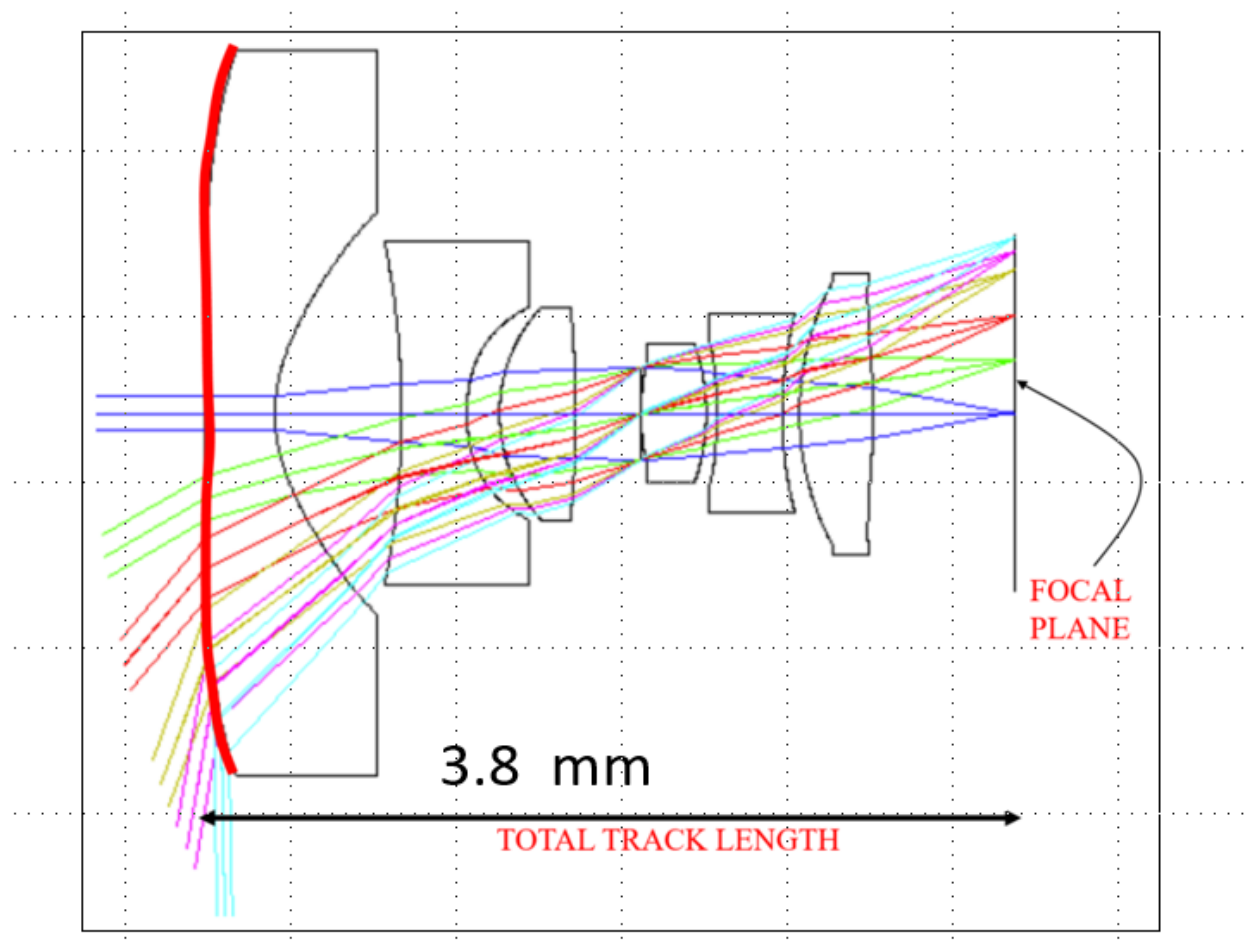


EX1004, FIG. 5 (annotated)

4. [1c] a total track length measured from a center of the first surface to the focal plane;

114. Thibault discloses this element. EX1004, FIG. 5. Thibault describes “two miniature all plastic megapixel panomorph lenses for consumer electronics (*total track length (TTL)*³ of 6.56 mm) and mobile devices (*TTL* of 3.80 mm).” EX1004, 1. In particular, Thibault states that the miniature wide-angle lens design illustrated in FIG. 5 (an annotated version of which is included below) “achieved a *TTL* of 3.80 mm including a 0.2 mm cover glass (3.72 mm in air).” EX1004, 6. As noted with respect to limitation [1b], the “0.2 mm cover glass” is optional, so the TTL of the lens design illustrated in FIG. 5 is “3.72 mm in air” (i.e., without the “0.2 mm cover glass”). *Id.*

³ The “total track length (TTL)” was a known term of art to POSITAs and was known to be measured from “from a center of the first surface to the focal plane,” as claimed. EX1010, 40:7-9. This is particularly true for Thibault, where the authors are four of the six inventors of the ’120 Patent, which suggests that the same authors would use the same language consistently.

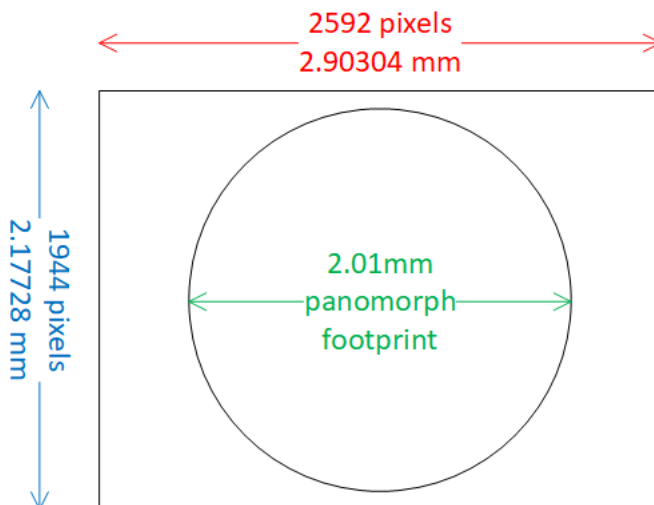


EX1004, Figure 5 (annotated)

5. [1d] a miniaturization ratio with a value less than 3.0, the miniaturization ratio being a ratio of the total track length divided by an image circle diameter; and

115. Thibault discloses this element. EX1004, 6. In particular, as stated with respect to element [1c], the lens design shown in Figure 5 has a total track length of 3.80 mm with the cover glass and “3.72 mm in air” (i.e., without the “0.2 mm cover glass”). EX1004, 6. Thibault additionally describes that the “*panomorph footprint is 2.01 x 2.01 mm* and is designed for the full 360° image to fit the height on a 5.04 MPx 4:3 sensor with 2592 x 1944 pixels of 1.12 μm .” EX1004, 6. As

illustrated below, a POSITA would have understood that the “panomorph footprint” described by Thibault is the claimed “image circle diameter.”



116. As such, with the cover glass, the miniaturization ratio of the lens design is the TTL of 3.80 mm divided by the image circle diameter of 2.01 mm, or **1.89**, which is less than 3.0. Similarly, without the cover glass, the miniaturization ratio of the lens design is the TTL of 3.72 mm divided by the image circle diameter of 2.01 mm, or **1.85**, which is less than 3.0.

6. [1e] a non-linear targeted resolution to intentionally create a zone in an image captured by the miniature wide-angle optical apparatus with a lower or higher object to image magnification compared to linear targeted resolution, the lower or higher object to image magnification being used to compensate, at least in part, for a lower image quality due to at least one of a drop of relative illumination or a drop of MTF in a zone of the image,

117. Thibault discloses or at least renders obvious this element. EX1004, 6, 7, 10, FIGS. 6-7. The only place where the '120 Patent describes “image

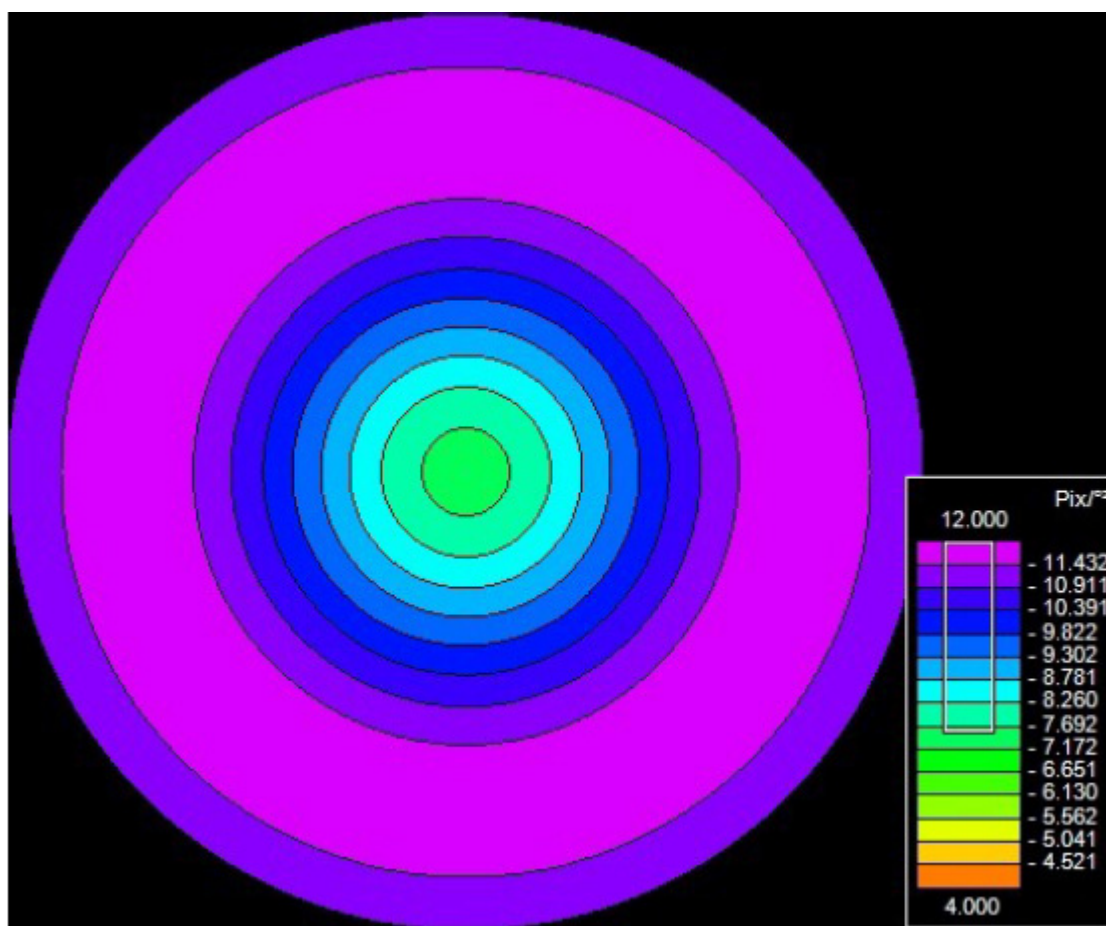
magnification” and “resolution” is with respect to FIG. 7. Specifically, the ’120 Patent describes:

FIG. 7 shows another example embodiment of a ***non-linear targeted resolution curve 700*** for a miniature wide-angle lens according to the present invention. The targeted resolution curve is chosen to have an upward curve between the center ***resolution value 710*** and a maximum 712 (***number of pixels/degree***), followed by a downward curve between the maximum 712 and a region near the edge of the field of view around position 714. ***This downward curve between maximum value 712 and position 714 allows the lens system*** to have a higher relative illumination value toward the edge of the field of view ***by having a lower object to image magnification ratio in that region*** and hence redirecting the same quantity of light from an object to a smaller region in the image with more illumination.

EX1001, 6:28-41. In other words, the ’120 Patent conflated a negative or downward sloped resolution curve as having lower object to image magnification ratio. *Id.* For the same reasons, a POSITA would understand the ’120 Patent to teach that a positive or upward sloped resolution curve as having higher object to image magnification ratio. *Id.*

118. Thibault similarly describes that the lens assembly of FIG. 5 is a “f/2.8 lens [that] has a 1:1 anamorphic ratio and use[s] ***targeted distortion to increase the number of pixels in the zone of interest*** for mobile video chat applications as shown at figure 6.” EX1004, 6. In particular, the bottom portion of Figure 6 (reproduced

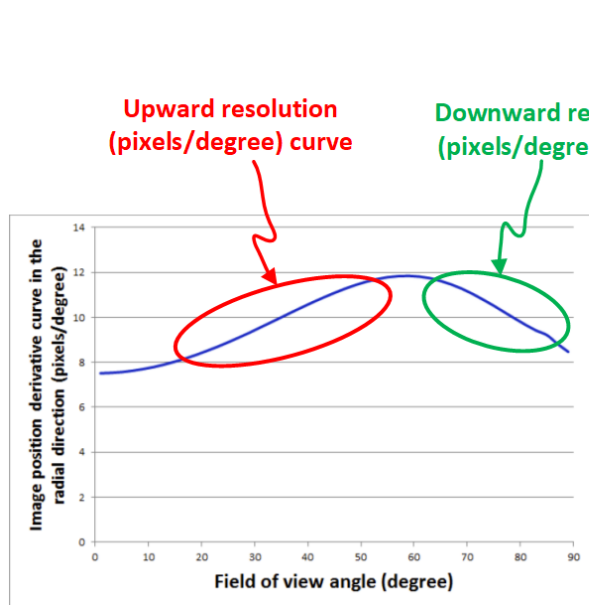
below) shows the surface resolution over the full circular panomorph image. EX1004, 7, FIG. 6. As shown in the resolution graph, the lens design has non-linear targeted resolution such that some zones have higher resolution (e.g., purple and magenta zones) and other zones have a lower resolution (e.g., green and cyan zones). *Id.*, FIG. 6.



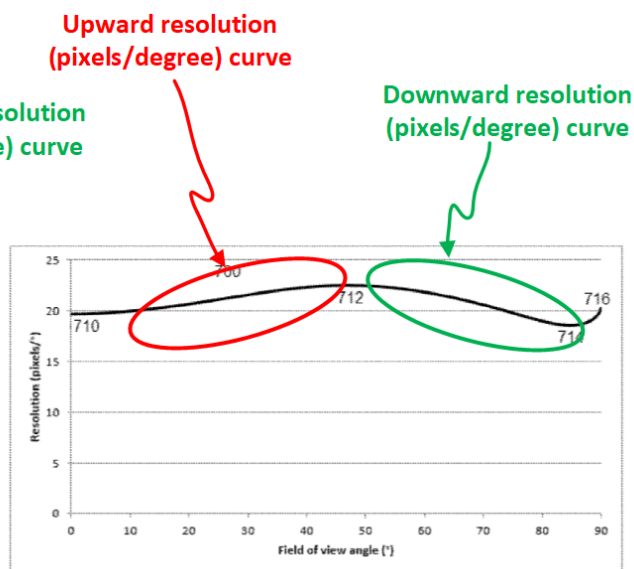
EX1004, Excerpt of Figure 6

119. The top portion of Thibault's Figure 6 (reproduced below) shows curves with areas of increasing and decreasing values, just as in FIG. 7 of the '120 Patent. Thibault refers to the Y-axis of its Figure 6 graph as "image position

derivative curve in the radial direction” and labels it as “pixels/degree.” EX1004, 6-7. Thibault describes this graph as illustrating “the distortion profile ratio from minimum to maximum number of pixels/degree.” EX1004, 6.



EX1004, Annotated Figure 6



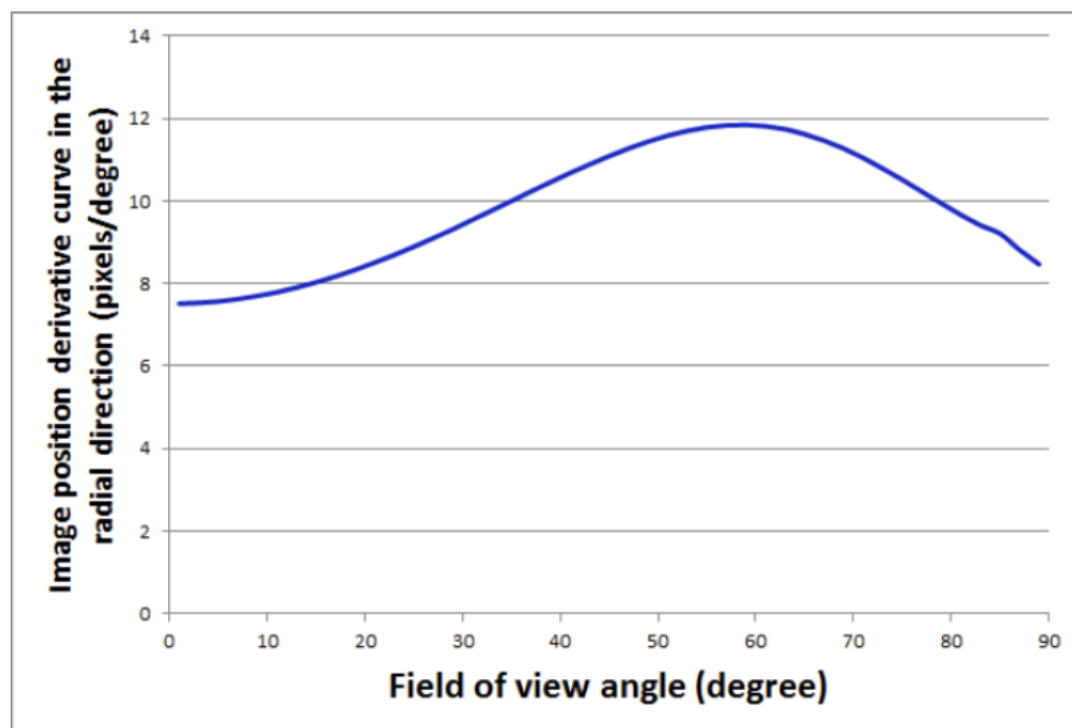
EX1001, Annotated FIG. 7

120. A POSITA would have understood from Thibault that this “distortion profile ratio” is the resolution of the image projected onto the focal plane in pixels/degree. That is, the image of the object is being distorted such that portions of the object are magnified and therefore imaged at a higher resolution than other portions. This is illustrated in Thibault’s Figure 11, where an image/picture was taken using a testing setup in which the object/target “consist[s] of alternating black and white rectangles each 2° wide.” EX1004, 8-9. That is, each black rectangle would have the same width in an undistorted lens, but the lens of Figure 5 causes the

black rectangles at approximately 60° to be magnified (i.e. wider horizontally), and therefore have a greater resolution (i.e., pixels/degree) and perceived size in the image than the black rectangles nearer the center or edges of the image, where the magnification drops (i.e. the images are thinner horizontally) and therefore the resolution (i.e., pixels/degree) decreases.

Lower magnification and fewer pixels/degree, so black rectangle is narrower

Higher magnification and greater pixels/degree, so black rectangle is wider



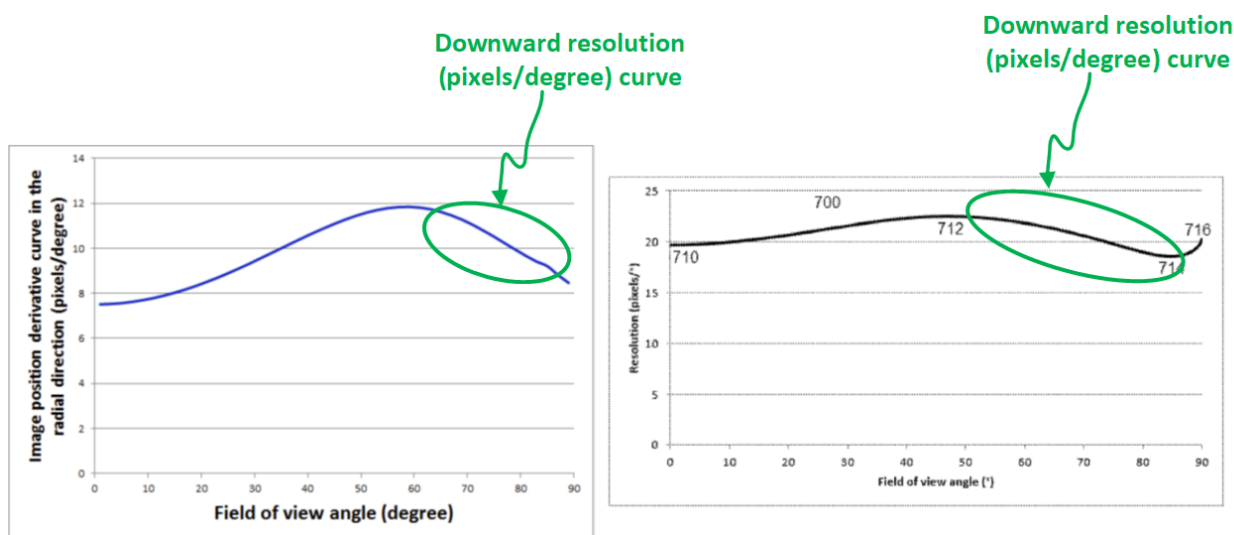
EX1004, Annotated Excerpts of FIGS. 11 and 6

121. Thus, the lens' non-linear targeted resolution creates a zone in a captured image with a higher or lower object to image magnification compared to linear targeted resolution.

122. Further, Thibault teaches or at least renders obvious that the distortion described above is introduced "intentionally." As noted above, Thibault teaches that the lens of Figure 5 "use[s] *targeted* distortion to increase the number of pixels in the zone of interest." EX1004, 6. A POSITA would have understood or at least found it obvious that, by "target[ing] . . . the zone of interest" with distortion, the designers of the Figure 5 lens "intentionally create[d] a zone in an image captured by the miniature wide-angle optical apparatus with a higher object to image magnification compared to linear targeted resolution," as claimed.

123. As noted above, it is my opinion that the final clause of limitation [1e] that recites the "zone . . . being used to compensate" does not define any structure for the claimed optical apparatus. However, to the extent that the final clause of this limitation is considered further limiting, the curvature of the resolution curve in Thibault's Figure 6 will "compensate, at least in part, for a lower image quality due to at least one of a drop of relative illumination or a drop of MTF in a zone of the image" for the same reasons as described in the '120 Patent. The '120 Patent describes that the "downward curve between maximum value 712 and position 714 allows the lens system to have a higher relative illumination value toward the edge

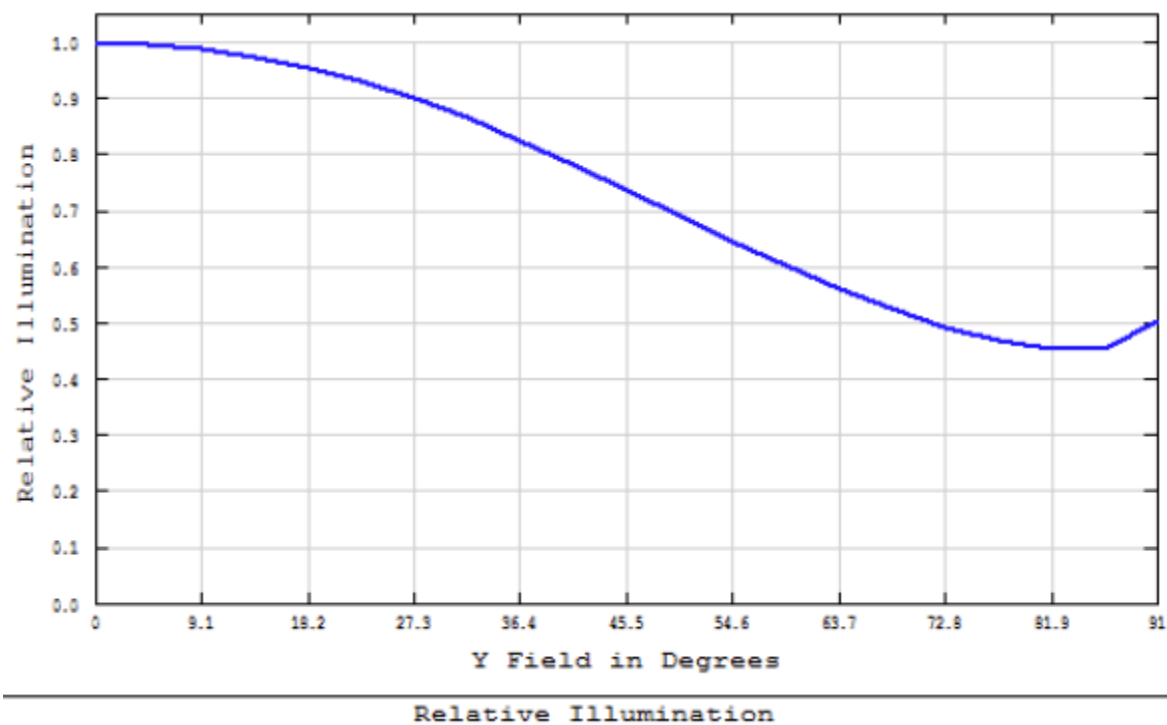
of the field of view by having a lower object to image magnification ratio in that region and hence redirecting the same quantity of light from an object to a smaller region in the image with more illumination.” EX1001, 6:36-41. The resolution curve in Thibault’s Figure 6 has a similar downward slope to Figure 7 of the ’120 Patent as annotated below, and would therefore have the same impact on relative illumination as described in the ’120 Patent.



EX1004, Annotated Figure 6

EX1001, Annotated FIG. 7

124. Indeed, Thibault’s Figure 7 (reproduced below) illustrates an increase in relative illumination toward the edge of the field of view, just as predicted by the ’120 Patent.

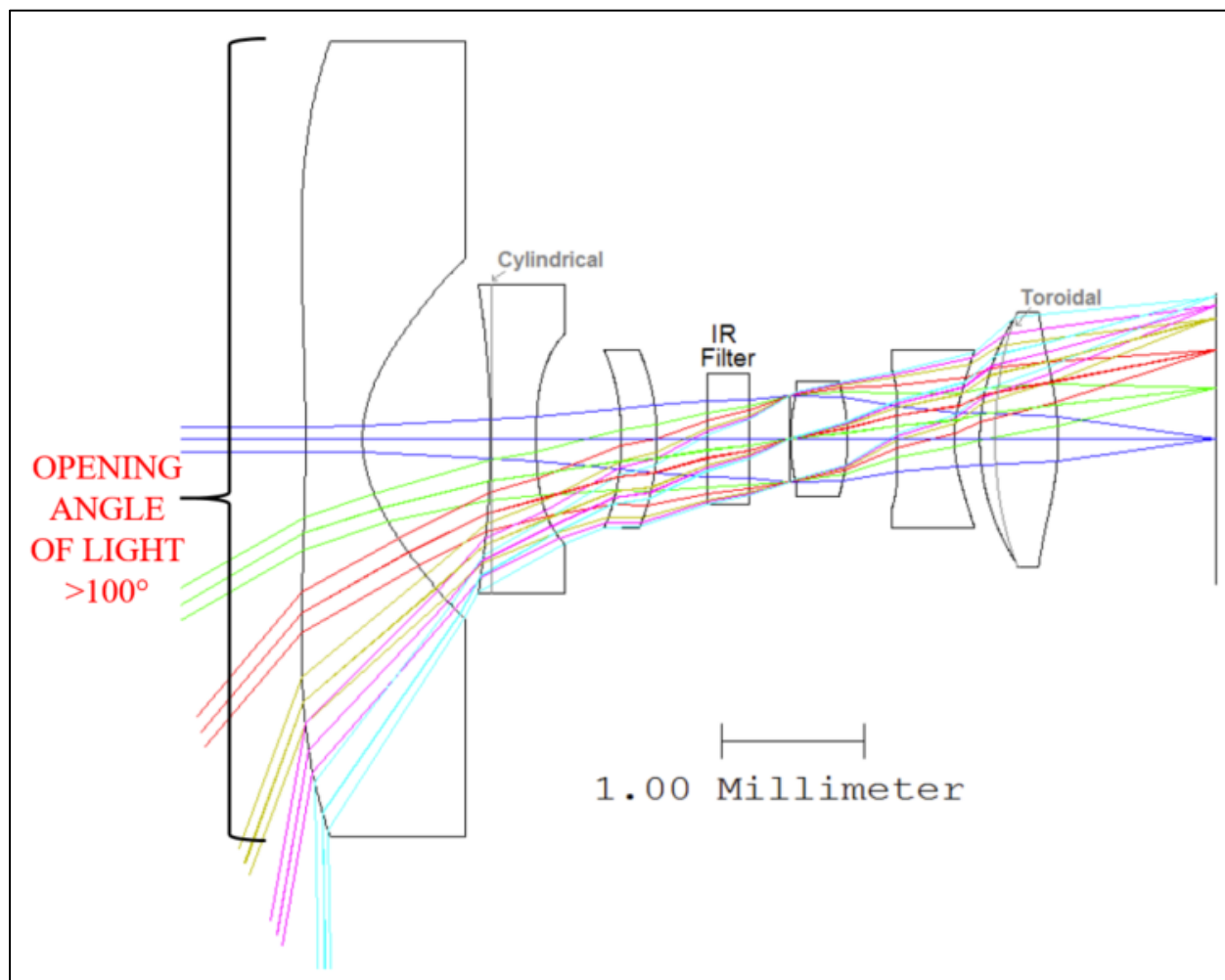


EX1004, FIG. 7

7. *[1f] an opening angle of light entering the optical apparatus being over 100°.*

125. Thibault discloses this element. EX1004, FIG. 5. Thibault describes itself as introducing “the two smallest panomorph wide-angle lenses *with fields of view of 180°*.” EX1004, 10. This is illustrated in Thibault’s Figure 5, where various rays of light are shown as multi-colored lines. EX1004, FIG. 5. A POSITA would have understood from these light rays that the opening angle of light of the lens design is 180°, which is over 100°. This is clear at least from the bottom-most set of rays in cyan, which, given the symmetrical nature of the lens element, would have a counterpart top-most set of rays (not shown), forming a 180° opening angle of light. EX1004, 6 (“symmetric”). Indeed, the ’120 Patent also refers to the claimed

100° of light entering the optical apparatus as the “field of view,” consistent with Thibault. *See* EX1001, 3:55-61, 4:38-44, 5:16-22.



EX1004, FIG. 5 (annotated)

B. Claim 2

126. Claim 2 of the '120 Patent recites:

2. The miniature wide-angle optical apparatus of claim 1, wherein the optical apparatus is configured to create a resulting image with a constant image quality across a whole field of view.

127. This claim limitation would have been obvious to a POSITA. All intentional and considered optical designs were and continue to be “configured” to create an apparatus with as close to constant image quality over the image as physically possible. Perfectly constant image quality is not always physically possible, though, and even the term “image quality” is not always well defined, so allowances and tradeoffs are usually made. For example, a POSITA would have known how to trade MTF for field shading (illumination fall-off with the field), or to trade cost with performance, since higher performance usually means more complex and costly lenses. However, the goal or “mission statement” of a designer/POSITA has always been to get the best performance over the field. During the design process, the POSITA carefully monitors the performance of his apparatus over the field. The POSITA can use different ways to calculate the performance like using MTF curves, wavefront variance, Strehl ratios, or RMS spot sizes in addition to distortion, lateral color and other attributes—which a POSITA can evaluate using programs like Zemax. No matter what criteria the POSITA used—the subject incidentally of my 1981 dissertation “Image Quality Criteria in the Presence of Moderately Large Aberrations”—the POSITA’s aim in whatever optical system he/she is designing is to achieve this goal. Thus, to the extent that Thibault’s lenses do not “create a resulting image a constant image quality across a whole field of

view,” as claimed, a POSITA would nonetheless have found it obvious to modify them to do so.

128. Consistent with this, Thibault teaches that, “[t]o *control the image quality* in production so that it remains in the specification, special optimization to make sure that the MTF stays within a range of a few % from the nominal MTF for all fields are required. To achieve that, desensitization of the several worst offenders was done during the optical design optimization using typical tolerance guidelines from mobile industry.” EX1004, 3. From this teaching, a POSITA would have understood that Thibault’s lens designs were intended to achieve “constant image quality across a whole field of view,” or that it would have been obvious to achieve such an outcome using known “guidelines” within the industry.

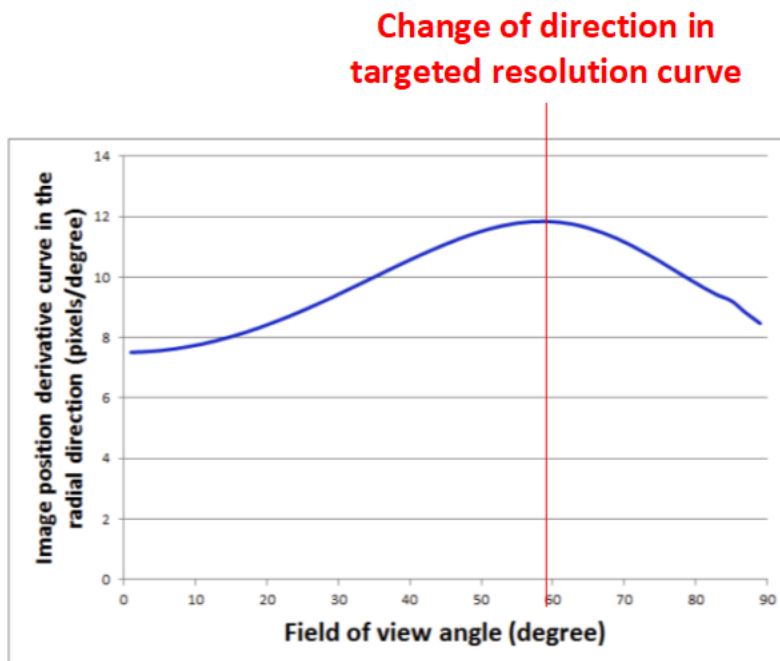
C. Claim 3

129. Claim 3 of the ’120 Patent recites:

3. The miniature wide-angle optical apparatus of claim 1, wherein a targeted resolution curve has a change of direction near an edge of a field of view.
--

130. Thibault discloses claim 3. EX1004, FIG. 6. As I described above in relation to limitation [1e], the image position derivative curve in the radial direction in the top-portion of Thibault’s Figure 6 is a target resolution curve, as it plots the pixel/degree resolution with respect to the field of view angle of the 3.80 mm TTL lens illustrated in Figure 5. The top-portion of Thibault’s Figure 6 shows a change

of direction of the targeted resolution curve at approximately 60°, which is annotated in red below.



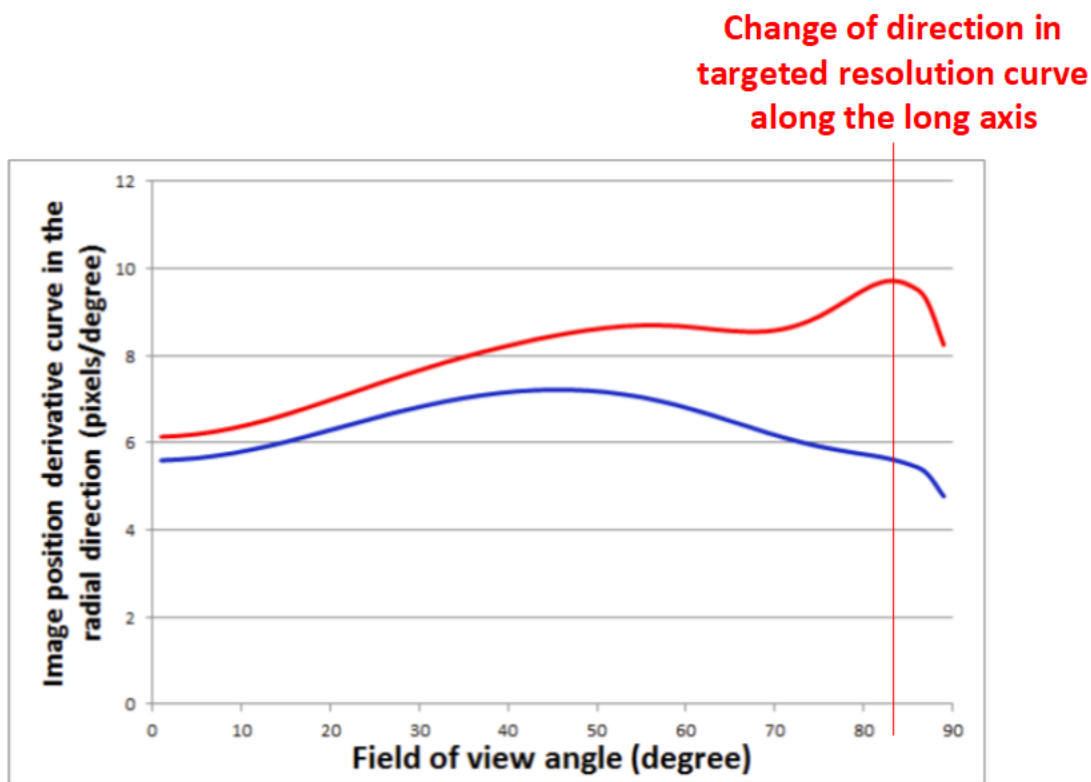
EX1004, FIG. 6 (cropped; annotated).

131. The '120 Patent does not define the word “near.” Rather, the only place that the specification uses the word “near” is when it describes that FIG. 7 includes “a downward curve between the maximum 712 and a region *near* the edge of the field of view around position 714.” EX1001, 6:30-35. This contrasts the change of direction between positions 714 and 716 of FIG. 7, which the '120 Patent describes as “a change of direction *at* the edge of the field of view 716” (as opposed to “near” the edge). EX1001, 6:42-44. Because the change of direction in the top-portion of Thibault’s Figure 6 happens nearer to the edge of the field of view (i.e., 90°) than to the center (i.e., 0°) and the resulting downward sloping portion of the resolution

curve is in a similar range of the field of view as the downward sloping portion between positions 712 and 714 of the '120 Patent, a POSITA would have found it reasonable to consider the change of direction at 60° to be “near an edge of a field of view,” as that term is loosely used in the '120 Patent.

132. However, if Patent Owner argues that claim 3's use of the phrase “near an edge of a field of view” is intended to refer to the change of direction nearer the positions 714 and 716 of FIG. 7 of the '120 Patent (e.g., somewhere approximately between $80\text{-}90^\circ$), a POSITA would have found it obvious to modify the lens assembly such that the change in direction is shifted to that region based on Thibault's overall teachings, and particularly those with respect to the 6.56 mm TTL lens illustrated in Figure 2.

133. As shown in the top-portion of Figure 3, the targeted resolution curve of the 6.56 mm TTL lens has a change of direction between $80\text{-}90^\circ$, which is annotated in red below.



EX1004, Figure 3 (annotated)

134. Thibault generally teaches a POSITA that there is a benefit to designing a lens so that the resulting image includes an “increase [in] the number of pixels in an area of interest.” EX1004, 2. This is achieved in part through “controlled distortion to selectively stretch or compress the number of pixels in areas of interest in the field of view.” EX1004, 2. With respect to the 6.56 mm TTL lens, Thibault acknowledges that there are at least a subset of use cases where it is desirable to design the targeted distortion of the lens “to increase the number of pixels/degree *toward the edge of the FoV* as shown in figure 3.” EX1004, 4. This is consistent

with the maximum value of pixels/degree being between 80-90°, as annotated above with respect to Figure 3.

135. Based on these teachings, a POSITA would have found it obvious to modify the design of the 3.80 mm TTL lens illustrated in Figure 5 such that the area of interest is closer to the edge of the field of view, similar to where it is shown in the top portion of Thibault's Figure 3. This would have resulted in a lens that has a peak pixels/degree resolution between 80-90° of the field of view, as opposed to at 60°, where it is shown in Figure 6. For example, in the context of video chat, as shown in Thibault's Figure 3, a POSITA would have recognized that moving the area of interest and targeted distortion closer to edge of the field of view would beneficially allow the users to position themselves closer to edge of the field (e.g., by sitting back more comfortably from the lens) and would allow more users to be positioned within the field of view at the area of interest with the increased resolution.

136. As I described above in my Technological Overview, a POSITA would have achieved this using optical design software through manipulation of the merit functions associated with the optical apparatus. I have not undergone the process of such a modification for purposes of preparing this declaration. However, Thibault provides at least as much teaching regarding the properties of its 6.56 and 3.80mm TTL lenses as the '120 Patent does regarding the claimed lens. Thus, if the '120

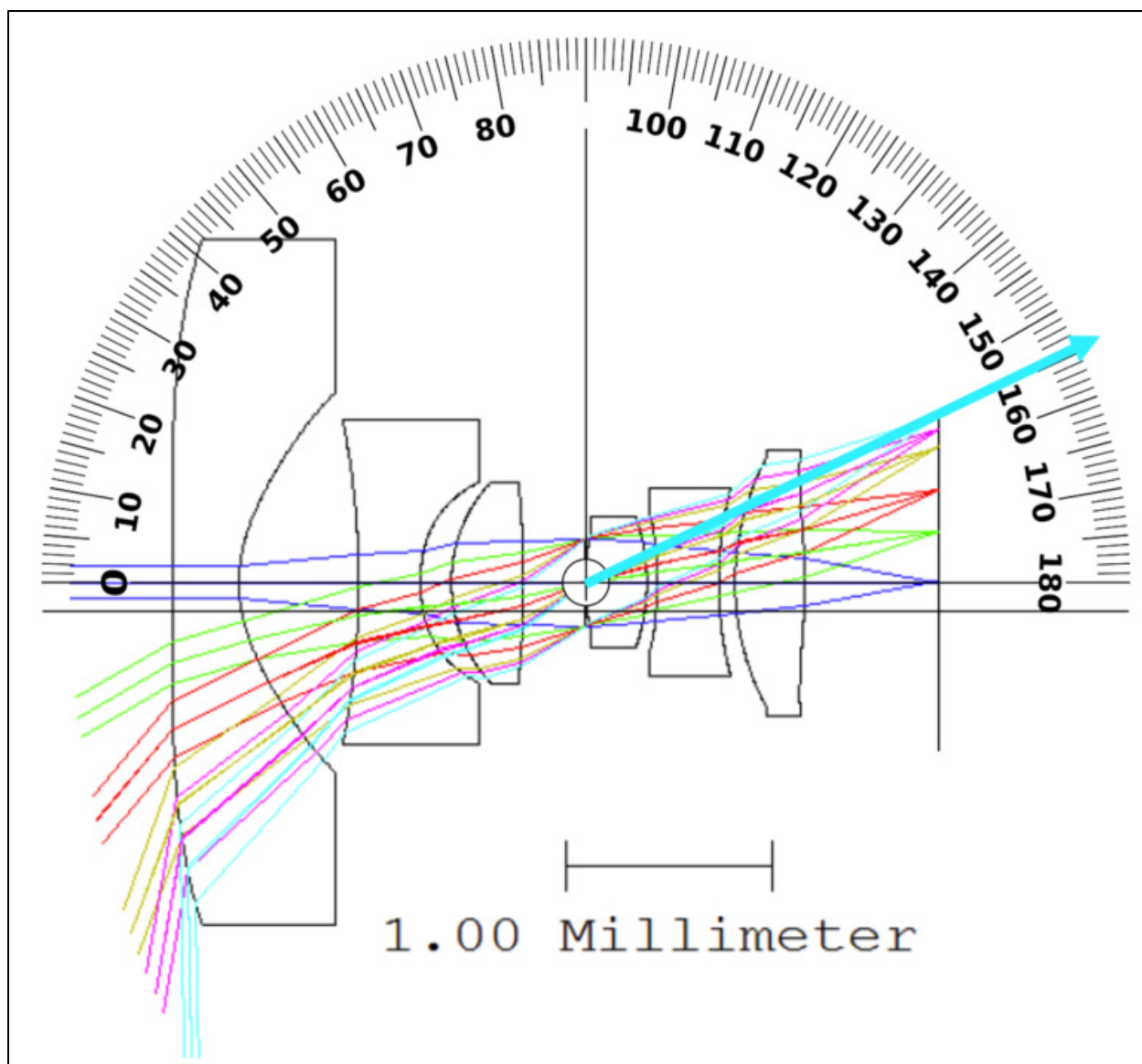
Patent contains a disclosure that would enable a POSITA to build its lenses, the disclosure of Thibault is sufficient to enable a POSITA to make this obvious modification.

D. Claim 4

137. Claim 4 of the '120 Patent recites:

4. The miniature wide-angle optical apparatus of claim 1, wherein an angle of chief-rays reaching the focal plane is over 20° from an optical axis of the optical apparatus.
--

138. Thibault discloses claim 4. EX1004, FIG. 5. In particular, as illustrated in the modified image of Figure 5 below, the chief-rays reaching the focal plane are over 20° (approximately 26°) from the optical axis of the lens. *Id.*



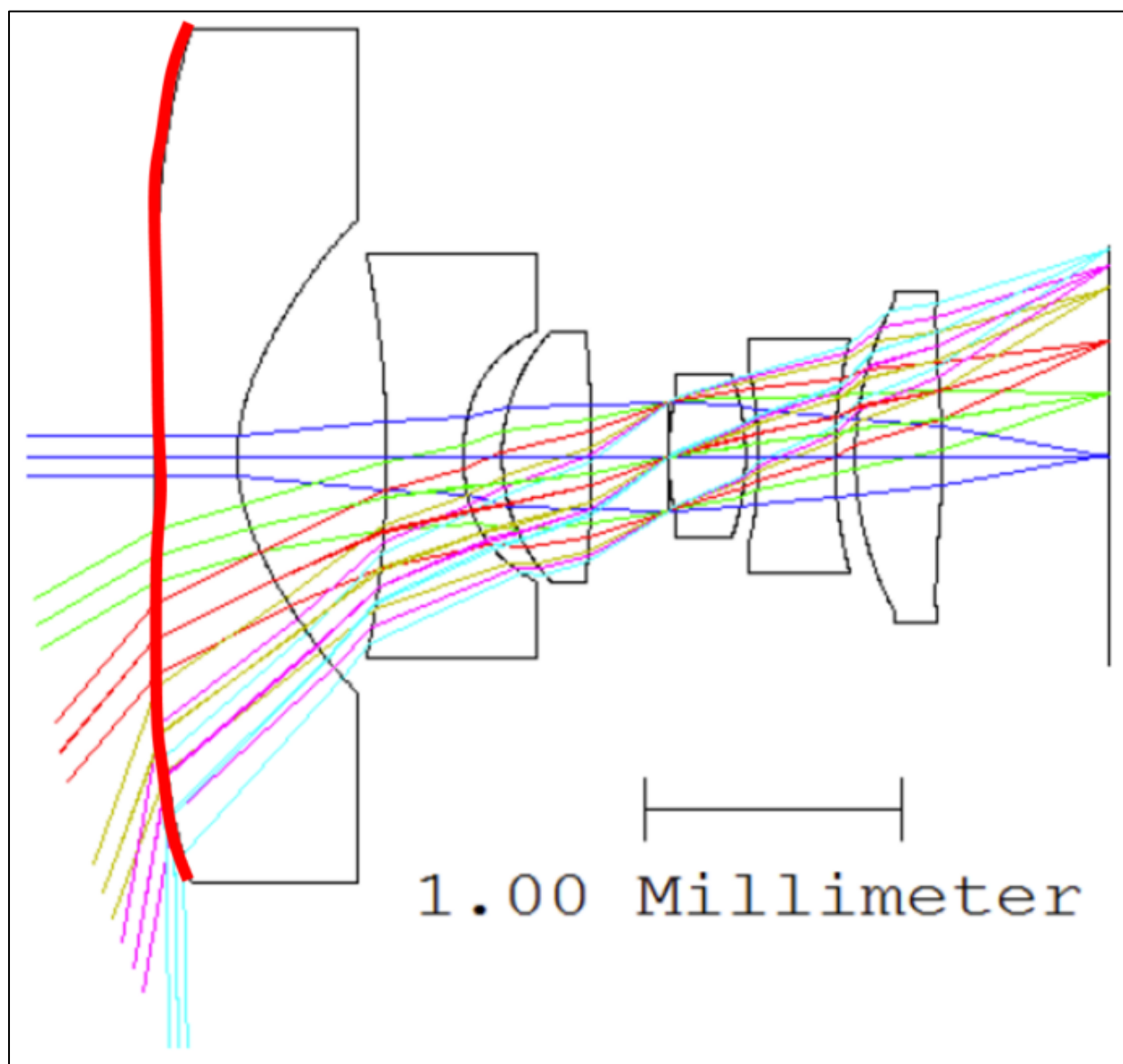
EX1004, FIG. 5 (modified)

E. Claim 5

139. Claim 5 of the '120 Patent recites:

5. The miniature wide-angle optical apparatus of claim 1, further comprising a plurality of optical elements, at least one of the plurality of optical elements defining the first surface.

140. Thibault discloses claim 5. EX1004, 6, FIG. 5. As shown in Thibault's Figure 5, the lens design having a TTL of 3.80 mm has a plurality of optical elements ("6 plastic elements" and a "0.2 mm cover glass"). EX1004, 6-7.



EX1004, FIG. 5 (highlighted)

141. As I described above for limitation [1a], a POSITA would have understood that, for this lens design, the "0.20 mm cover glass" is an optional optical

element positioned on the object-side of the panomorph lens that helps protect the system. EX1004, 3 (“the front lens vortex can be leveled with the mechanical surrounding or the lens can be behind a thin cover-glass”). Thus, in those implementations that include the “0.20 mm cover glass,” the object-side of cover glass would have been the claimed “light-receiving first surface.” On the other hand, where the “0.20 mm cover glass” is omitted (or located somewhere else within the system), the above red highlighted object-side of the first element of the panomorph lens would have been the claimed “light-receiving first surface.”

F. Claim 6

142. Claim 6 of the '120 Patent recites:

6. The miniature wide-angle optical apparatus of claim 5, wherein at least one of the optical elements is made of glass.
--

143. Thibault discloses claim 6. EX1004, 6. In particular, the optical apparatus of Thibault having a TTL of 3.80 mm may include an optional “0.2 mm cover glass.” EX1004, 6. Thibault describes that “the front lens vortex can be leveled with the mechanical surrounding or the lens can be behind *a thin cover-glass*,” which means that the cover glass would be positioned on the object-side of the lens (i.e., on the left side of the six plastic elements shown in Figure 5). EX1004, 3, 6-7. As described above with respect to limitation 1[a], the “0.20 mm cover glass” described by Thibault is necessarily an optical element because it would have to pass

light through to the remainder of the panomorph lens assembly for the assembly to operate. Thus, in those implementations that include the “0.20 mm cover glass,” at least one of the optical elements is made of glass, as claimed.

G. Claim 7

144. Claim 7 of the '120 Patent recites:

7. The miniature wide-angle optical apparatus of claim 1, wherein the miniaturization ratio value is less than 2.0.
--

145. Thibault discloses claim 7. EX1004, 6. As discussed with respect to element [1d], with the cover glass, the miniaturization ratio of the lens design is the TTL of 3.80 mm divided by the image circle diameter of 2.01 mm, or **1.89**, which is less than 2.0. Similarly, without the cover glass, the miniaturization ratio of the lens design is the TTL of 3.72 mm divided by the image circle diameter of 2.01 mm, or **1.85**, which is less than 2.0.

XI. GROUND 2: MATSUSAKA ANTICIPATES OR RENDERS OBVIOUS CLAIMS 1 AND 3-6

A. Claim 1

146. Claim 1 of the '120 Patent recites:

1. A miniature wide-angle optical apparatus comprising:
a light-receiving first surface;
a focal plane;
a total track length measured from a center of the first surface to the focal plane;
a miniaturization ratio with a value less than 3.0, the miniaturization ratio being a ratio of the total track length divided by an image circle diameter; and
a non-linear targeted resolution to intentionally create a zone in an image captured by the miniature wide-angle optical apparatus with a lower or higher object to image magnification compared to linear targeted resolution, the lower or higher object to image magnification being used to compensate, at least in part, for a lower image quality due to at least one of a drop of relative illumination or a drop of MTF in a zone of the image,
an opening angle of light entering the optical apparatus being over 100°.

147. As I explain in more detail below through my feature-by-feature analysis, Matsusaka discloses or renders obvious claim 1.

1. [1pre] A miniature wide-angle optical apparatus comprising:

148. Matsusaka is directed to a “**wide-angle optical system** that is **compact** and copes with a wide angle of view, and in particular, relates to a wide-angle optical system that is **suitable to a super wide-angle optical system that copes with a super wide angle and has a total angle of view of 90° or more.**” *Id.*, ¶0002. As described in the Overview, Matsusaka provides twenty three (23) examples of “[s]pecific constructions of **wide-angle optical system** 1 shown in FIG. 1” that each “satisfy the required conditions relating to the present invention.” EX1005, ¶¶0234, 0449-0450.

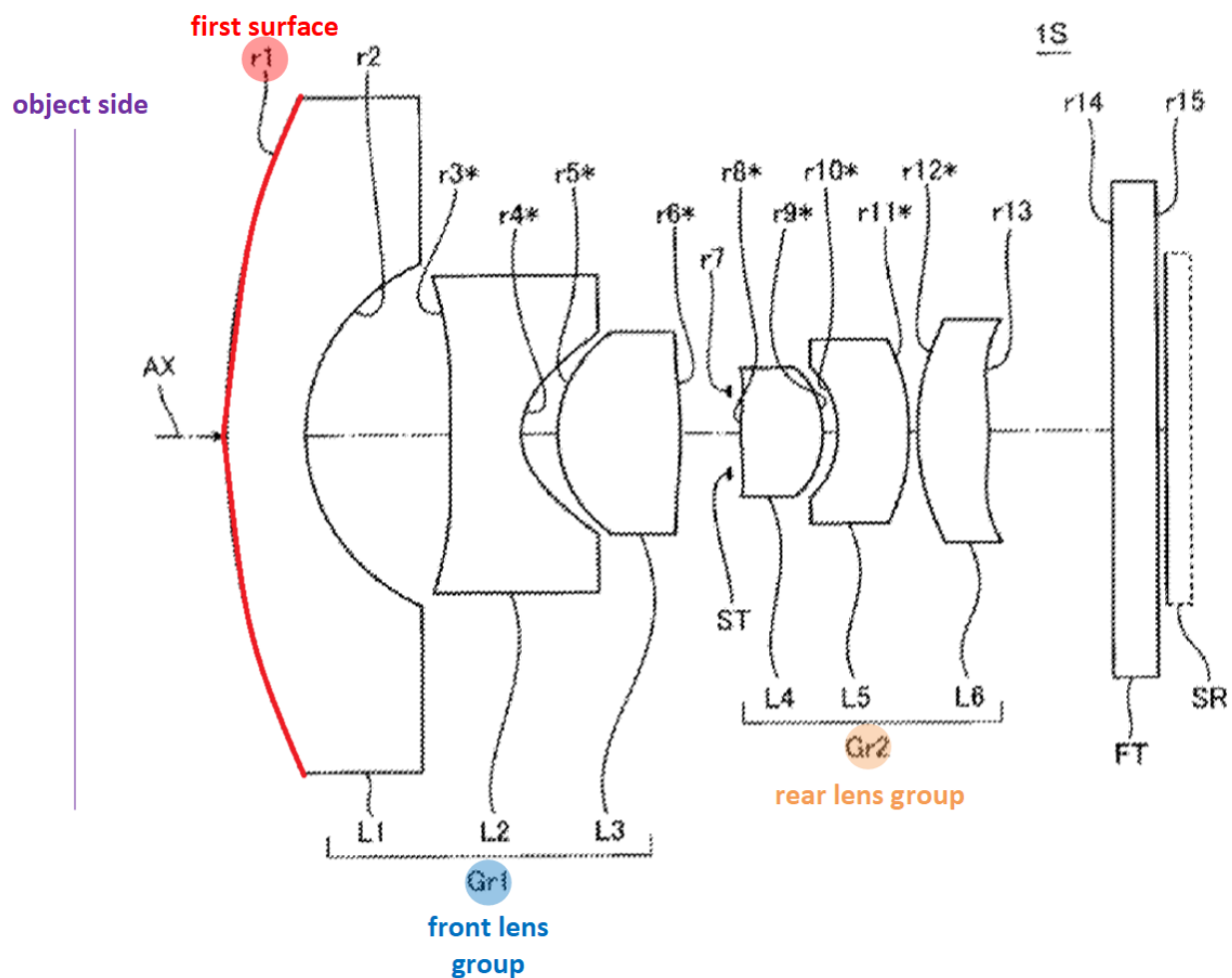
Matsusaka describes that each of “Examples 1 to 23 are capable of achieving a *super wide angle* which is a total angle of view of 180° or more.” EX1005, ¶0450.

149. Matsusaka describes that “the wide-angle optical system having such [] structure can provide a wide-angle optical system that has more excellent optical efficiency and *is made to be compact (downsized)*.” EX1005, ¶0233. Like the ’120 Patent, Matsusaka describes that its optical system is sufficiently compact “for being mounted on . . . a mobile terminal.” EX1005, ¶0450; EX1001, 1:26-30. As will be described in further detail with respect to limitation [1d], below, Matsusaka’s optical system has a miniaturization ratio that is smaller than the threshold set in the ’120 Patent, and is therefore “miniature,” as that term is used in the ’120 Patent. *See* EX1001, 1:26-30.

2. [1a] a light-receiving first surface;

150. Matsusaka discloses this element. EX1005, FIG. 23, ¶¶0404-0410. “FIG. 23 is a sectional view showing an arrangement of lens groups in a wide-angle optical system of Example 19.” EX1005, ¶0404. “Wide-angle optical system 1S of Example 19 has a two-component structure of negative-positive components which includes, as shown in FIG. 23, a front lens group (Gr1) having a negative optical power as the whole lens group, aperture stop ST for adjusting a light amount, and a rear lens group (Gr2) having a positive optical power as the whole lens group, which are arranged in order from the object side to the image side.” EX1005, ¶0405.

FIG. 23



EX1005, FIG. 23 (annotated)

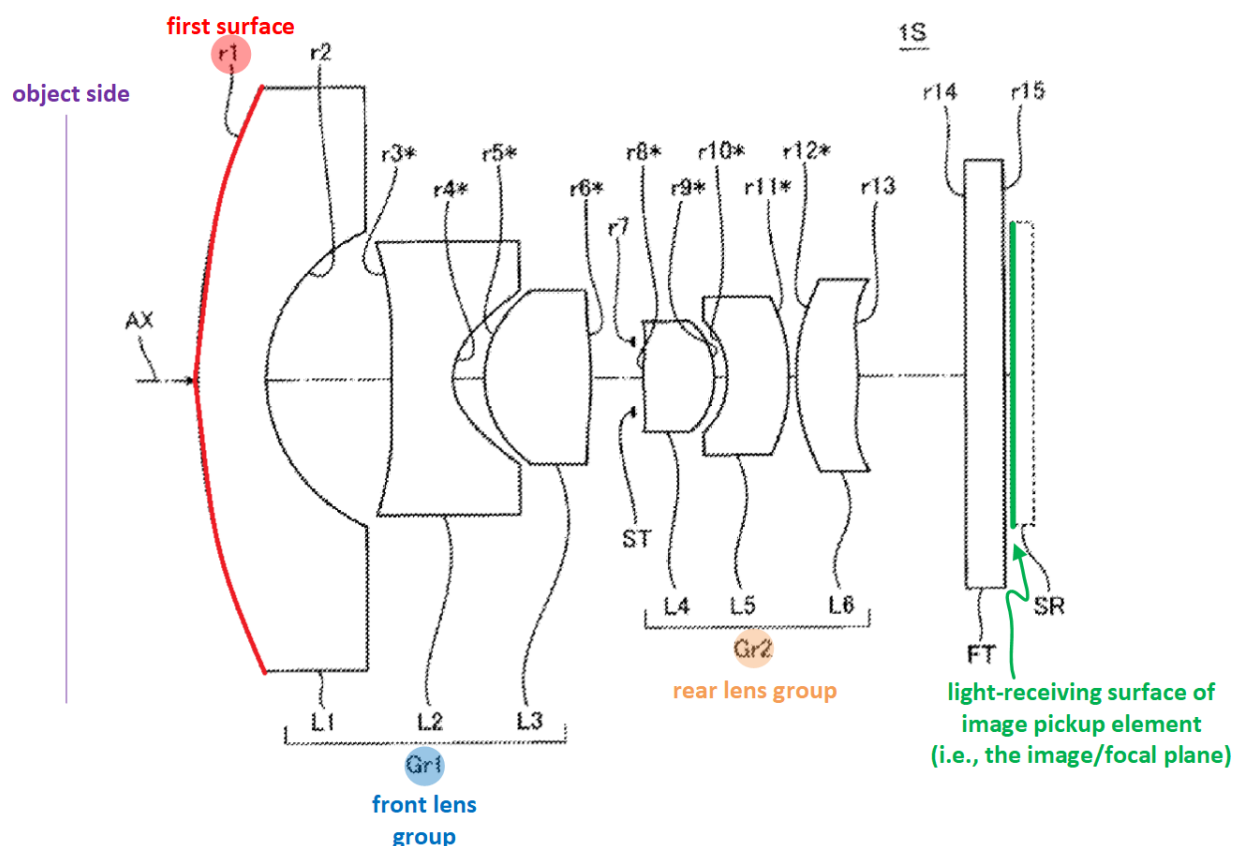
151. “The first lens group (Gr1) is composed of a negative meniscus lens (first lens L1) whose convex surface faces the object side.” EX1005, ¶0407. A POSITA would have understood that surface r1 of first lens L1 (highlighted in red above) is a “first surface,” as claimed. Surface r1 is the surface of exemplary optical system 1S that is closest to the object and furthest from the image plane, which is the “light-receiving surface of image pickup element SR.” EX1005, FIG. 23,

¶¶0404-0410. In order for light to be received on the surface of the image pickup element SR, as described by Matsusaka, it would necessarily have to pass through each surface of the exemplary optical system 1S (including the first surface r1) on its path from the object from which the light originates to the light-receiving surface of image pickup element SR. See EX1005, ¶¶0151 (“the optical image of a photographic object at the object side are guided to a light-receiving surface of image pickup element 15 by wide-angle optical system 1 along the optical axis AX, and the optical image of the photographic object is picked up by image pickup element 15.”), 0211.

3. [1b] a focal plane;

152. Matsusaka discloses this element. EX1005, FIG. 23, ¶¶0404-0410. Specifically, Matsusaka describes that the wide-angle optical system 1 of FIG. 1 (and thus all of the examples) “is equipped favorably on an image pickup lens device whose structure [is] capable of forming an optical image of an object (photographic object) on a predetermined image forming surface, for example, on a light-receiving surface (image plane) of image pickup element 15 that converts an optical image into electric signal.” EX1004, ¶0145; see also *id.*, ¶¶0221, 0232 (describing that the wide-angle optical system 1 focuses an image of an object on the light-receiving surface of image pickup element).

FIG. 23



EX1005, FIG. 23 (annotated)

153. The '120 Patent treats the light receiving surface of image sensor 127 as the “focal plane,” and uses these concepts interchangeably. See EX1001 4:15-21 (“lens 100 has a **total track length** 150, which is a measure from the first surface on the object side of lens 120 **to the image sensor 127**”); 7:14-15 (“a **total track length** measured from a center of the first surface **to the focal plane**”). Thus, a POSITA would have understood that the light-receiving surface, *i.e.*, image plane, of image pickup element SR (highlighted in green above) is the claimed “focal plane.”

4. [1c] a total track length measured from a center of the first surface to the focal plane;

154. Matsusaka discloses this element. EX1005, FIG. 23, ¶¶0404-0411. For wide-angle optical system 1S of Example 19, Matsusaka provides the following data:

Unit mm

Surface data				
Surface Number	r	d	nd	vd
Object plane	∞	∞		
1	10.286	0.900	1.83481	42.72
2	2.300	1.638		
3*	38.903	0.800	1.53048	55.72
4*	0.812	0.416		
5*	1.623	1.392	1.63200	23.41
6*	-4.562	0.561		
7 (Stop)	∞	0.132		
8*	6.361	0.921	1.53048	55.72
9*	-1.232	0.171		
10*	-1.225	0.800	1.63200	23.41
11*	-3.876	0.100		
12*	3.352	0.800	1.53048	55.72
13*	-3.490	1.400		
14	∞	0.500	1.51680	64.20
15	∞	0.100		
Image plane	∞			

Distance from surface r1 to surface r2

Distance from surface r15 to the image/focal plane

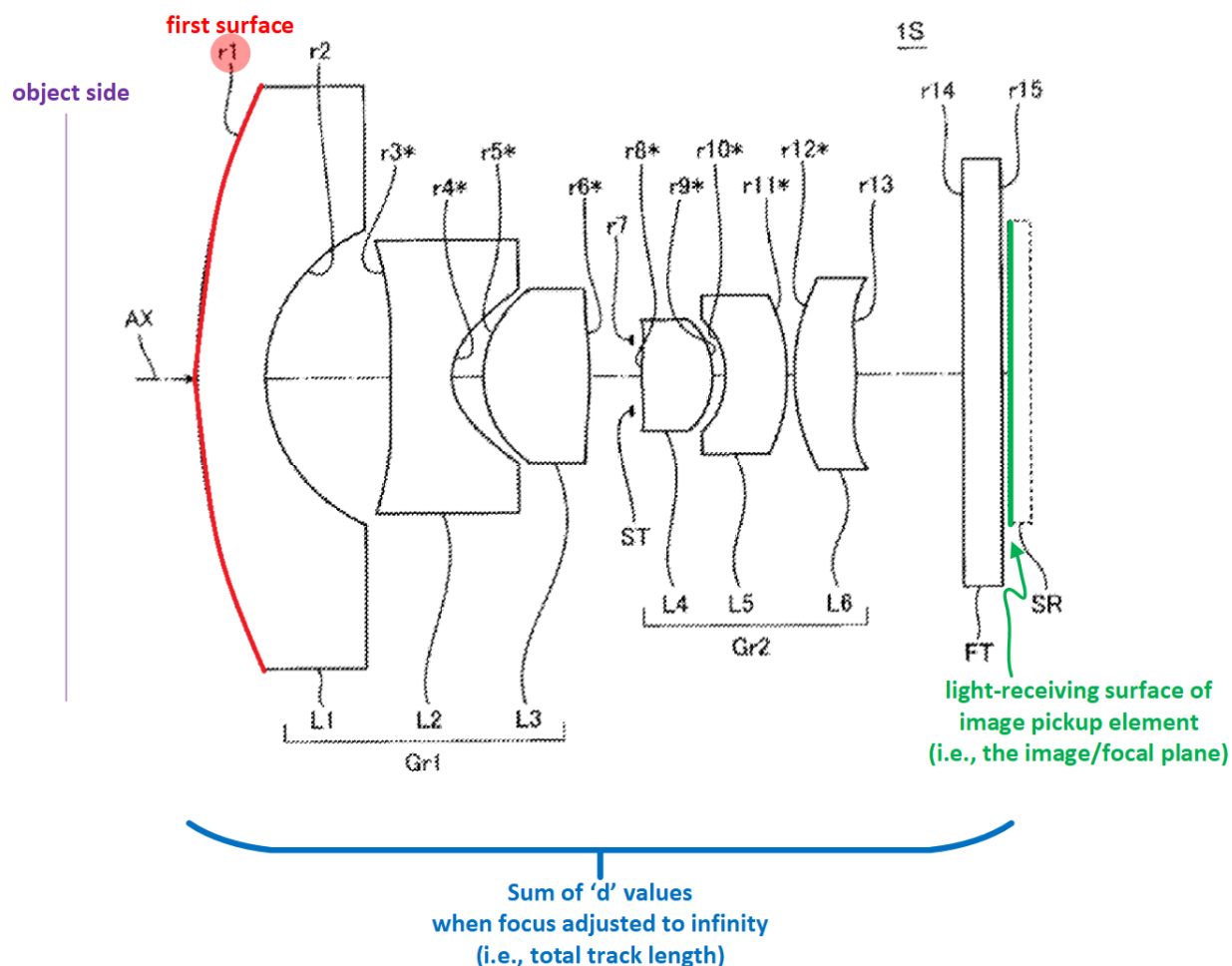
EX1005, ¶0411 (highlighted and annotated).

155. Matsusaka describes that “‘d’ represents a space between lens surfaces on the optical axis (an axial surface distance) under the condition that the focus is adjusted to infinity.” EX1005, ¶0246. Many optical apparatuses have the ability to change focus, like the one in Matsusaka. For these optical apparatuses, the focus allows objects at a given depth within the field of view of the optical apparatus to appear sharper (i.e., “in focus”) while other objects at other depths with the field of view may appear blurry (i.e., out of focus). By changing the focus, the optical apparatus “focuses” on a different depth within the field of view. For a given lens assembly, the total track length may change depending on the focus condition, because focusing may change to distance between individual lenses included in the optical apparatus and/or the distance between the lenses and the image sensor. Matsusaka’s description of the condition being “that the focus is adjusted to infinity” means that the lenses are positioned with respect to one another such that the depth of field of the image created by the optical apparatus is at its maximum and the maximum number of object are in focus regardless of their distance from the optical apparatus.

156. In the above table from Matsusaka, the first value of ‘d’ associated with surface r1 (demarked by a red box) is the distance between the surface r1 of first lens L1 and surface r2 of first lens L1 on the optical axis. See EX1005, ¶¶0246, 0411. Similarly, the last value of ‘d’ associated with surface r15 (demarked by a blue box)

is the distance between the surface r15 of parallel flat plate FT and the surface of the image/focal plane. *See id.* Thus, adding up all the ‘d’ values listed in ¶0411 would represent the distance from a center of surface r1 (*i.e.*, the claimed “first surface”) to the image plane (*i.e.*, the claimed “focal plane”) under the condition that the focus is adjusted to infinity. *See id.* Using this method of calculation, the total track length of the wide-angle optical system 1S of Example 19 is 10.631 mm under the condition that the focus is adjusted to infinity.

FIG. 23



EX1005, FIG. 23 (annotated)

157. Matsusaka also discloses the following additional data about wide-angle optical system 1S of Example 19:

Various types of data	
Focal length	1.010
F number	2.828
Half angle of view	104.183
Image height	2.110
Total lens length	10.503
BF	1.872

EX1005, ¶0411 (highlighted). As highlighted in yellow, Matsusaka describes the “total lens length” as 10.503 mm. *Id.* Based on the teachings of Matsusaka and their general knowledge, a POSITA would have understood the “total lens length” disclosed by Matsusaka to be the distance from a center of surface r1 (i.e., the claimed “first surface”) to the image plane (i.e., the claimed “focal plane”) under the condition that the focus is adjusted to less than infinity. This stands to reason because the “total lens length” disclosed by Matsusaka (i.e., 10.503 mm) is slightly less than 10.631 mm, which a POSITA would have understood accounts for the case where the optical elements are moved with respect to the image plane in order to focus on a closer object. Accordingly, Matsusaka discloses different total track lengths under different conditions.

5. [1d] a miniaturization ratio with a value less than 3.0, the miniaturization ratio being a ratio of the total track length divided by an image circle diameter; and

158. Matsusaka discloses this element. EX1005, ¶¶0161, 0246, 0411. As I described with respect to limitation [1c], a POSITA would have understood that the “total track length” of Matsusaka’s wide-angle optical system 1S of Example 19 is either 10.631 mm or 10.503 mm, depending on the adjustment of the lens’ focus. See EX1005, ¶¶0246, 0411.

159. Matsusaka also discloses the following additional data about the wide-angle optical system 1S of Example 19:

Various types of data	
Focal length	1.010
F number	2.828
Half angle of view	104.183
Image height	2.110
Total lens length	10.503
BF	1.872

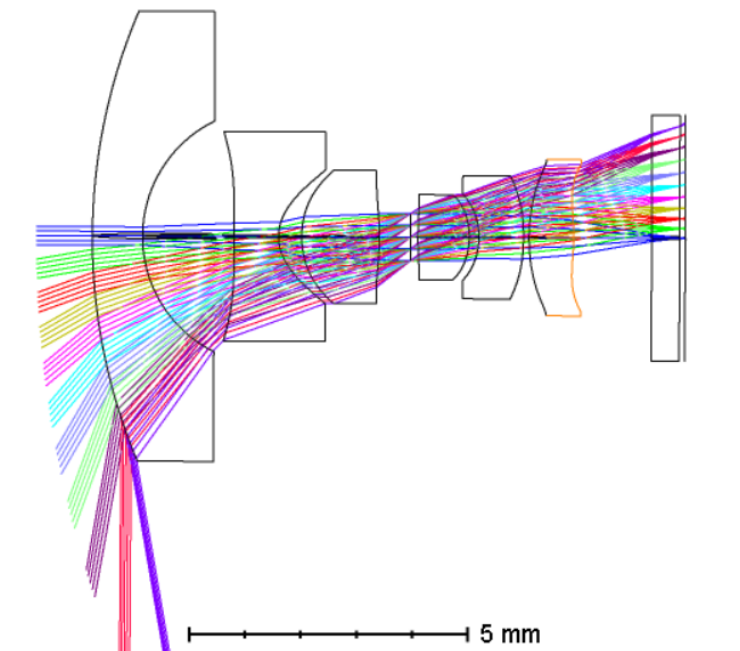
EX1005, ¶0411. As shown, Matsusaka teaches that the “image height” of the wide-angle optical system 1S of Example 19 is 2.110 mm (highlighted in green above). *Id.* Based on the teachings of Matsusaka and their knowledge, a POSITA would have understood that Matsusaka’s disclosed “image height” is a distance from the optical axis to the extent of the image circle. See EX1005, ¶0161 (explaining height as “distance from the optical axis”). Thus, the “image circle diameter” would be twice the image height disclosed by Matsusaka, since the

optical axis is at the center of the circle. Accordingly, for the wide-angle optical system 1S of Example 19, the image circle diameter is 4.220 mm. As I explain with respect to dependent claim 4, below, I was able to confirm this image circle diameter using my Zemax model.

160. Under either of the disclosed total track lengths, the miniaturization ratio of the wide-angle optical system 1S of Example 19 is less than 3.0 (10.631 mm divided by 4.220 mm is **2.519**, and 10.503 mm divided by 4.220 mm is **2.489**).

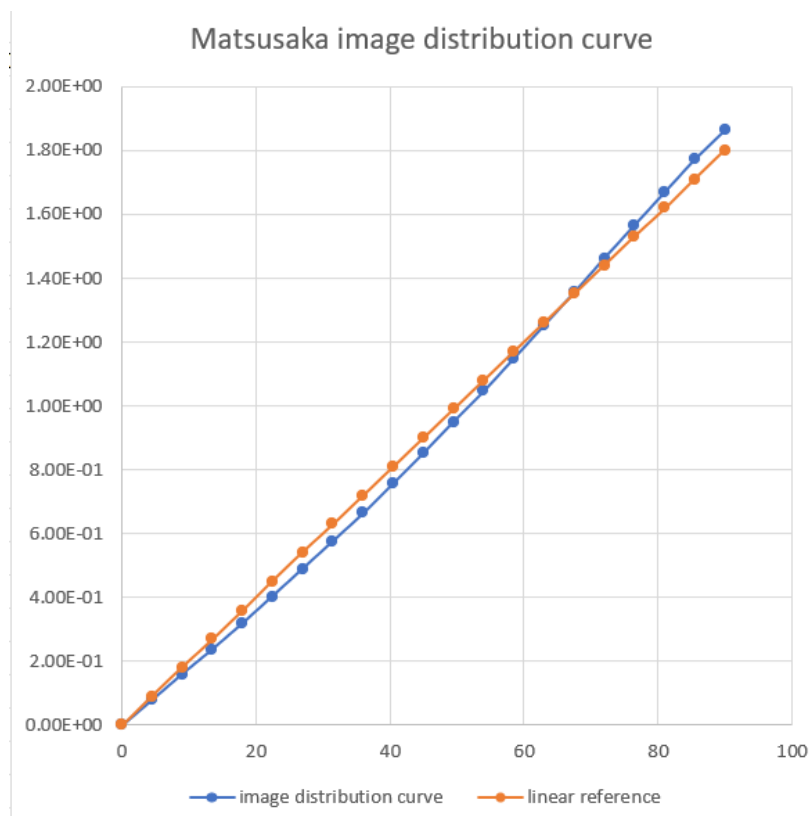
6. [1e] a non-linear targeted resolution to intentionally create a zone in an image captured by the miniature wide-angle optical apparatus with a lower or higher object to image magnification compared to linear targeted resolution, the lower or higher object to image magnification being used to compensate, at least in part, for a lower image quality due to at least one of a drop of relative illumination or a drop of MTF in a zone of the image,

161. Matsusaka discloses this element or at least renders it obvious. EX1005, FIGS. 23, 43A, 43B, ¶¶0404-0412. As I described above in my overview of Matsusaka, I modeled the wide-angle optical system 1S of Example 19 in Zemax. By entering the values provided in the table “Numerical Example 19” in paragraph 0411, I was able to create the following model:



Zemax Model of Matsusaka's Optical System 1S of Example 19

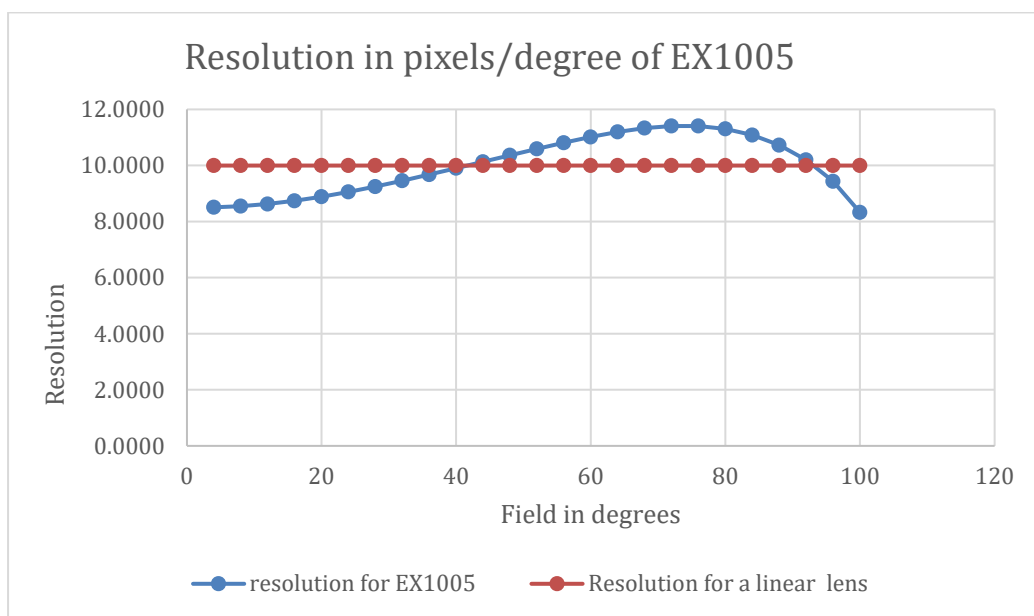
162. Zemax provides the image height at the sensor as a function of the field angle. I refer to this as the “image distribution curve.” Following is the image distribution curve corresponding to the model of Matsusaka’s wide-angle optical system 1S of Example 19:



163. As shown in this “image distribution curve,” there is deviation in the image height at the sensor compared to the orange linear reference line. Where the slope of the blue image distribution curve differs from the slope of the orange linear reference line, there is a change of magnification such that these areas of deviation are “zone(s) in an image captured by the miniature wide-angle optical apparatus with a lower or higher object to image magnification compared to linear targeted resolution,” as claimed.

164. From this data, a POSITA would have been able to calculate the derivative of the image height and convert it to resolution in terms of pixels/degree. To do so, the POSITA could arbitrarily assume that the sensor uses 1000 pixels over

its semi full size of 2.06 mm. With this assumption the following resolution curve in terms of pixels/degree is derived. Choosing 2000 pixels for the semi full size results in the numbers doubling but the shape of the curve will remain unchanged. For a linear f-theta lens, the equivalent curve will just be a straight line as shown with the 1000 pixels evenly spread over 100 degrees.



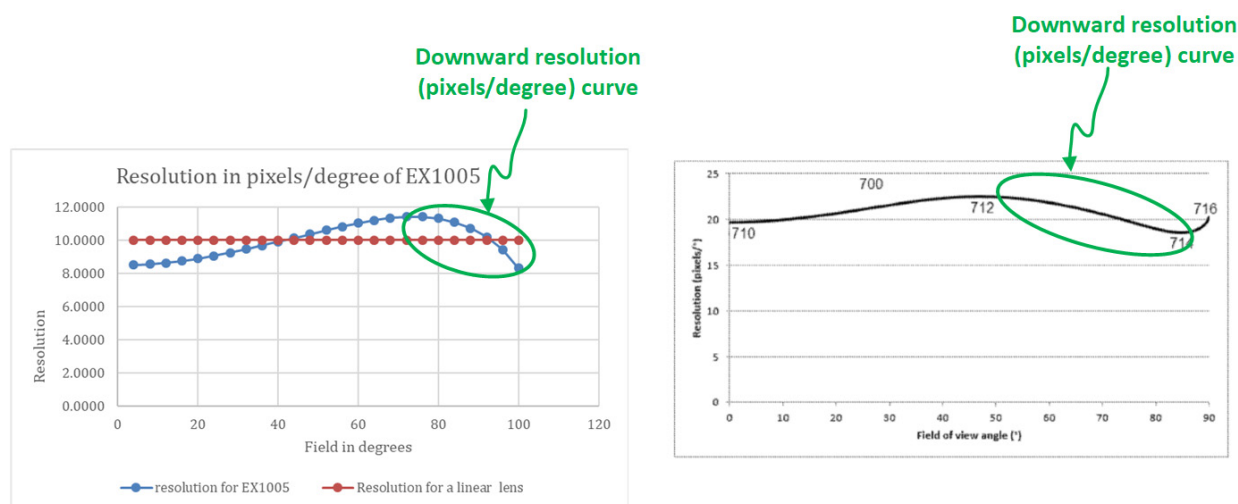
165. Areas where the blue curve are above the red curve are areas of increased magnification with respect to the linear targeted resolution, and areas where the blue curve are below the red curve are areas of decreased magnification with respect to the linear targeted resolution.

166. Matsusaka does not explicitly describe that these areas or zones of increased and decreased magnification with respect to the linear targeted resolution are “intentional.” Nonetheless, based on the teachings Matsusaka and a POSITA’s

ability to analyze the lens examples using an optical CAD such as Zemax, it would have been obvious to a POSITA to intentionally utilize the areas or zones of increased and decreased magnification, depending on the relevant use case. For example, Matsusaka describes using its lenses in “an onboard camera for monitoring rear view of a vehicle.” EX1005, ¶¶0004, 0229-0233. Based on the teachings of Matsusaka and their own knowledge of the art, a POSITA would have recognized that there may be areas or zones of the image that are more important for a user of such a vehicle-mounted camera (e.g., the portion of the image where obstacles are often present), and that these areas or zones may benefit from increased magnification, while other areas or zones are not as important and may have decreased magnification.

167. As noted above, it is my opinion that the final clause of limitation [1e] that recites the “zone . . . being used to compensate” does not define any structure for the claimed optical apparatus. However, to the extent that the final clause of this limitation is considered further limiting, the curvature of the above resolution curve of Matsusaka’s wide-angle optical system 1S of Example 19 will “compensate, at least in part, for a lower image quality due to at least one of a drop of relative illumination or a drop of MTF in a zone of the image” for the same reasons as described in the ’120 Patent. The ’120 Patent describes that the “downward curve between maximum value 712 and position 714 allows the lens system to have a

higher relative illumination value toward the edge of the field of view by having a lower object to image magnification ratio in that region and hence redirecting the same quantity of light from an object to a smaller region in the image with more illumination.” EX1001, 6:36-41. The resolution curve of Matsusaka’s wide-angle optical system 1S of Example 19 has a similar downward slope to Figure 7 of the ’120 Patent as annotated below, and would therefore have the same impact on relative illumination as described in the ’120 Patent.



7. [1f] an opening angle of light entering the optical apparatus being over 100°.

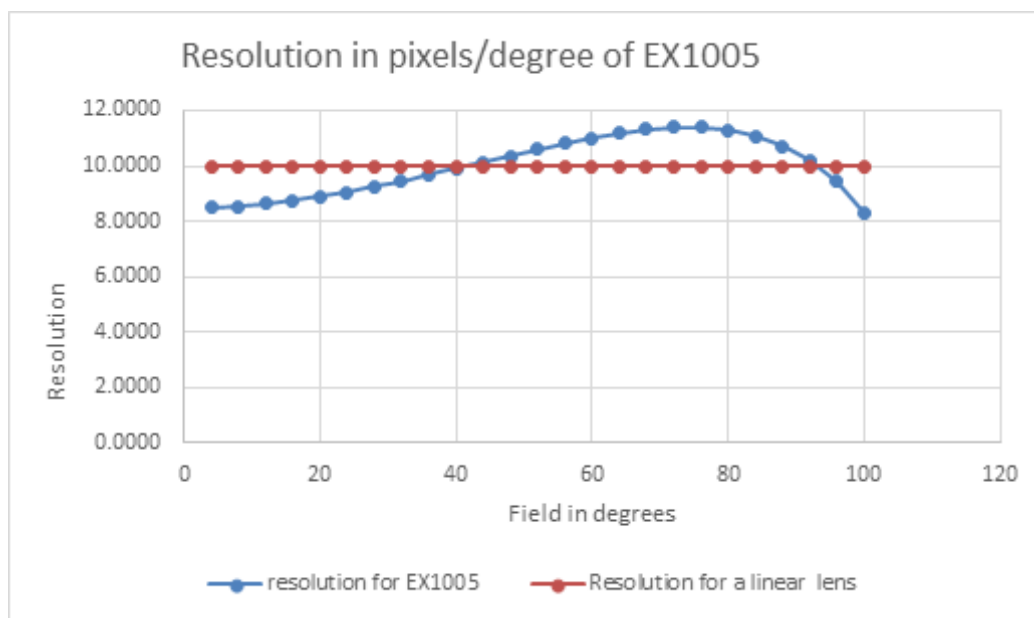
168. Matsusaka discloses this element. EX1005, ¶0450. Specifically, Matsusaka describes that each of “Examples 1 to 23 are capable of achieving a super wide angle which is *a total angle of view of 180° or more.*” EX1005, ¶0450.

B. Claim 3

169. Claim 3 of the '120 Patent recites:

3. The miniature wide-angle optical apparatus of claim 1, wherein a targeted resolution curve has a change of direction near an edge of a field of view.

170. Matsusaka discloses claim 3 or at least renders it obvious. EX1005, FIG. 2. As I described with respect to limitation [1e], a POSITA would have been able to derive the derivative of the image height from the image distribution curve provided by Zemax and convert it to resolution in terms of pixels/degree, which results in the following plot that I introduced above:



171. As shown in this graph, there is a change of direction of the targeted resolution curve between approximately 75° and 80°. For reasons similar to those I noted with respect to Thibault, a POSITA would have found it reasonable to consider

the change of direction at between approximately 75° and 80° to be “near an edge of a field of view,” as that term is loosely used in the ’120 Patent. Furthermore, for the same reasons that I described with respect to Thibault, a POSITA would have found it obvious to modify Matsusaka’s wide-angle optical system 1S of Example 19 such that the area of interest is closer to the edge of the field of view.

C. Claim 4

172. Claim 4 of the ’120 Patent recites:

4. The miniature wide-angle optical apparatus of claim 1, wherein an angle of chief-rays reaching the focal plane is over 20° from an optical axis of the optical apparatus.
--

173. Matsusaka discloses this element or at least renders it obvious. EX1005, FIGS. 23, 43A, 43B, ¶¶0404-0412. Zemax provides the following “single ray trace” corresponding to my model of Matsusaka’s wide-angle optical system 1S of Example 19:

Ray Trace Data						
Units : Millimeters						
Wavelength: 5.876E-01 μm						
Real Ray Trace Data:						
Surf	Y-coordinate	Y-cosine	Y-normal	Angle in	Path length	Comment
OBJ	Infinity	9.848E-01				
1	-1.03E+01	9.85E-01	-5.16E-01	6.90E+01	-1.65E+01	
2	-3.74E+00	8.05E-01	-3.64E-01	7.87E+01	6.67E+00	1st element
3	-1.97E+00	7.58E-01	-8.56E-01	5.21E+00	2.20E+00	
4	-1.45E+00	3.95E-01	1.99E-01	6.07E+01	6.90E-01	2nd element
5	-8.68E-01	1.66E-01	-7.22E-01	2.30E+01	1.46E+00	
6	-8.34E-01	3.33E-01	-5.65E-01	2.49E+01	2.04E-01	3rd element
7	-4.37E-01	6.02E-01	7.78E-02	2.39E+01	1.19E+00	
8	6.85E-12	6.02E-01	0.00E+00	3.70E+01	7.26E-01	STOP
9	1.00E-01	3.87E-01	1.58E-02	3.79E+01	1.66E-01	4th element
10	4.51E-01	3.97E-01	-3.69E-01	1.13E+00	9.06E-01	
11	5.13E-01	4.08E-01	-4.26E-01	1.86E+00	1.56E-01	5th element
12	8.60E-01	4.51E-01	-3.38E-01	4.33E+00	8.51E-01	
13	1.08E+00	1.33E-01	3.69E-01	4.85E+01	4.83E-01	7th element
14	1.17E+00	4.51E-01	3.69E-01	2.93E+01	6.67E-01	
15	1.85E+00	2.98E-01	0.00E+00	2.68E+01	1.50E+00	filter
16	2.00E+00	4.51E-01	0.00E+00	1.73E+01	5.24E-01	
17	2.05E+00	4.51E-01	0.00E+00	2.68E+01	1.12E-01	sensor

174. In this “single ray trace,” the ray is the chief ray for 100 degrees off axis (the lens actually can go up to 104 degrees). As shown, the angle of this chief-ray reaching the focal plane is 26.8 degrees (over 20°) from an optical axis of the optical apparatus. Also shown on the single trace is the image semi-size at the sensor for 100 degrees off axis field of 2.05 mm (at 104 degrees it is 2.1 mm), as shown in Matsusaka’s Fig 23. *Id.*

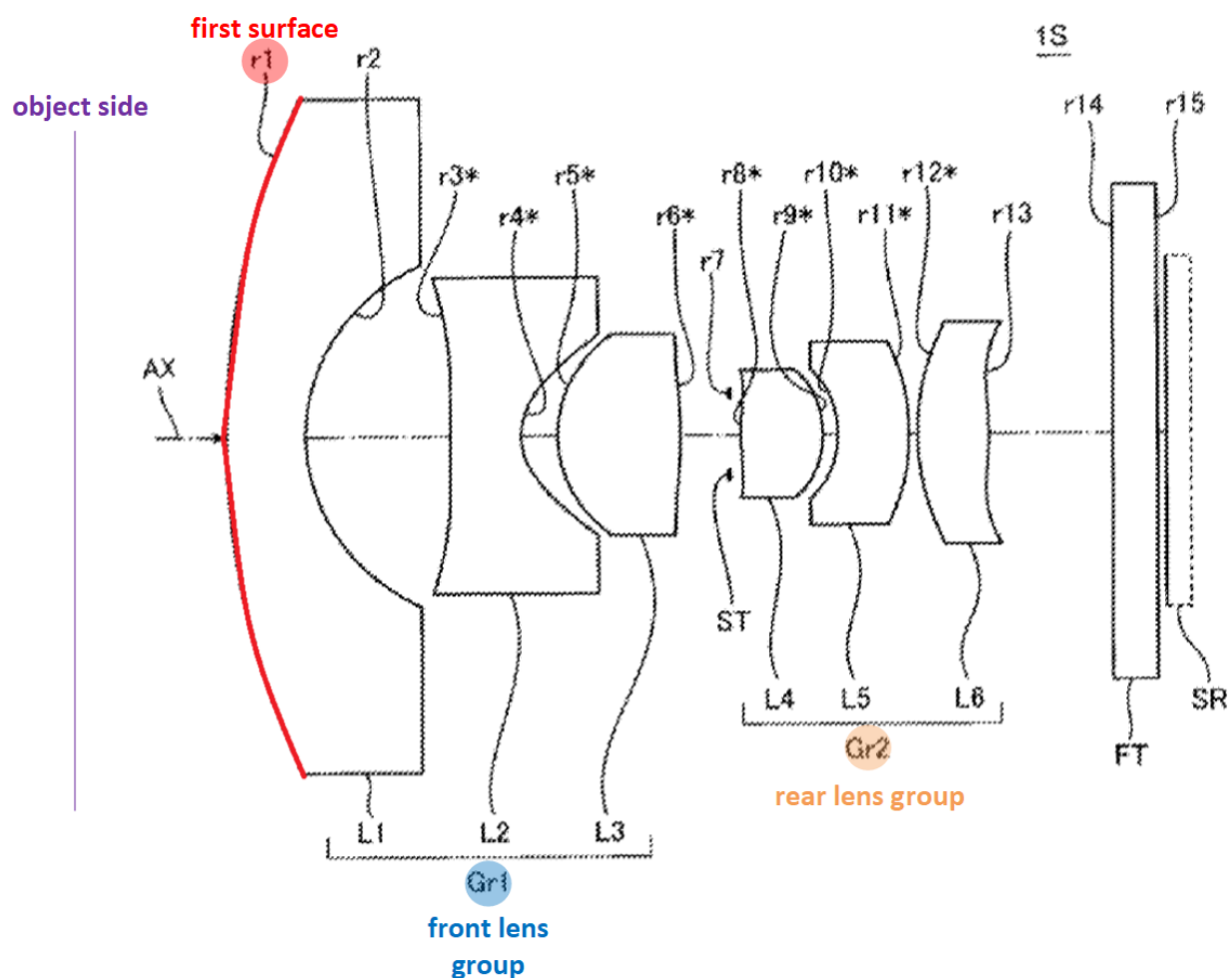
D. Claim 5

175. Claim 5 of the ’120 Patent recites:

5. The miniature wide-angle optical apparatus of claim 1, further comprising a plurality of optical elements, at least one of the plurality of optical elements defining the first surface.

176. Matsusaka discloses claim 5. EX1005, FIG. 23, ¶¶0404-0410. As I described for limitation 1[a], a POSITA would have understood that surface r1 of first lens L1 (highlighted in red above) is a “first surface,” as claimed.

FIG. 23



EX1005, FIG. 23 (annotated)

177. Surface r1 is the object-side surface of first lens L1 of the first lens group (Gr1). EX1005, FIG. 23, ¶0406. Matsusaka describes that there are three lenses (L1-L3) that are part of the first lens group (Gr1) and three lenses (L4-L6) that are part of the second lens group (Gr2). EX1005, FIG. 23, ¶¶0406-0408. Thus, Matsusaka's wide-angle optical system 1S of Example 19 comprised a plurality of optical elements (*e.g.*, L1-L6), at least one of the plurality of optical elements (L1) defining the first surface (r1).

E. Claim 6

178. Claim 6 of the '120 Patent recites:

6. The miniature wide-angle optical apparatus of claim 5, wherein at least one of the optical elements is made of glass.
--

179. Matsusaka discloses claim 6. EX1005, FIG. 23, ¶¶0180, 0404-0407. In particular, Matsusaka describes that, “[i]n the wide-angle optical system 1, it is preferable that a lens arranged at the closest position to the object *is made of glass*.” EX1005, ¶0180. Thus, in the wide-angle optical system 1S of Example 19 the first lens L1 of the first lens group (Gr1) is preferably made of glass. *See* EX1005, FIG. 23, ¶¶0180, 0234, 0404-0407. Matsusaka describes that, “[w]hen the lens closest to the object side . . . *is composed of a glass lens* as state[d] above, the lens is high in strength, and its anti-scratch property can be improved.” EX1005, ¶0180.

XII. GROUND 3: KIM ANTICIPATES OR RENDERS OBVIOUS CLAIMS 1 4, 5, AND 7

A. Claim 1

180. Claim 1 of the '120 Patent recites:

1. A miniature wide-angle optical apparatus comprising:
a light-receiving first surface;
a focal plane;
a total track length measured from a center of the first surface to the focal plane;
a miniaturization ratio with a value less than 3.0, the miniaturization ratio being a ratio of the total track length divided by an image circle diameter; and
a non-linear targeted resolution to intentionally create a zone in an image captured by the miniature wide-angle optical apparatus with a lower or higher object to image magnification compared to linear targeted resolution, the lower or higher object to image magnification being used to compensate, at least in part, for a lower image quality due to at least one of a drop of relative illumination or a drop of MTF in a zone of the image, an opening angle of light entering the optical apparatus being over 100°.

181. As I explain in more detail below through my feature-by-feature analysis, Kim discloses or renders obvious claim 1.

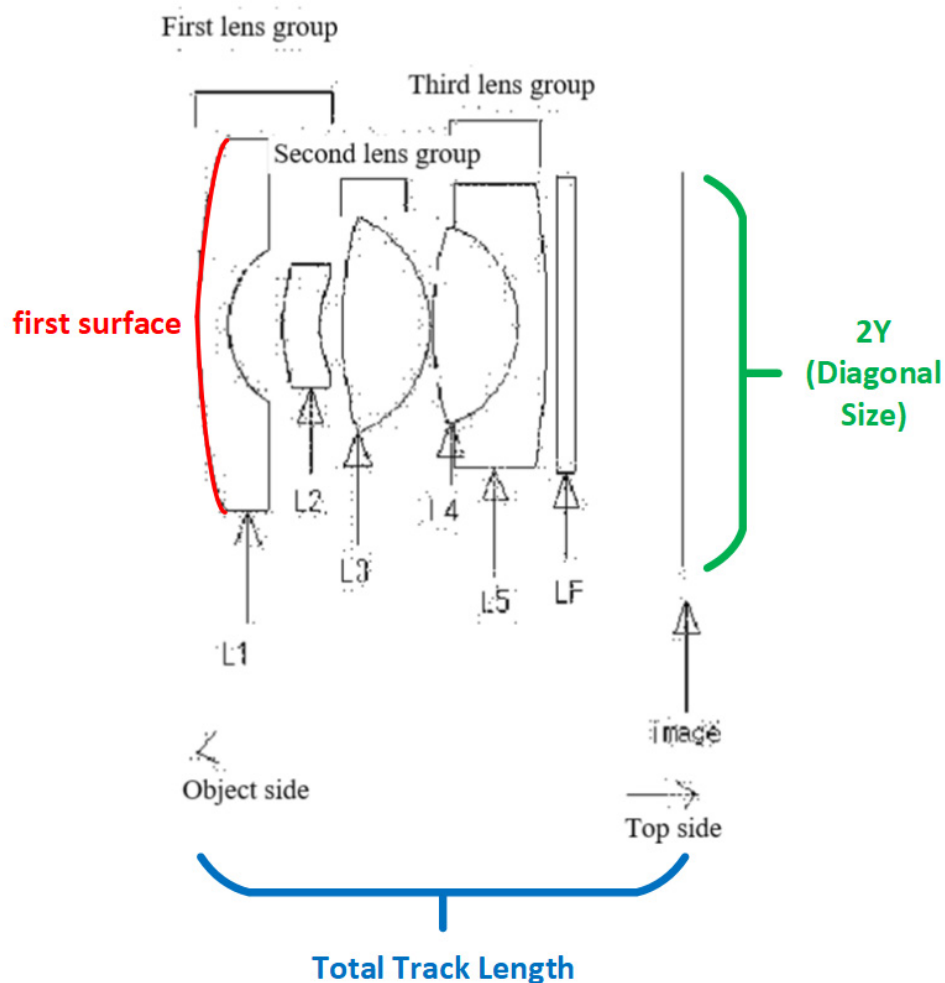
1. [1pre] A miniature wide-angle optical apparatus comprising:

182. Kim discloses “compact superwide angle optical system[s].” EX1007, Summary. Diagram, 1A (reproduced below) is an example of Kim’s compact superwide optical system. *Id.*, 5, FIG. 1A. Kim describes that its “*superwide angle*

optical system that drastically improves the lens brightness and resolution performance compared to conventional methods and *significantly reduces the overall size.*” EX1007, 4.

183. With respect to a “wide-angle lens,” the ’120 Patent states that “*any total field of view over 100°* can be considered as a wide-angle lens according to the present invention.” EX1001, 4:38-44; *see also* EX1002, 28. The lens shown in Diagram 1A of Kim is such a wide-angle lens. The lens system of Diagram 1A has an angle of view, or total field of view, of 144°, which is greater than 100°, so Kim discloses a wide-angle optical apparatus. EX1007, 6 (Table 1).

Diagram 1a



EX1007, Diagram 1a (annotated)

184. With respect to “miniature,” the ’120 patent states that “a miniature wide-angle imaging lens *has a miniaturization ratio*, of a total track length from the center of a first surface to a focal plane by an image circle diameter, *with a value less than 3.0.*” EX1001, Abstract, 1:26-30. As I will describe in further detail below with respect to limitation [1d], Kim’s optical system has a miniaturization ratio that

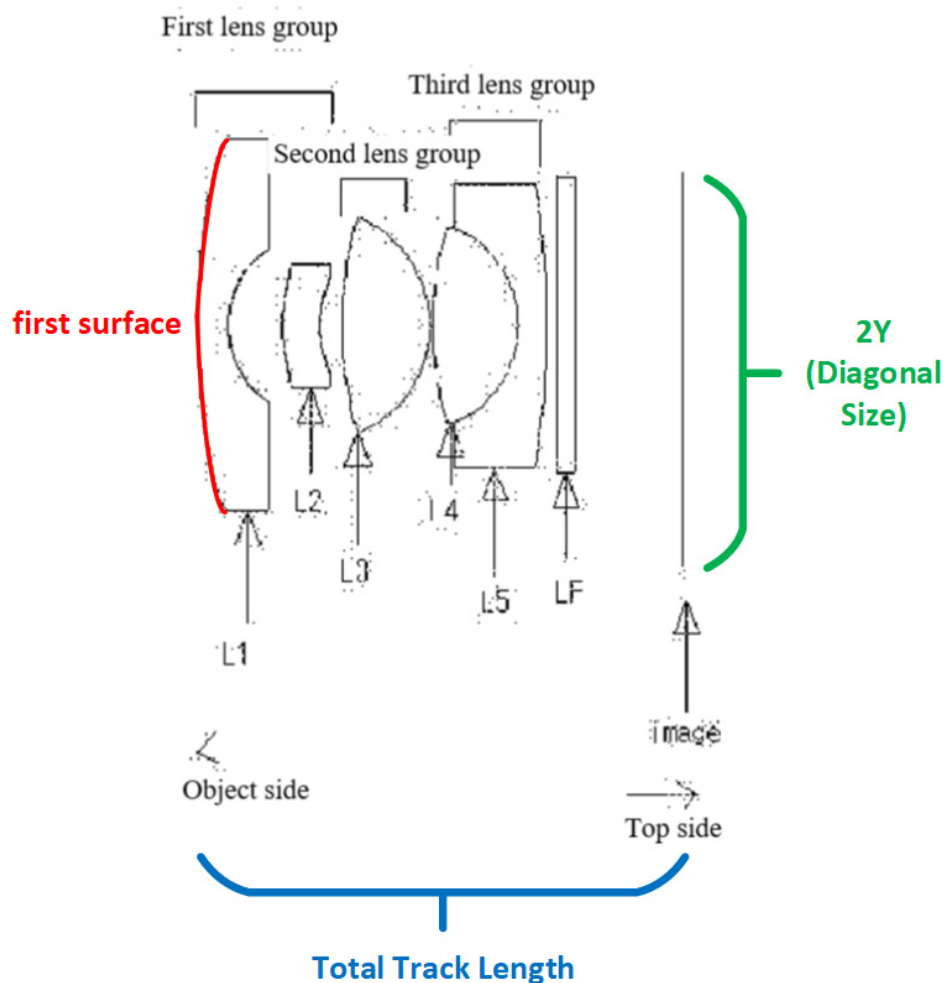
is smaller than the threshold set in the '120 Patent, and is therefore “miniature,” as that term is used in the '120 Patent. EX1007, 6 (Table 1).

2. [1a] a light-receiving first surface;

185. Kim discloses this element. EX1007, Diagram 1A. Kim describes three examples of its compact superwide-angle optical system, each of which include a first lens group (from the object side) having a negative refractive power as a whole, second lens group having positive refractive power, an aperture provided between the first lens group and the second lens group, and third lens group having a positive refractive power as a whole. EX1007, 4-5.

186. In the first embodiment, illustrated in Diagram 1A, “the first lens group in front of the aperture has a strong negative refractive power, making it possible to construct a superwide angle system.” EX1007, 4. The first element L1 (from the left, object side) is “a meniscus-shaped lens having a convex object side . . . so as to be suitable for incident light in the superwide angle areas.” EX1007, 4. As illustrated below, includes a light-receiving first surface (highlighted red). EX1007, Diagram 1A.

Diagram 1a



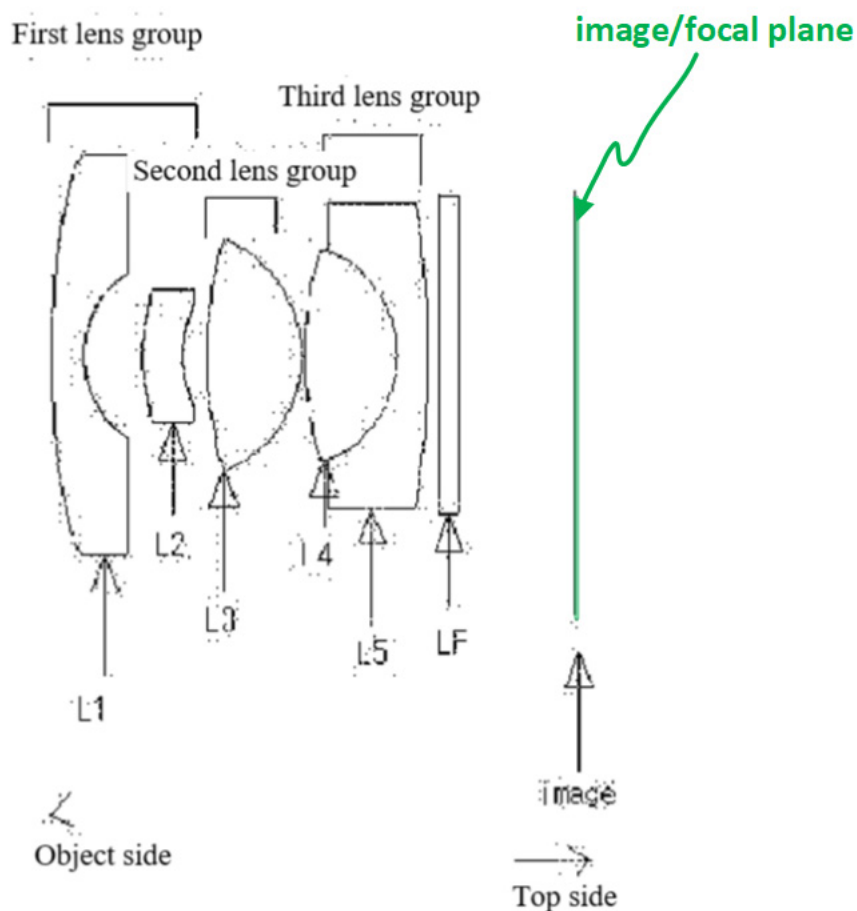
EX1007, Diagram 1a (annotated)

3. [1b] a focal plane;

187. Kim discloses this element. EX1007, Diagram 1A. In particular, Diagram 1A of Kim shows a plane labeled “image” that is a focal plane. EX1007, 6, 8, Diagram 1A. Given that the total track length (TTL) is considered the distance “from the center of a first surface to a focal plane,” and Kim refers to the TTL as “the distance from the front surface of the lens to the image sensor,” a POSITA

would have understood that the image plane is where the image sensor is located and also the focal plane. EX1001, Abstract; EX1007, 6, 8. Indeed, Kim describes that “even if the total length of the optical system is shortened, a sufficient margin for the back focal length (the distance from the last lens surface to the image sensor) can be secured.” EX1007, 4. In other words, the image sensor is the point of focus.

Diagram 1a



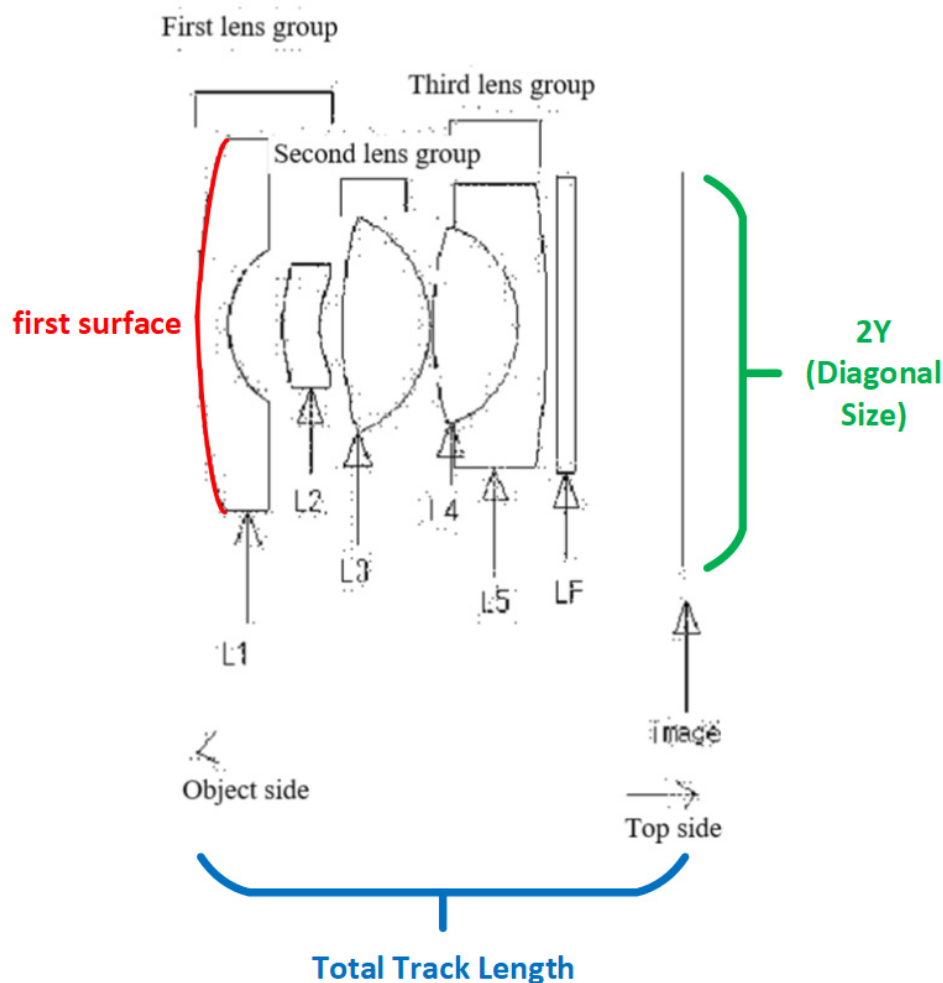
EX1007, Diagram 1A (annotated)

4. [1c] a total track length measured from a center of the first surface to the focal plane;

188. Kim discloses this element. EX1007, 7, Diagram 1A. In particular, Kim teaches that “TTL/2Y is the *total length of the lens* divided by the *diagonal size of the image*, and represents information on the total length of the lens.” EX1007, 6. Kim further teaches that “TTL is the *distance from the first surface of the lens to the image sensor . . .*” *Id.*

189. Kim teaches that “[a]ll of the three embodiments shown in Table 1 assume a lens system in which the image height Y value is 1 (in other words, the image diagonal size is 2).” EX1007, 6. Kim further teaches that the lens of Diagram 1A has a TTL / 2Y of 1.9189, and since the value of Y (image height) is 1, the total track length is 1.9189 multiplied by 2, which is 3.8378. EX1007, 6 (referring to the TTL as the “total length of the lens” and “the distance from the first surface of the lens to the image sensor”) (Table 1). The TTL is shown below in Figure 1.

Diagram 1a

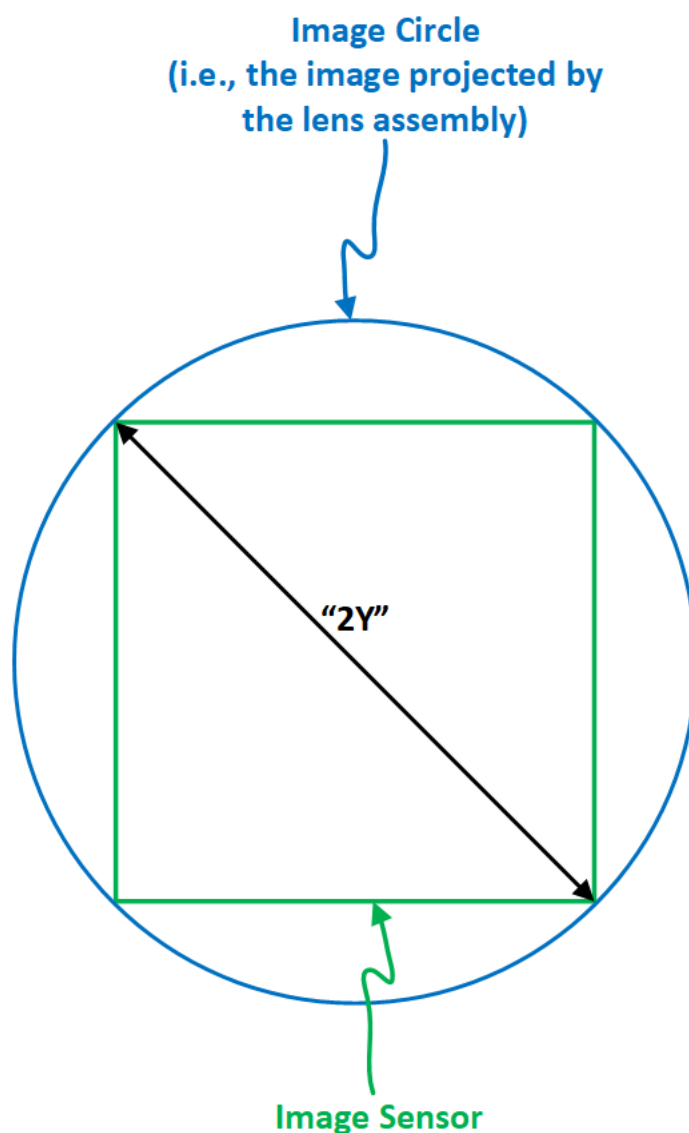


EX1007, Diagram 1a (annotated)

5. *[1d] a miniaturization ratio with a value less than 3.0, the miniaturization ratio being a ratio of the total track length divided by an image circle diameter; and*

190. Kim discloses this element. EX1007, 6 (Table 1). In particular, as discussed with respect to element [1c], the lens system of Diagram 1A has a total track length (TTL) / image circle diameter (2Y), of 1.9189. EX1007, 6. Kim describes that “2Y is the diagonal size of the image sensor.” EX1007, 6. A POSITA

would have understood that $2Y$ is the image circle diameter, because optical designers often design their systems such that the image sensor covers as much of the “image circle” created by the lens as possible. This is commonly accomplished by aligning the diagonal length of the image sensor ($2Y$ in the case of Kim) with the diameter of the image circle, as illustrated below.



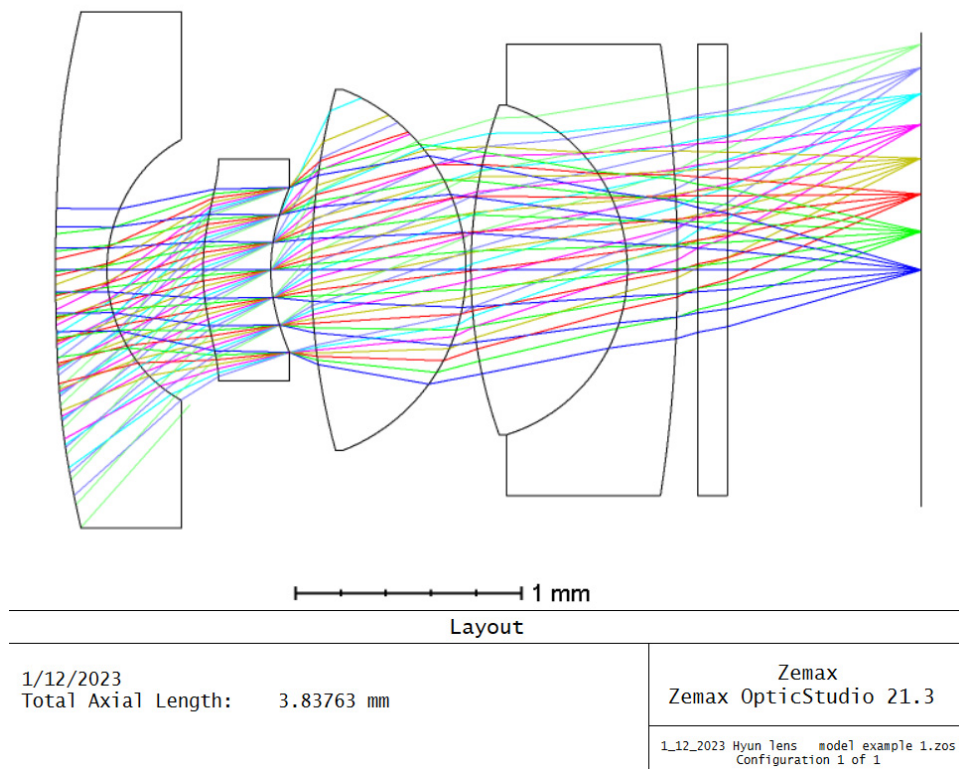
191. Thus, the miniaturization ratio of the lens system of Diagram 1A is 1.9189, which is less than 3.0.

	Embodiment 1	Embodiment 2	Embodiment 3
FNO	1.7916	1.7916	1.8200
Angle of view	144	148	154
TTL/2Y	1.9189	1.9750	1.9415
Image height - Y	1	1	1
Total length of the lens	0.97760	0.97730	0.96280
$\phi 12 / \phi t$ - Conditional Expression 1	0.62729	0.70657	0.61669
$\phi 3 / \phi t$ - Conditional Expression 2	0.22170	0.15353	0.20317
V4/V5 - Conditional Expression 3	2.18726	2.18726	2.18726

EX1007, 6 (Table 1).

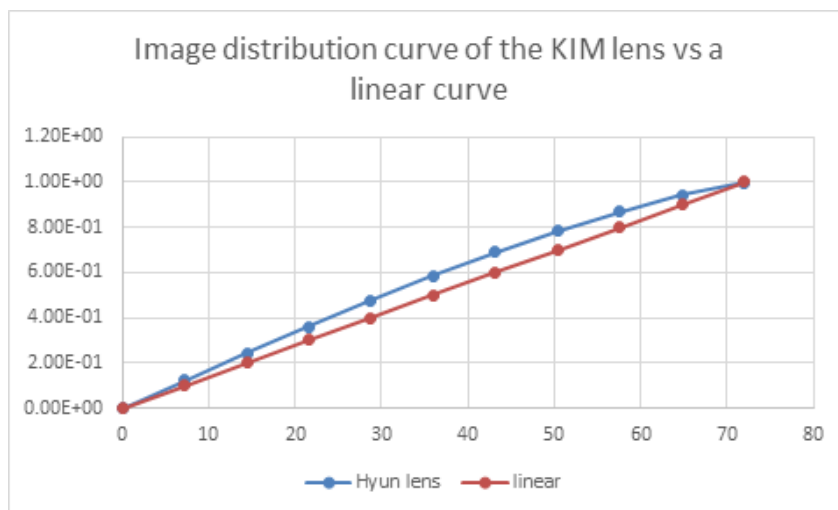
6. *[1e] a non-linear targeted resolution to intentionally create a zone in an image captured by the miniature wide-angle optical apparatus with a lower or higher object to image magnification compared to linear targeted resolution, the lower or higher object to image magnification being used to compensate, at least in part, for a lower image quality due to at least one of a drop of relative illumination or a drop of MTF in a zone of the image,*

192. Kim discloses or renders obvious this element. EX1007, Diagrams 1A-1B, 6. As I described above, I have modeled the first embodiment illustrated in Diagram 1A in Zemax. By entering the values provided in the detailed table of parameters for the first embodiment included on page 6 of Kim, I was able to create the following model:



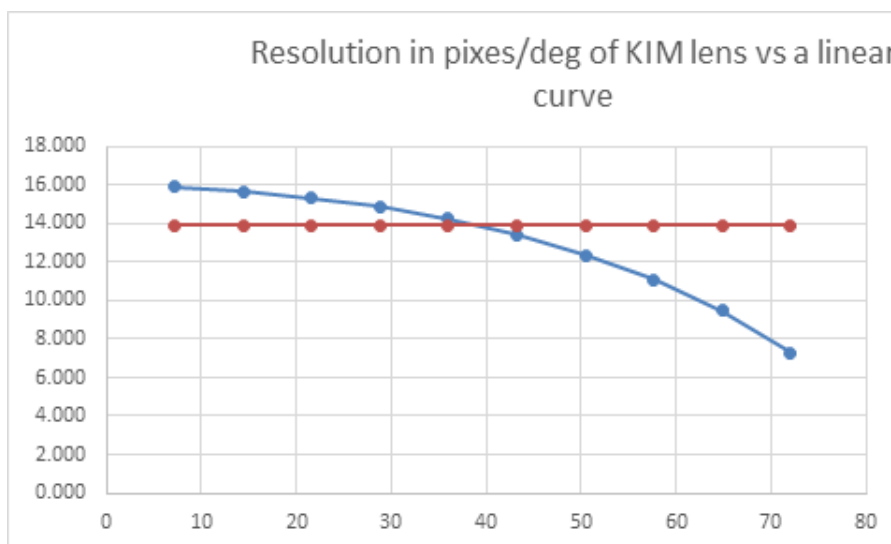
Zemax Model of Kim's First Embodiment

193. Zemax provides the image height at the sensor as a function of the field angle. I refer to this as the “image distribution curve.” Following is the image distribution curve corresponding to the model of Kim's First Embodiment:



194. As shown in this “image distribution curve,” there is deviation in the image height at the sensor compared to the red linear reference line. Where the slope of the blue image distribution curve differs from the slope of the orange linear reference line, there is a change of magnification such that these areas of deviation are “zone(s) in an image captured by the miniature wide-angle optical apparatus with a lower or higher object to image magnification compared to linear targeted resolution,” as claimed.

195. From this data, a POSITA would have been able to calculate the derivative of the image height and convert it to resolution in terms of pixels/degree. To do so, the POSITA could arbitrarily assume that the sensor uses 1000 pixels over its semi-full size. With this assumption the following resolution curve in terms of pixels/degree is derived. Choosing 2000 pixels for the semi-full size, the numbers will just be doubled but the shape of the curve will remain unchanged. For a linear f-theta lens, the equivalent curve will just be a straight line as shown with the 1000 pixels evenly spread over 70 degrees.



196. Areas/zones where the blue curve are above the red curve are areas of increased magnification with respect to the linear targeted resolution, and areas/zones where the blue curve are below the red curve are areas of decreased magnification with respect to the linear targeted resolution.

197. Kim does not explicitly describe that these areas or zones of increased and decreased magnification with respect to the linear targeted resolution are “intentional.” Nonetheless, based on the teachings Kim and a POSITA’s ability to analyze the lens examples using an optical CAD such as Zemax, it would have been obvious to a POSITA to intentionally utilize the areas or zones of increased and decreased magnification, depending on the relevant use case. For example, Kim describes that its “superwide angle optical system ha[s] an angle of view of about 140 to 160 degrees is used in surveillance cameras *for vehicles*.” EX1007, 3. Based on the teachings of Kim and their own knowledge of the art, a POSITA would have

recognized that there may be areas or zones of the image that are more important for a user of such a vehicle-mounted camera (e.g., the portion of the image where obstacles are often present), and that these areas or zones may benefit from increased magnification, while other areas or zones are not as important and may have decreased magnification. Indeed, Kim describes that its goal is to “provide a superwide angle optical system that *drastically improves the lens brightness and resolution performance* compared to conventional methods.” EX1007, 4.

198. As noted above, it is my opinion that the final clause of limitation [1e] that recites the “zone . . . being used to compensate” does not define any structure for the claimed optical apparatus. However, to the extent that the final clause of this limitation is considered further limiting, the curvature of the above resolution curve of Kim’s First Embodiment will “compensate, at least in part, for a lower image quality due to at least one of a drop of relative illumination or a drop of MTF in a zone of the image” for the same reasons as described in the ’120 Patent. The ’120 Patent describes that the “downward curve between maximum value 712 and position 714 allows the lens system to have a higher relative illumination value toward the edge of the field of view by having a lower object to image magnification ratio in that region and hence redirecting the same quantity of light from an object to a smaller region in the image with more illumination.” EX1001, 6:36-41. The resolution curve of Kim’s First Embodiment has a downward slope, and would

therefore have the same or similar impact on relative illumination as described in the '120 Patent.

7. [1f] an opening angle of light entering the optical apparatus being over 100°.

199. Kim discloses this element. EX1007, 6 (Table 1). In particular, as discussed with respect to element [1pre], the lens system of Diagram 1A has an angle of view, or total field of view, of 144°, which is greater than 100°. EX1007, 6 (Table 1).

B. Claim 4

200. Claim 4 of the '120 Patent recites:

4. The miniature wide-angle optical apparatus of claim 1, wherein an angle of chief-rays reaching the focal plane is over 20° from an optical axis of the optical apparatus.
--

201. Kim discloses this element or at least renders it obvious. EX1007, Diagram 1A, p. 6.

202. The '120 Patent provides two definitions for the “chief ray.” EX1001 4:3-5, 4:54-59. The first definition of “chief ray” is “the middle ray of the three rays drawn because it passes through the center of the aperture stop 124.” EX1001 4:3-5. The second definition of “chief ray” is the center of the cone of light reaching the image sensor at the max image height (positions 140 and 144 on Fig. 1). EX1001 4:54-59. The two definitions coincide for systems where there is no vignetting.

Vignetting is intentionally cutting rays at the periphery of the aperture for large field angles, and is a known and useful way of improving image quality at large field angles. The center of the cone of light no longer goes through the center of the aperture stop. In these situation, the chief ray angle (CRA) is the center of the cone of light reaching the edge of the sensor, but the ray going through the center of the iris stop is no longer at the center of the cone, and if vignetting is cutting half of the unvignetted beam it may not even reach the sensor.

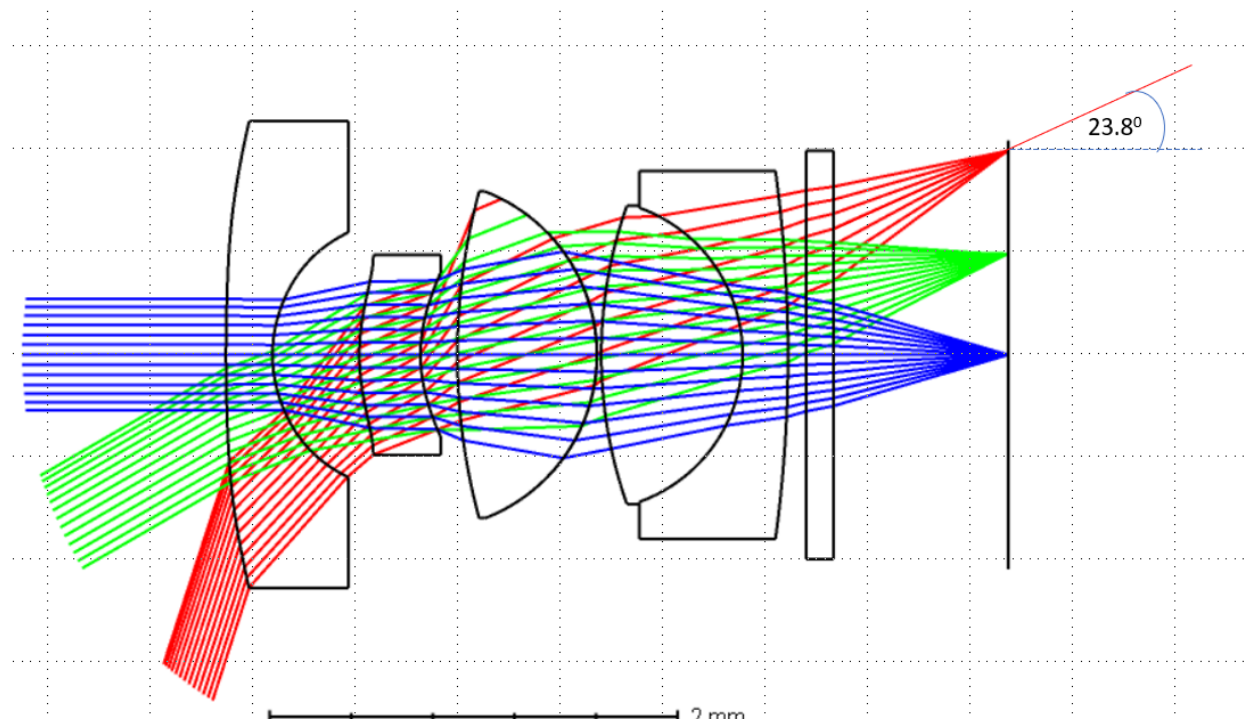
203. Kim is using vignetting in his design as shown on his First Embodiment reproduced below:

surface #		R value	D value	R.d	V.d		aperture
1	Sphere	infinity	infinity			Refract	
2	Asphere	6.94754	0.22838	1.48749	70.41	Refract	0.57285
3	Asphere	0.65740	0.42632			Refract	
4	Asphere	1.02110	0.33019	1.75520	27.58	Refract	
STOP	Asphere	0.73063	0.18040			Refract	
5	Sphere	3.04516	0.66443	1.03545	52.89	Refract	
6	Sphere	-0.85783	0.02222			Refract	0.56997
7	Sphere	2.18749	0.69376	1.62041	60.32	Refract	
8	Sphere	-0.76481	0.32217	1.75520	27.58	Refract	
9	Sphere	-6.64433	0.08887			Refract	
10	Sphere	infinity	0.13330	1.48749	70.41	Refract	
11	Sphere	infinity	0.00000			Refract	
12	Sphere	infinity	0.8578			Refract	
Image	Sphere	infinity	0.00000			Refract	1

EX1007, 6.

204. The vignetting apertures on surfaces 2 and 6 are highlighted. With this vignetting in place, my model shows the beams through the lens for three field

positions. Specifically, Zemax provides the following cone angle directions corresponding to my model of Kim's first embodiment illustrated in FIG. 1A:



205. The chief ray angle, the center of the red cone of light, is at 23.8 degrees at the sensor, which is larger than 20 degrees in claim 4.

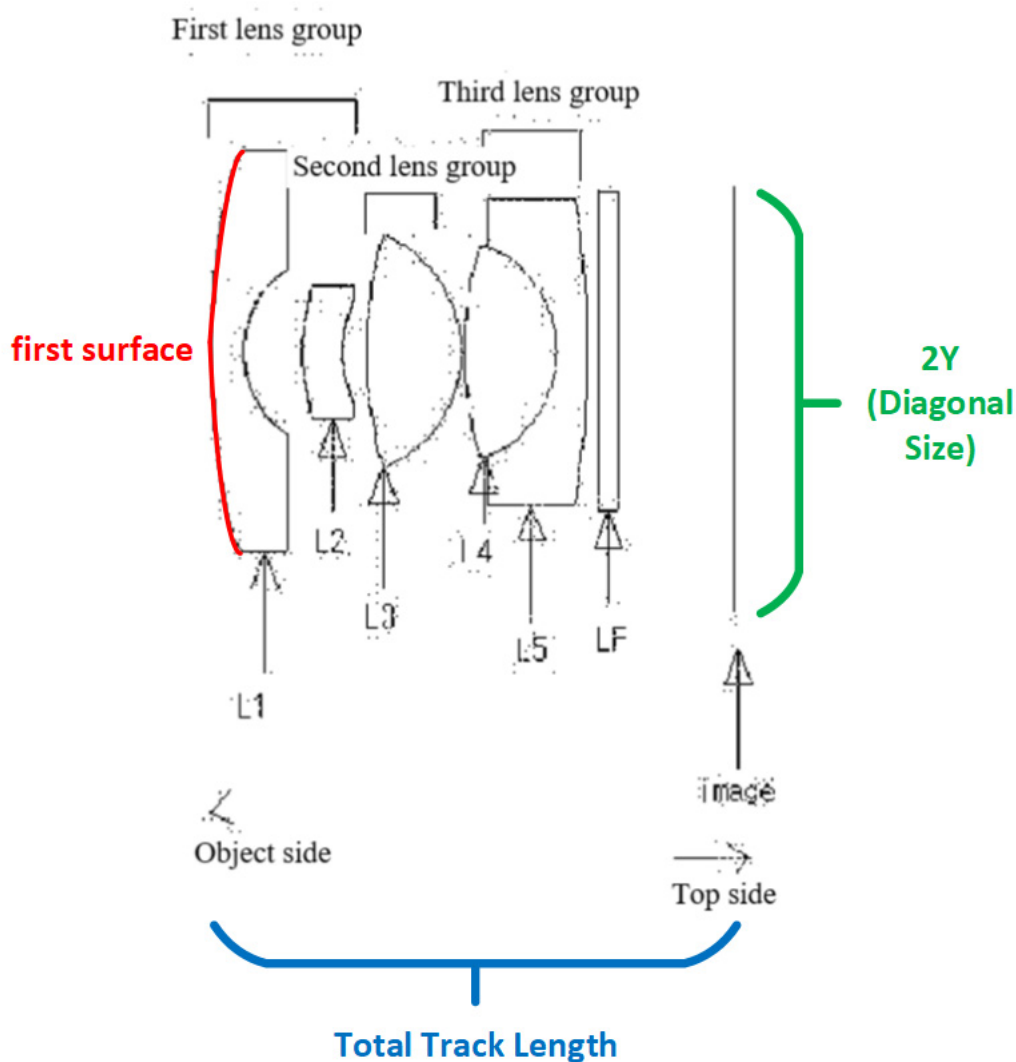
C. Claim 5

206. Claim 5 of the '120 Patent recites:

5. The miniature wide-angle optical apparatus of claim 1, further comprising a plurality of optical elements, at least one of the plurality of optical elements defining the first surface.

207. Kim discloses claim 5. EX1007, 7, Diagram 1A. As shown in Diagram 1A, the lens has a plurality of optical elements (e.g., lenses L1-L5), where the first element on the object side, 1 (at left), defines the first surface (highlighted red). *Id.*

Diagram 1a



EX1007, Diagram 1A (annotated)

D. Claim 7

208. Claim 7 of the '120 Patent recites:

**7. The miniature wide-angle optical apparatus of claim 1,
wherein the miniaturization ratio value is less than 2.0.**

209. Kim discloses claim 7. EX1007, 6 (Table 1). As I discussed above for element [1d], the lens system of Diagram 1A has a miniaturization ratio, total track length (TTL) / image circle diameter (2Y), of 1.9189, which is less than 2.0. EX1007, 6 (Table 1).

XIII. 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: 1/18/2023

By: /David Kessler/