UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HP INC.,

Petitioner,

v.

LARGAN PRECISION CO., LTD.,

Patent Owner.

U.S. Patent No. 8,988,796

Filing Date: December 13, 2013
Issue Date: March 24, 2015

Title: Image Capturing Lens System, Imaging Device and Mobile Terminal

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PETITION FOR *INTER PARTES* REVIEW

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I. Introduction

HP Inc. ("HP") requests review of claims 1–11 and 15–25 of U.S. Patent No. 8,988,796. The '796 patent discloses a lens system for image capture, e.g., on a smartphone, comprising four lens elements. It discloses well-known properties for the individual lens-elements and provides lens data in table format for ten embodiments. Neither the design of the lens elements, nor the four-lens system were new at the time of the '796 patent.

The Yu patent (Ex.1003), filed before the '796 patent, discloses all elements of sixteen claims, and with a minor and obvious size selection for one non-lens component, renders the remaining six claims obvious. The design of the '796 patent's lens system was known even earlier. Yamaguchi (Ex.1006), an application disclosing the same lens design, published nine years before the '796 patent. Pixels and sensors were larger then, so it was larger, but over the interim nine years, sensor technology advanced. As sensors got smaller, so did the associated lenses. The process of scaling a lens design is not complicated; it could be performed easily in software in use at the time of the '796 patent. Such simple adjustments were obvious (and routine) to a person of ordinary skill.

Examination of the '796 patent's application was not robust. This Petition demonstrates that the challenged claims should not have issued. Trial should be instituted and they should be canceled.

II. The ’796 Patent

The ’796 patent “relates to a compact image capturing lens system applicable to a mobile terminal.” Ex.1001, 1:14–16. It recites that demand driven by “the popularity of mobile terminals having camera functionalities” and reductions in “the pixel size of sensors” has increased demand for smaller optical systems. *Id.*, 1:18–25. It asserts that its lens system is an improvement over “conventional compact optical systems provid[ing] a four-element lens structure.” *Id.*, 1:34–41.

The ’796 patent’s lens system comprises four lens elements. *Id.*, 1:45–48. The lens system is described with reference to the object-side (to the left) and image-side (to the right). In order from the object side to the image side, it comprises first, second, third, and fourth lens elements. *Id.*, 1:45–48. The first lens element 110, second lens element 120, third lens element 130, and fourth lens element 140 are shown in Fig. 1A’s first embodiment. *Id.*, 7:10–11, 7:17–23.

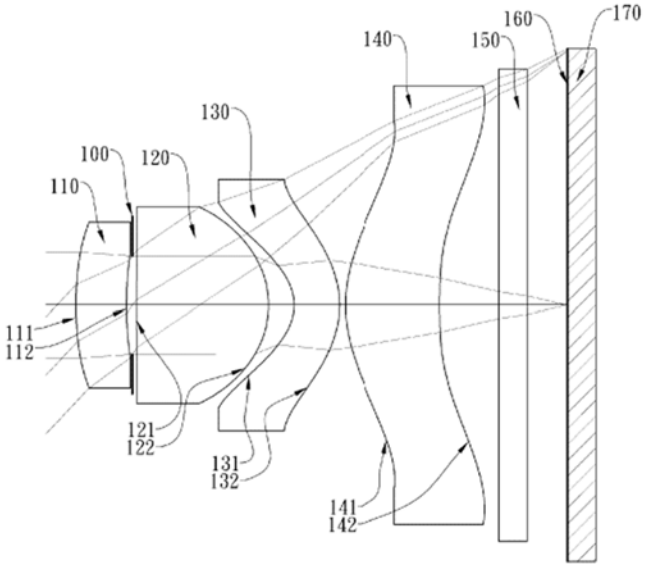


Fig. 1A

One property of lenses is their refractive power, which can be positive or negative. A lens with positive refractive power causes light to converge upon its central axis and is thicker near its central axis. Ex.1007 ¶ 34. A lens with negative refractive power causes light to spread through a wider angle and is thinner near its central axis. *Id.* The '796 patent discloses that "[t]he first lens element has refractive power"; it is positive in eight embodiments and negative in two embodiments. Ex.1001, 1:48–49, 7:24–28, 10:65–11:2, 14:4–8, 16:23–27, 18:36–40, 20:38–42, 22:38–42, 24:38–42, 26:38–42, 28:37–41. The second lens element has positive refractive power, and the third lens element has negative refractive power. *Id.*, 1:49–54. The fourth lens element has refractive power, which is positive in all ten embodiments. *Id.*, 1:54–59, 7:39–43, 11:13–12:3, 14:21–25, 16:39–43, 18:52–56, 20:53–57, 22:53–57, 24:53–57, 26:53–57, 28:52–56.

A lens has an object-side surface (on the left) and an image-side surface (on the right). A lens surface can be convex or concave. A convex surface protrudes outward, and a concave surface protrudes inward. Ex.1007 ¶ 35. By convention, this is defined by the shape of the surface near its central axis, i.e., "in the paraxial region" in the language of the '796 patent. *Id.* The '796 patent discloses that the second lens element "has a convex image-side surface," the third lens element "has a concave object-side surface" and "a convex image-side surface," and the fourth lens element "has a concave image-side surface." Ex.1001, 1:48–59. For example, it is

easy to see the concave object-side surface (131) and the convex image-side surface (132) of the third lens element (130) in Fig. 1A. Ex.1007 ¶ 35.

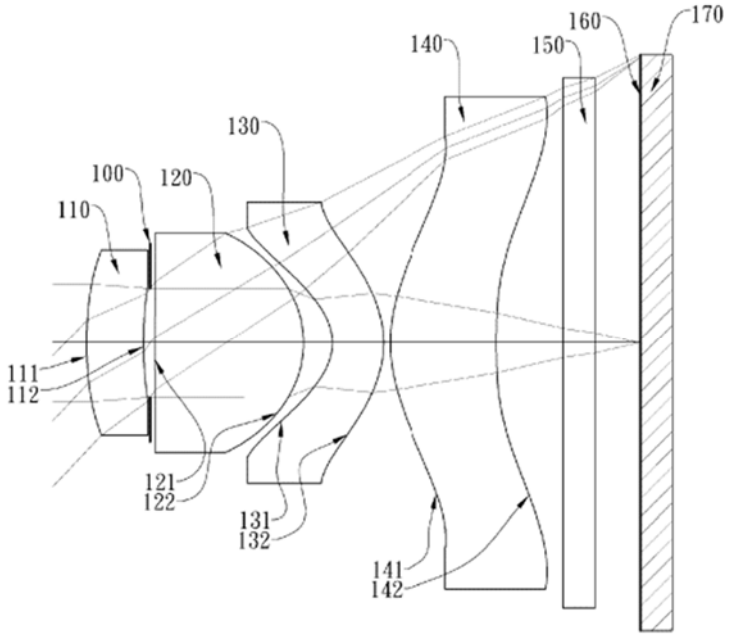


Fig. 1A

The concave or convex shape of a lens surface can be identified from other information in the '796 patent. For each embodiment, the '796 patent provides a table of "detailed optical data." *E.g.*, Ex.1001, 9:5–6. Table 1 for the first embodiment is reproduced below. The first column identifies the surface number. Ex.1007 ¶ 36. Some surfaces are lenses, while others indicate the object (Surface No. 0), aperture stop (Surface No. 3), IR-cut filter (Surface No. 10), or image (Surface No. 12). *Id.* The numbering begins with the object (Surface No. 0) and increases from left to right (object-side to image-side), ending with the image (Surface No. 12). *Id.* The second column lists the curvature radius. *Id.* "Plano"

denotes a flat surface. *Id.* Each lens surface has a curvature radius in millimeters. *Id.*

TABLE 1

Embodiment 1
f = 1.17 mm, Fno = 2.20, HFOV = 46.7 deg.

Surface #		Curvature Radius	Thickness	Material	Index	Abbe #	Focal Length
0	Object	Plano	Infinity				
1	Lens 1	1.666 ASP	0.256	Plastic	1.650	21.4	9.56
2		2.139 ASP	0.031				
3	Ape. Stop	Plano	0.019				
4	Lens 2	5.712 ASP	0.671	Plastic	1.544	55.9	0.82
5		−0.464 ASP	0.130				
6	Lens 3	−0.228 ASP	0.230	Plastic	1.634	23.8	−1.06
7		−0.480 ASP	0.030				
8	Lens 4	0.679 ASP	0.483	Plastic	1.535	55.7	1.52
9		3.062 ASP	0.300				
10	IR-cut filter	Plano	0.145	Glass	1.517	64.2	—
11		Plano	0.204				
12	Image	Plano	—				

Note:
Reference wavelength is 587.6 nm (d-line).

A radius is positive if its center is to the right of the surface and negative if its center is to the left of the surface. *Id.* ¶ 37. For an object-side (left) surface of a lens, a positive radius denotes a convex surface that protrudes outward to the left and a negative radius denotes a concave surface that protrudes inward to the right. *Id.* For an image-side (right) surface of a lens, a positive radius denotes a concave surface that protrudes inward to the left and a negative radius denotes a convex surface protrudes outward to the right. *Id.*

The ’796 patent’s third lens element 130 has a concave object-side surface 131 and a convex image-side surface 132. Ex.1001, 1:51–54. In Table 1, the radius for both surfaces (6 and 7) is negative. *Id.*, Table 1. Table 1 confirms the ’796

patent's text because a negative radius denotes a concave object-side surface and a convex image-side surface. Ex.1007 ¶ 38.

Other specified values include thickness, material, Abbe number, and focal length. *E.g.*, Ex.1001, Table 1. Thickness for a lens surface specifies either the thickness of the lens at its center if specified for the object-side surface or the distance from the image-side surface to the next surface. For example, the third lens in Table 1 comprises object-side surface 6 and image-side surface 7. *Id.* The thickness of 0.230 mm for surface 6 means the third lens is 0.230 mm thick at the center, and the thickness of 0.030 mm for surface 7 means that there is a space of 0.030 mm from the center of the image-side surface of the third lens to the object-side surface of the fourth lens (8). *Id.*; Ex.1007 ¶ 39. The 0.019 mm thickness of the aperture stop (3) in Table 1 denotes the space between it and the object-side surface of the second lens (4). Ex.1001, Table 1; Ex.1007 ¶ 39. The material column indicates if a lens is glass or plastic; the index column provides the refractive index, which describes how fast light travels through the material; the Abbe number is a measure of how the material's refractive index changes with the wavelength of light; and the focal length is a measure of how strongly the lens converges (positive) or diverges (negative) light. Ex.1007 ¶ 39.

The '796 patent discloses aspheric lenses. A spherical lens has a surface that has the shape of the surface of a sphere; an aspherical lens is non-spherical. *Id.* ¶ 40.

The ’796 patent includes the following “equation of the aspheric surface profiles” and includes tables showing “the aspheric surface data,” which, along with the curvature radius defines the shape of the lens surface:

> The equation of the aspheric surface profiles of the aforementioned lens elements of the 1st embodiment is expressed as follows:
>
> $$X(Y) = (Y^2/R)/(1+sqrt(1-(1+k)\times(Y/R)^2)) + \sum_i (Ai)\times(Y^i),$$
>
> where,
> X is the relative distance between a point on the aspheric surface spaced at a distance Y from the optical axis and the tangential plane at the aspheric surface vertex on the optical axis;
> Y is the vertical distance from the point on the aspheric surface to the optical axis;
> R is the curvature radius;
> k is the conic coefficient; and
> Ai is the i-th aspheric coefficient.

Id.; Ex.1001, 7:52–8:2, Tables 2, 4, 6, 8, 10, 12, 14, 16, 18, 20.

A. Prosecution History

U.S. Patent Application No. 14/105,811 was filed on December 13, 2013, claiming priority to Taiwan Patent Application No. 102139029. Ex.1001, [21], [22]; Ex.1002, 1, 4. The claims were allowed in an initial office action without rejection and without a substantive explanation of the reasons for allowance. Ex.1002, 208–14. The prior art in this Petition was not before the Examiner.

B. Person of Ordinary Skill

The ’796 patent’s earliest claimed priority date is October 29, 2013. Ex.1001, 1:6–8. A person of ordinary skill in the art (“POSITA”) as of October 29, 2013,

would have had a bachelor's degree in optical engineering, mechanical engineering, electrical engineering, optics, or physics with at least three years of experience working in optical engineering; a master's degree in one of the above disciplines with at least two years of experience working in optical engineering; a Ph.D. in one of the above disciplines focusing on optical engineering; or equivalent experience. Ex.1007 ¶¶ 62–63.

III. Standing

Petitioner certifies that that, under 37 C.F.R. § 42.104(a), the '796 patent, is available for *inter partes review* and that Petitioner is not barred or estopped from requesting *inter partes review* of the '796 patent based on the grounds identified.

IV. Grounds

HP requests review and cancellation of the challenged claims on the following grounds:

Ground	Claims	Basis
Ground 1	1–11, 15–25	35 U.S.C. § 103 based on U.S. Patent No. 9,097,860 ("Yu").
Ground 2	1–11, 15–16, 19–24	35 U.S.C. § 103 based on U.S. Patent Application Publication No. 2004/0012861 ("Yamaguchi") and Yu.

The '796 patent is subject to the first-inventor-to-file provisions of 35 U.S.C. §§ 102, 103. Yu was filed on December 27, 2013, and issued on August 4, 2015.

Yu claims priority to Taiwanese Application No. 102131525, which was filed on September 2, 2013. Yu is prior art as of its September 2, 2013 foreign filing date pursuant to 35 U.S.C. § 102(a)(2), (d)(2). Yu is entitled to claim a right of priority under 35 U.S.C. § 119 and Taiwanese Application No. 102131525 describes the same subject matter as Yu. 35 U.S.C. § 102(d)(2); Ex.1007 ¶¶ 71–79; *see generally* Ex.1003, Ex.1005. In accordance with 35 U.S.C. § 119 and 37 C.F.R. § 1.55, Taiwan is a WTO member, the U.S. application was filed within twelve months of the Taiwan application, and a claim of priority was filed with the Patent Office. MPEP § 213.01 (9th ed. Rev. 10.2019, June 2020); Ex.1003, [22], [30]; Ex.1004, 9, 58–86, 170; Ex.1005, 2. Yamaguchi was published on January 22, 2004, and is prior art under 35 U.S.C. § 102(a)(1).

V. Claim Construction

The Board gives claims their ordinary and customary meaning, or "the meaning that the term would have to a [POSITA] at the time of invention." *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (en banc). At this time, HP proposes no terms for construction, but HP reserves the right to respond to any constructions proposed by Largan. HP does not waive, and expressly reserves, the claim scope arguments, constructions, and evidence it may raise in other proceedings.

VI. Prior Art

A. U.S. Patent No. 9,097,860 ("Yu")

Petitioner's prior art reference Yu relates to "a compact wide-angle four-piece imaging lens assembly." Ex.1003, 1:12–14. Yu discloses "a four-piece imaging lens assembly which has compact and thin dimensions and which has a wider angle of view for improving resolving power thereof." *Id.*, 1:41–44. It "comprises a lens set and a non-adjustable diaphragm." *Id.*, 1:45–46. "The lens set includes a first lens, a second lens, a third lens and a fourth lens arranged in sequence from an object side to an image side along an optical axis of the lens assembly." *Id.*, 1:46–49.

Yu's first lens has "a positive optical power adjacent to the optical axis" and "a convex object-side surface." *Id.*, 1:49–52, 2:58–61. Yu's second lens has "a positive optical power adjacent to the optical axis" and "a convex image-side surface." *Id.*, 1:54–57, 2:63–66. Yu's third lens has "a negative optical power adjacent to the optical axis," "a concave object-side surface," and "a convex image-side surface." *Id.*, 1:59–62, 3:1–5. Yu's fourth lens has "a positive optical power adjacent to the optical axis," a concave image-side surface, and "[e]ach of the object-side surface and the image-side surface … is an aspherical surface." *Id.*, 1:64–2:4, 3:7–18. "At least one of the object-side surface and the image-side

surface of the fourth lens has an inflection point located between the optical axis and the peripheral surface." *Id.*, 2:4–7.

Figs. 1, 4, and 7 show first, second, and third preferred embodiments of Yu's lens assembly. *Id.*, 2:24–26, 2:37–39, 2:40–42. The lens assembly "comprises a lens set 1, a non-adjustable diaphragm 2, and a filter lens 2." *Id.*, 2:52–54. "The lens set 1 includes a first lens 11, a second lens 12, a third lens 13 and a fourth lens 14 arranged in sequence from an object side to an image side along an optical axis L of the lens assembly." *Id.*, 2:55–58.

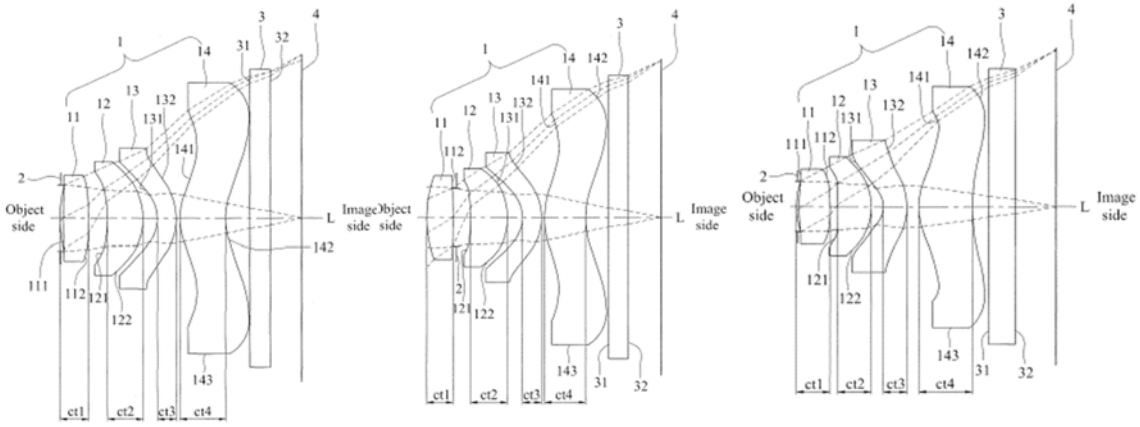


FIG.1 FIG.4 FIG.7

For each embodiment, Yu provides a table listing the "component/surface," "radius of curvature," "thickness/interspace," "refractive index," "Abbe number," and "focal length." *Id.*, 4:39–43, 4:54–5:20, 5:52–57, 6:58–7:24, 8:36–41, 8:48–9:14. Yu also provides a table for each embodiment providing the aspheric coefficients. *Id.*, 5:21–49, 7:25–8:32, 9:16–43.

B. U.S. Patent Application Publication No. 2004/0012861 ("Yamaguchi")

Yamaguchi relates to "an image pickup lens preferable as an optical system of a solid state pickup element such as a CCD type image sensor or a CMOS type image sensor." Ex.1006 ¶ 0002. Yamaguchi teaches that the "heightened performance and the miniaturization of an image pickup device," along with "the miniaturization and the dense arrangement of pixels," necessitated "the further miniaturization of an image pickup lens mounted on the image pickup device." *Id.* ¶¶ 0004–0005. Thus, Yamaguchi discloses "an image pickup lens which is composed of a plurality of lenses and is miniaturized." *Id.* ¶ 0008.

Yamaguchi's image pickup lens comprises "four lenses arranged in an order of a first lens, a second lens, a third lens, and a fourth lens from an object side." *Id.* ¶ 0009. "[T]he first lens has positive refractive power and has a convex surface facing toward the object side …." *Id.* ¶ 0010. "[T]he second lens has … positive refractive power …." *Id.* "[T]he third lens has negative refractive power and has a concave surface facing toward the object side to be formed in a meniscus shape, and the fourth lens has … positive or negative refractive power and has a convex surface facing toward the object side to be formed in the meniscus shape." *Id.*

Yamaguchi discloses that "the image side surface of the fourth lens … is formed in the aspherical surface shape satisfying the formulas (10), (11), and (12)," which are reproduced below:

[0036] Preferably, an image side surface of the fourth lens satisfies a following conditional formula (10):

$$X-X0<0 \tag{10}$$

[0037] for a displacement value X of an aspherical surface expressed in the formula (11):

$$X = \frac{h^2 / R8}{1 + \sqrt{1 - (1 + K8)h^2 / R8^2}} + \sum A_i h^i \tag{11}$$

[0038] and a displacement value X0 of a rotational quadratic surface component of the aspherical surface expressed in the formula (12):

$$X0 = \frac{h^2 / R8}{1 + \sqrt{1 - (1 + K8)h^2 / R8^2}} \tag{12}$$

[0039] in a range of h satisfying hmax X 0.5<h<hmax, where a vertex of the image side surface of the fourth lens is set as an origin, a direction of an optical axis is set as an X-axis, h denotes a height in an arbitrary direction perpendicular to the optical axis, Ai denotes an i-th order coefficient of the aspherical surface for the image side surface of the fourth lens, hmax denotes a maximum effective radius, R8 denotes a curvature radius of the image side surface of the fourth lens, and K8 denotes a conic constant for the image side surface of the fourth lens.

Id. ¶¶ 0036–0039, 0041; *see also id.* ¶¶ 0054–0057, 0062.

Figs. 5 (Examples 1 and 2), 8 (Example 3), and 10 (Example 4) show sectional views of four examples of pickup lenses. *Id.* ¶¶ 0112, 0115, 0117.

FIG.5

FIG.8

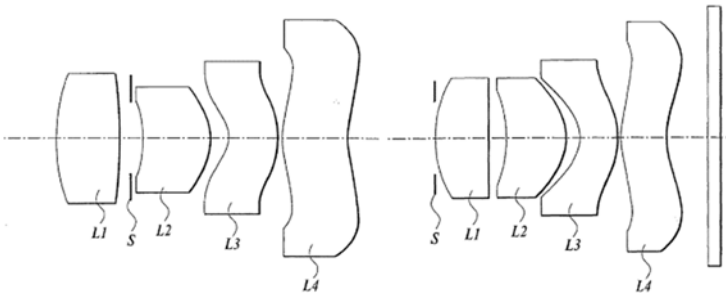
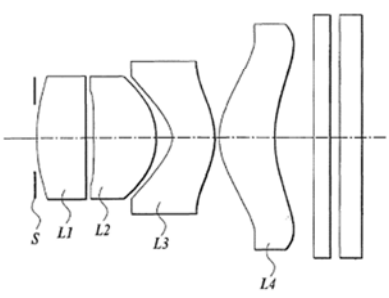


FIG.10



For each example, Yamaguchi provides four tables listing various lens data, which includes "f: focal length of the whole image pickup lens," "F: F number," "2Y: length of diagonal line on effective image screen," "R: curvature radius of refractive surface," "D: interval between refractive surfaces on axis," and "vd: Abbe number of lens material." *Id.* ¶¶ 0154–0162, 0167–0169, 0172–0175, 0178–0181, 0185–0188, 0192. In Examples 1–4, "the shape of an aspherical surface is expressed in a rectangular coordinate system," as indicated below:

> **[0163]** Also, in Examples, the shape of an aspherical surface is expressed in a rectangular coordinate system, which has a vertex of the surface set as an origin and an optical axial direction set as an X axis, according to a following formula by using R denoting a curvature radius of the aspherical surface at the vertex, K denoting a conic constant, and A4, A6, A8, A10 and A12 denoting coefficients of the aspherical surface.
>
> $$X = \frac{h^2/R}{1+\sqrt{1-(1+K)h^2/R^2}} + A_4h^4 + A_6h^6 + A_8h^8 + A_{10}h^{10} + A_{12}h^{12},$$
>
> **[0164]** where
>
> $h=\sqrt{Y^2+Z^2}$
>
> **[0165]** is satisfied

Id. ¶ 0163–0165.

VII. How the Challenged Claims are Unpatentable

The following demonstrates where each element of the challenged claims is found in the prior art for each of the above-listed grounds.

A. Ground 1: Yu Renders Claims 1–11, and 15–25 Obvious.

Yu discloses three embodiments. Ex.1003, 4:39–47, 5:52–6:53, 8:36–44. The analysis below focuses on the first and third embodiments. Yu's first embodiment renders claims 1–9, 11, and 15–25 obvious, and Yu's third embodiment renders claims 1, 8, and 10 obvious.

1. Claim 1

(a) Preamble: "An image capturing lens system comprising, in order from an object side to an image side:"

Yu discloses a "a compact wide-angle four-piece imaging lens assembly." Ex.1003, 1:12–14. Yu's "lens assembly … comprises a lens set and a non-adjustable diaphragm." *Id.*, 1:45–46. "The lens set includes a first lens, a second lens, a third lens and a fourth lens arranged in sequence from an object side to an image side along an optical axis of the lens assembly." *Id.*, 1:46–49. Yu's Fig. 1 and Fig. 7 show a first and third embodiment of the lens assembly, respectively. *Id.*, 2:40–42, 2:52–54. To the extent the preamble is limiting, Yu's lens assembly is "[a]n image capturing lens system." Ex.1007 ¶¶ 86–90.

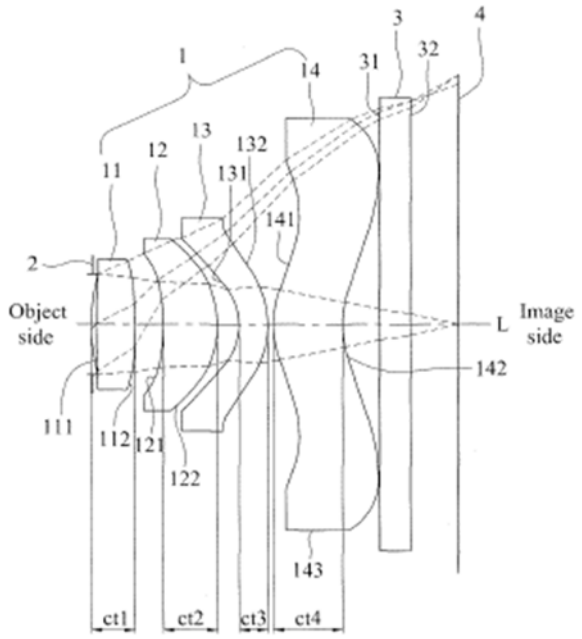


FIG.1

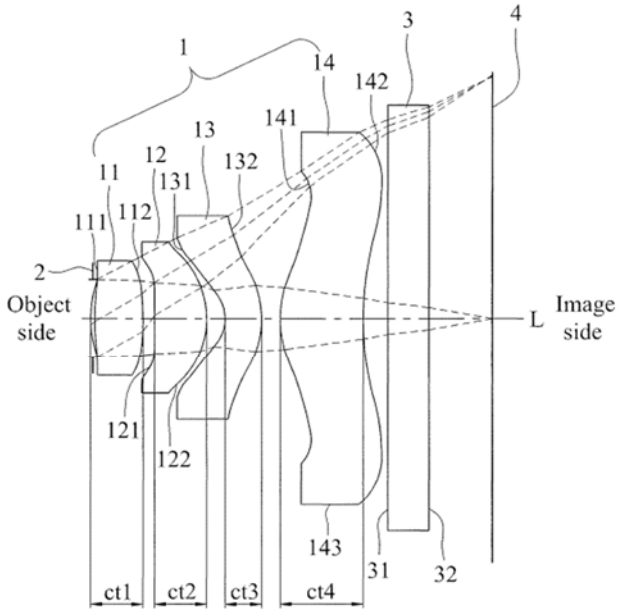


FIG.7

(b) Element 1a: "a first lens element having refractive power;"

In order from the object side to the image side, Yu's lens assembly comprises first "a first lens 11." Ex.1003, 2:55–58, Figs. 1, 7. "The first lens 11 has a positive optical power adjacent to the optical axis L …." *Id.*, 2:58–61. Positive optical power means positive refractive power. Ex.1007 ¶ 92. Yu's first lens 11 is a "first lens element having refractive power." *Id.* ¶¶ 91–92.

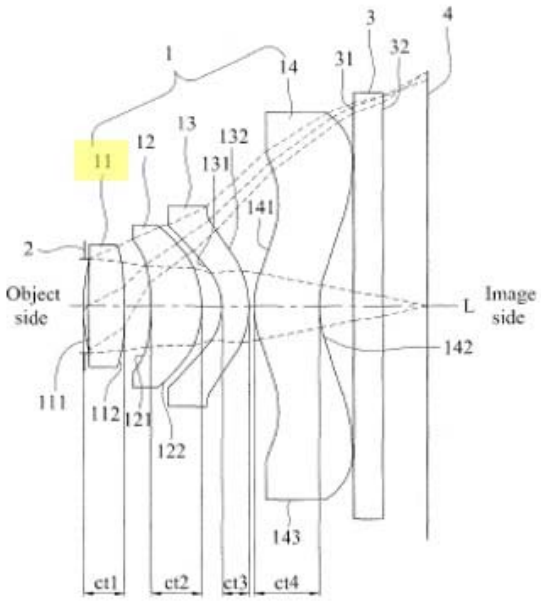


FIG.1

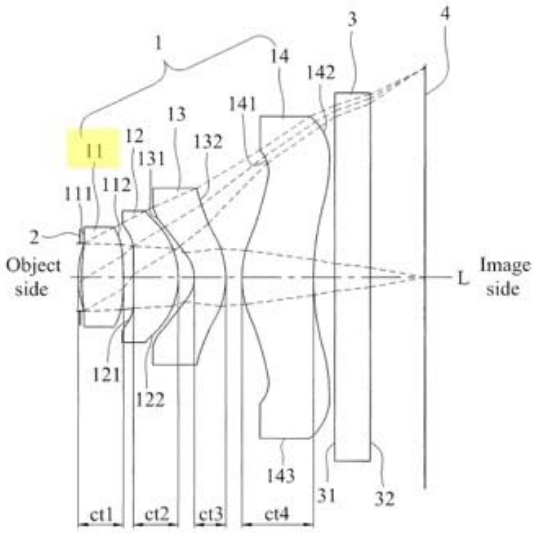


FIG.7

(c) Element 1b: "a second lens element with positive refractive power having a convex image-side surface in a paraxial region thereof;"

After the first lens 11, from the object side to image side in Yu's lens assembly, is "a second lens 12." Ex.1003, 2:55–58, Figs. 1, 7. "The second lens 12 has a positive optical power adjacent to the optical axis L, and has a convex image-side surface [122][1] …." *Id.*, 2:63–66, Figs. 1, 7.

[1] The labels 121 and 122 are transposed in this sentence, but the image-side surface 122 is properly identified in Figs. 1 and 7 and the next sentence. Ex.1007 ¶ 94; Ex.1003, 2:66–3:1, Figs. 1, 7.

first lens **11** is an aspherical surface. The second lens **12** has a positive optical power adjacent to the optical axis L, and has a convex image-side surface **121** which faces the image side, and an object-side surface **122** which faces the object side. At least one of the object-side surface **121** and the image-side surface **122** of the second lens **12** is an aspherical surface. The third lens **13** has a negative optical power adjacent to the optical axis L, and has a concave object-side surface **131** which faces the object side, and a convex image-side surface **132** which faces the image side. At least one of the object-side

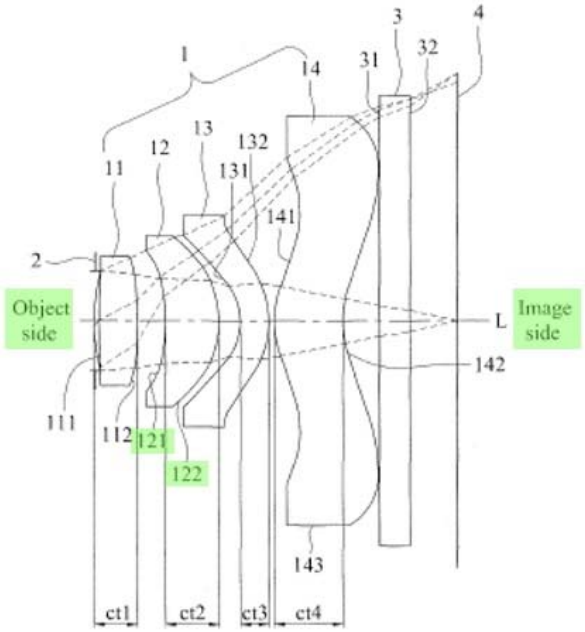


FIG.1

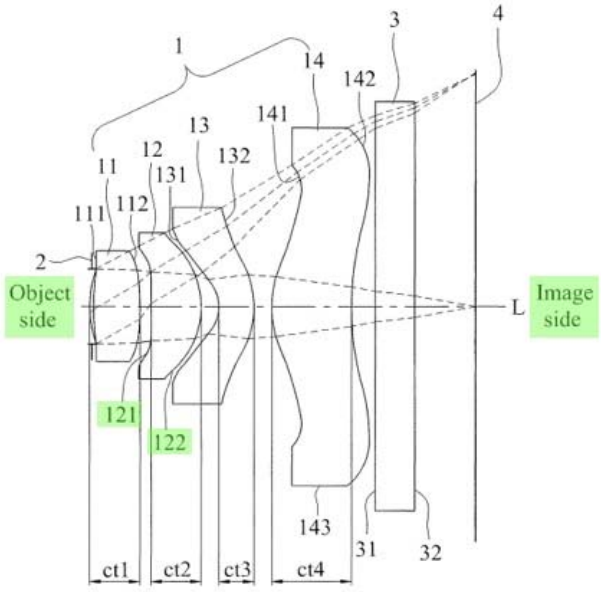


FIG.7

Positive optical power means positive refractive power, and Yu's description of the "convex image-side surface [122]" describes the surface in a paraxial region of the second lens 12. Ex.1007 ¶¶ 94–96.

Yu's Figs. 1 and 7 show that the second lens 12 has positive refractive power, because it is thicker in the paraxial region, and that the image-side surface 122 is convex, because it protrudes outward. *Id.* ¶¶ 35, 97. The negative radius for the

image-side surface 122 in Yu's Tables 1 and 5 also discloses a convex surface. *Id.* ¶ 98.

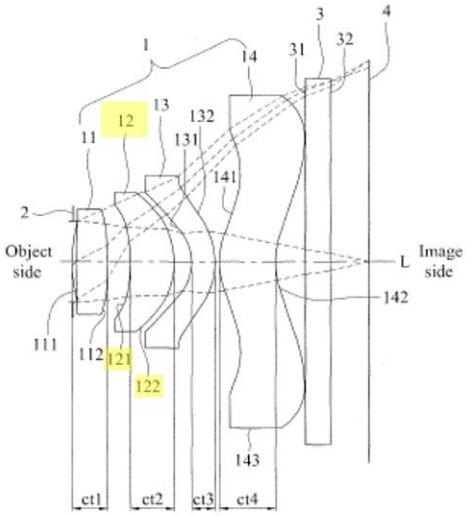


FIG.1

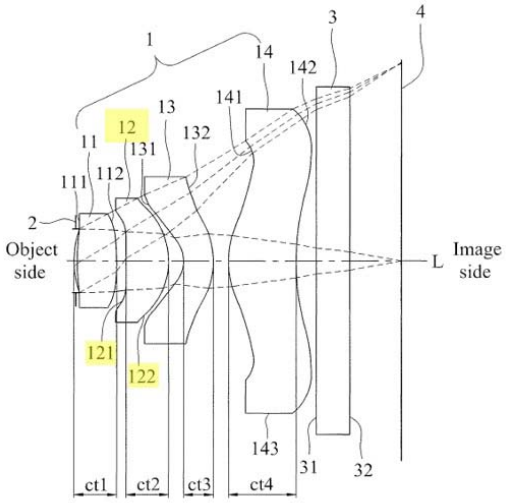


FIG.7

TABLE 1-continued

First preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Second lens 12	Object-side surface 121	−2.042	0.368	1.535	56.07	2.05
	Image-side surface 122	−0.760	0.159			
Third lens 13	Object-side surface 131	−0.289	0.190	1.636	23.89	−1.16
	Image-side surface 132	−0.596	0.038			
Fourth lens 14	Object-side surface 141	0.488	0.472	1.535	56.07	1.52
	Image-side surface 142	0.805	0.25			
Filter lens 3	Object-side surface 31	∞	0.21	1.517	64.17	
	Image-side surface 32	∞	0.332			

TABLE 5

Third preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Non-adjustable diaphragm 2		∞	−0.001			
First lens 11	Object-side surface 111	1.903	0.239	1.535	56.07	2.55
	Image-side surface 112	−4.616	0.062			
Second lens 12	Object-side surface 121	3.029	0.266	1.535	56.07	0.86
	Image-side surface 122	−0.528	0.095			
Third lens 13	Object-side surface 131	−0.184	0.187	1.636	23.89	−0.61
	Image-side surface 132	−0.483	0.092			

Yu's second lens 12 is a "second lens element with positive refractive power having a convex image-side surface in a paraxial region thereof." *Id.* ¶¶ 93–98.

(d) Element 1c: "a third lens element with negative refractive power having a concave object-side surface in a paraxial region thereof and a convex image-side surface in a paraxial region thereof; and"

After the second lens 12, from the object side to image side in Yu's lens assembly, is "a third lens 13." Ex.1003, 2:55–58, Figs. 1, 7. "The third lens 13 has a negative optical power adjacent to the optical axis L, and has a concave object-side surface 131 …, and a convex image-side surface 132 …." *Id.*, 3:1–5, Figs. 1, 7. Negative optical power means negative refractive power, and Yu's description of the "concave object-side surface 131" and "convex image-side surface 132" describes the surface in a paraxial region of the third lens 13. Ex.1007 ¶ 100.

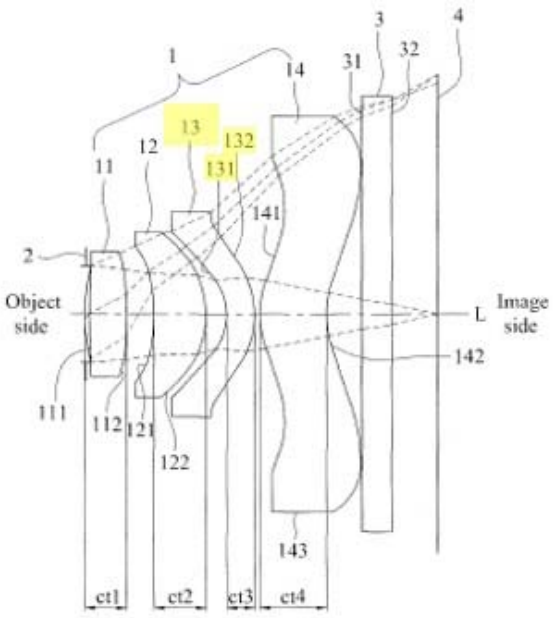


FIG.1

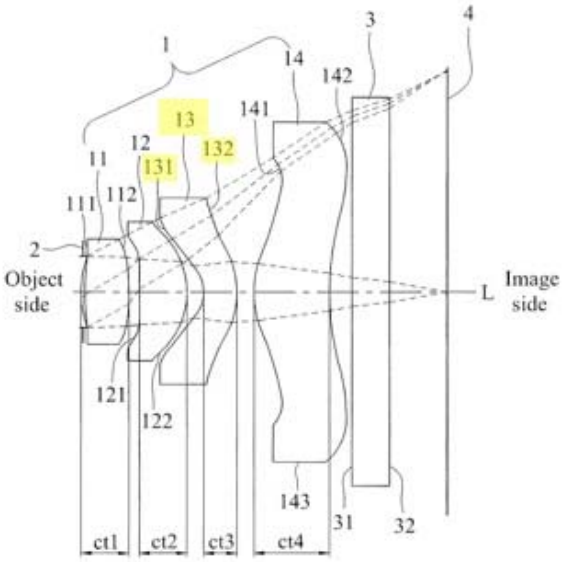


FIG.7

Yu's Figs. 1 and 7 show that the third lens 13 has negative refractive power, because it is thinner in the paraxial region. *Id.* ¶ 101. These figures also show that the object-side surface 131 is concave because it protrudes inward and the image-side surface 132 is convex because it protrudes outward. *Id.* ¶¶ 35, 101. The negative radius for the object-side surface 131 and the image-side surface 132 in Yu's Tables 1 and 5 also discloses a concave object-side surface and a convex image-side surface. *Id.* ¶ 102.

TABLE 1-continued

First preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Second lens 12	Object-side surface 121	−2.042	0.368	1.535	56.07	2.05
	Image-side surface 122	−0.760	0.159			
Third lens 13	Object-side surface 131	−0.289	0.190	1.636	23.89	−1.16
	Image-side surface 132	−0.596	0.038			
Fourth lens 14	Object-side surface 141	0.488	0.472	1.535	56.07	1.52
	Image-side surface 142	0.805	0.25			
Filter lens 3	Object-side surface 31	∞	0.21	1.517	64.17	
	Image-side surface 32	∞	0.332			

TABLE 5

Third preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Non-adjustable diaphragm 2		∞	−0.001			
First lens 11	Object-side surface 111	1.903	0.239	1.535	56.07	2.55
	Image-side surface 112	−4.616	0.062			
Second lens 12	Object-side surface 121	3.029	0.266	1.535	56.07	0.86
	Image-side surface 122	−0.528	0.095			
Third lens 13	Object-side surface 131	−0.184	0.187	1.636	23.89	−0.61
	Image-side surface 132	−0.483	0.092			

Yu's third lens 13 is a "third lens element with negative refractive power having a concave object-side surface in a paraxial region thereof and a convex image-side surface in a paraxial region thereof." *Id.* ¶¶ 99–102.

(e) Element 1d: "a fourth lens element with refractive power having a concave image-side surface in a paraxial region thereof, wherein both of an object-side surface and the image-side surface of the fourth lens element are aspheric, and the image-side surface of the fourth lens element has at least one convex shape in an off-axis region thereof;"

After the third lens 13, from the object side to image side in Yu's lens assembly, is "a fourth lens 14." Ex.1003, 2:55–58, Figs. 1, 7. "The fourth lens 14 has a positive optical power adjacent to the optical axis L, and has an image-side surface [142][2] … which has a concave portion around the optical axis L …." *Id.*, 3:7–13, Figs. 1, 7.

13 is an aspherical surface. The fourth lens **14** has a positive optical power adjacent to the optical axis L, and has an image-side surface **141** which faces the image side and which has a concave portion around the optical axis L, an object-side surface **142** which faces the object side, and a peripheral surface **143** which interconnects the object-side surface **141** and the image-side surface **142**. Each of the object-side surface **141** and the image-side surface **142** of the fourth lens **14** is an aspherical surface. At least one of the object-side surface **141** and the image-side surface **142** of the fourth lens **14** has an inflection point located between the optical axis L and the peripheral surface **143**.

[2] The labels 141 and 142 in this portion of the sentence are transposed, but the image-side surface 142 is properly identified in Figs. 1 and 7, later in the sentence, and in the next two sentences. Ex.1007 ¶ 104; Ex.1003, 3:12–18, Figs. 1, 7.

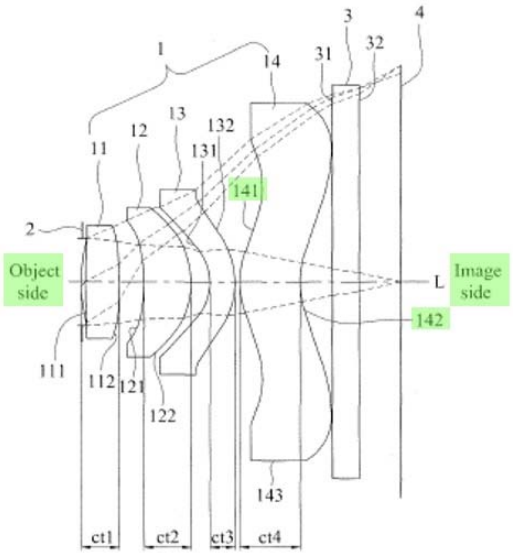


FIG.1

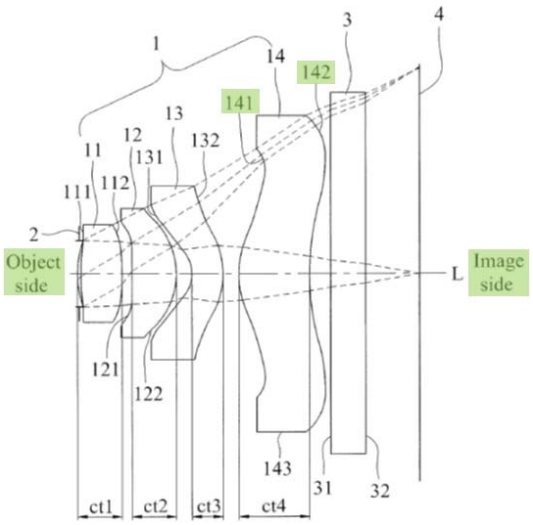


FIG.7

Positive optical power means positive refractive power, and Yu's description of the "image-side surface [142] … which has a concave portion around the optical axis L" describes the surface in a paraxial region of the fourth lens 14. Ex.1007 ¶¶ 104–05.

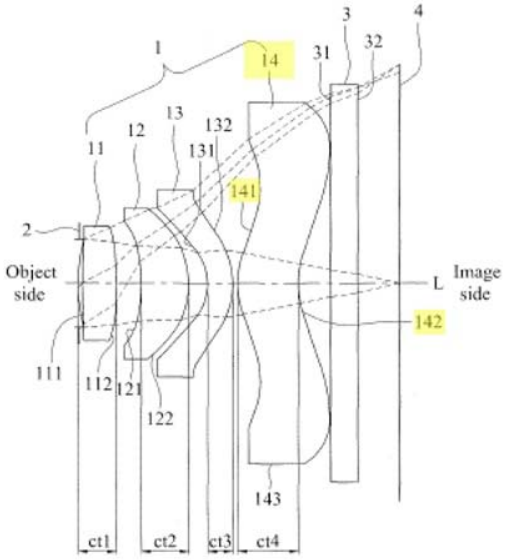


FIG.1

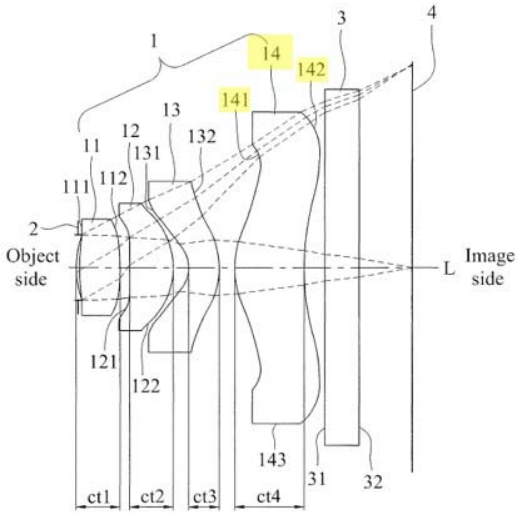


FIG.7

Yu's Figs. 1 and 7 show that the fourth lens 14 has positive refractive power, because it is thicker in the paraxial region. *Id.* ¶ 106. These figures also show that the image-side surface 142 is concave because it protrudes inward. *Id.* ¶¶ 35, 106. The positive radius for the image-side surface 142 in Yu's Tables 1 and 5 also discloses a concave image-side surface. *Id.* ¶ 107.

TABLE 1-continued

First preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Second lens 12	Object-side surface 121	−2.042	0.368	1.535	56.07	2.05
	Image-side surface 122	−0.760	0.159			
Third lens 13	Object-side surface 131	−0.289	0.190	1.636	23.89	−1.16
	Image-side surface 132	−0.596	0.038			
Fourth lens 14	Object-side surface 141	0.488	0.472	1.535	56.07	1.52
	Image-side surface 142	0.805	0.25			
Filter lens 3	Object-side surface 31	∞	0.21	1.517	64.17	
	Image-side surface 32	∞	0.332			

TABLE 5-continued

Third preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Fourth lens 14	Object-side surface 141	0.430	0.429	1.535	56.07	0.98
	Image-side surface 142	1.549	0.125			
Filter lens 3	Object-side surface 31	∞	0.210	1.517	64.17	
	Image-side surface 32	∞	0.325			

Yu's fourth lens 14 is "a fourth lens element with refractive power having a concave image-side surface in a paraxial region." *Id.* ¶¶ 104–07.

Yu discloses that "[e]ach of the object-side surface 141 and the image-side surface 142 of the fourth lens 14 is an aspherical surface." Ex.1003, 3:13–15. This is visible in Figs. 1 and 7, and confirmed by Yu's disclosure of aspherical coefficients for these surfaces in Tables 2 and 6. Ex.1007 ¶ 108.

TABLE 2

	First lens 11		Second lens 12	
	Object-side surface 111	Image-side surface 112	Object-side surface 121	Image-side surface 122
k	0	0	6.191788	−3.784132
A	−0.2065838	−0.7720604	−1.4905075	−1.1446487
B	−3.3390093	1.4937038	13.548352	−13.499105
C	45.617387	−48.87327	−222.85883	142.67618
D	−568.5172	417.56966	1762.543	−811.19607
E	3836.6411	−1866.3668	−7503.2608	2964.6502
F	−14300.609	3693.0414	17228.893	−6161.6996
G	22470.012	−1072.5651	−16174.808	5342.7346

	Third lens 13		Fourth lens 14	
	Object-side surface 131	Image-side surface 132	Object-side surface 141	Image-side surface 142
k	−3.838175	−1.077898	−7.06691	−2.241616
A	−4.9202522	−0.5217609	0.10412867	−0.3678477
B	18.914991	0.96784978	−1.6835431	0.10715581
C	−20.771041	12.065814	4.2811759	0.31062561
D	12.125511	−36.497597	−6.3438122	−0.5323217
E	−142.85927	22.957229	5.6351203	0.37789525
F	243.02698	33.940443	−2.7711759	−0.1331061
G	30.761799	−33.635537	0.58039414	0.018683511

TABLE 6

	First lens 11		Second lens 12	
	Object-side surface 111	Image-side surface 112	Object-side Surface 121	Image-side surface 122
k	8.58328	−2824.922	42.97767	0.7395685
A	−1.2031657	−9.8439198	−7.1130345	0.63242517
B	12.223278	116.10956	4.0234552	−132.3459
C	−1918.3111	−1775.4567	−507.43521	2590.488
D	6722.3948	−15124.178	−7707.7496	−20847.637
E	2123163.2	652775.39	80989.53	138170.7
F	−52922573	−5158083.1	1130631.4	−1000249.5
G	3.7786e+008	11596365	−8089358.7	3411687.3

	Third lens 13		Fourth lens 14	
	Object-side Surface 131	Image-side surface 132	Object-side Surface 141	Image-side surface 142
k	−1.926854	−0.3569793	−5.810289	1.443596
A	−4.0319876	−0.15762397	−0.05755995	−0.20237191
B	−130.00916	8.7724173	−1.4813813	0.7721049
C	3983.5728	116.23539	9.9370396	−8.9338663
D	−22497.967	−218.09901	−60.63752	26.574088
E	−103474.15	−4855.6445	190.69088	−38.350854
F	1277642.5	24221.919	−287.85565	27.456949
G	−3002346	−32489.178	163.69987	−8.006268

Yu's fourth lens 14 is "a fourth lens element … wherein both of an object-side surface and the image-side surface of the fourth lens element are aspheric." *Id.*

Yu discloses that "[a]t least one of the object-side surface 141 and the image-side surface 142 of the fourth lens 14 has an inflection point located between the optical axis L and the peripheral surface 143." Ex.1003, 3:15–18. The image-side surface 142 of the fourth lens 14 is concave in a paraxial region, and the existence of "an inflection point located between the optical axis L and peripheral surface 143" means that it is convex in its off-axis region as shown in Figs. 1 and 7. *Id.*, 3:7–18; Ex.1007 ¶ 109.

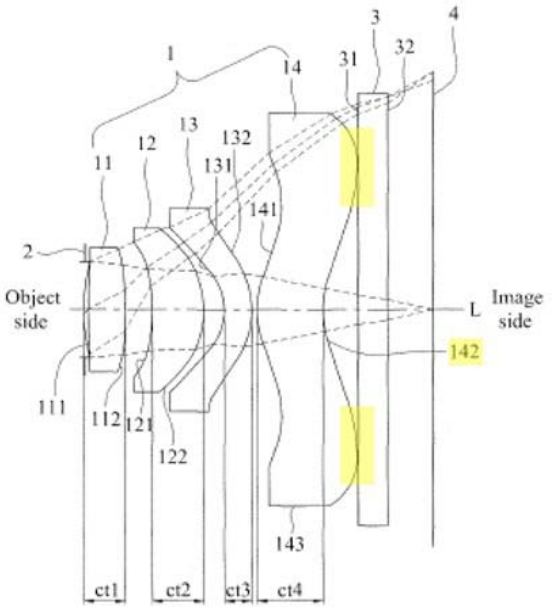


FIG.1

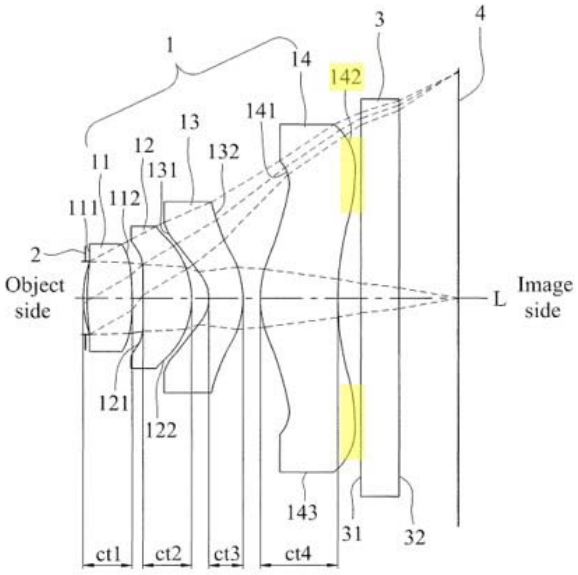


FIG.7

Yu's fourth lens 14 is "a fourth lens element … wherein … the image-side surface of the fourth lens element has at least one convex shape in an off-axis region

thereof." Ex.1007 ¶ 109. Yu's fourth lens 14 is the "fourth lens element" of Element 1d. *Id.* ¶¶ 103–10.

(f) Element 1e: "wherein the image capturing lens system has a total of four lens elements with refractive power,"

Yu discloses that its lens assembly "has a total of four lens elements with refractive power," i.e., the first lens 11, second lens 12, third lens 13, and fourth lens 14 discussed above. Ex.1003, 2:55–3:18, Figs. 1, 7. As shown in Figs. 1 and 7, Yu's lens assembly comprises these four lenses and two non-lens components that do not have refractive power, i.e., "a non-adjustable diaphragm 2" and "a filter lens 3." *Id.*, 2:52–58, Figs. 1, 7; Ex.1007 ¶ 112. Surface 4 is the receiving surface of the image sensor. Ex.1007 ¶ 112; Ex.1005 ¶ 0030. Yu discloses Element 1e. Ex.1007 ¶¶ 111–12.

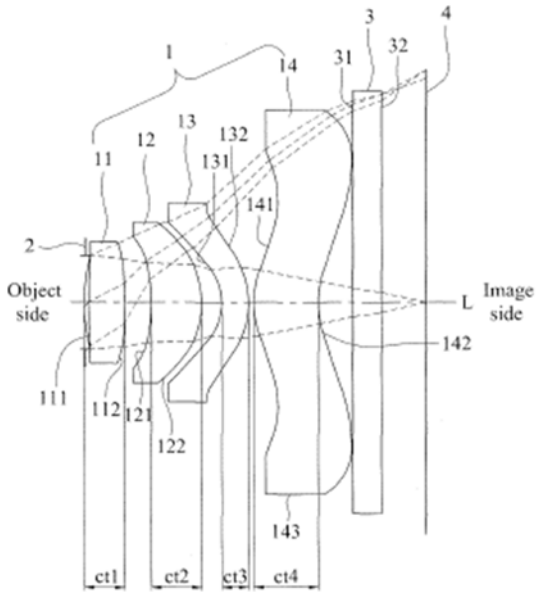


FIG.1

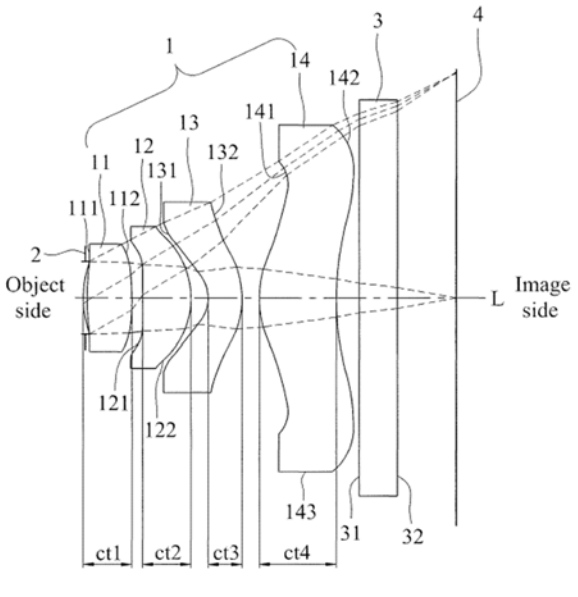


FIG.7

(g) Element 1f: "an axial distance between an object-side surface of the first lens element and the image-side surface of the fourth lens element is Td, half of a maximal field of view of the image capturing lens system is HFOV, a focal length of the image capturing lens system is f, a focal length of the fourth lens element is f4, a focal length of the second lens element is f2, a focal length of the third lens element is f3, and the following conditions are satisfied: 0.5 mm<Td<3.2 mm; 1.0 mm<Td/tan(HFOV)<3.75 mm; |f/f4|<1.20; and f2/f3<-0.65."

Yu's Table 1 "shows the parameters of components of the first preferred embodiment." Ex.1003, 4:39–43, 4:51–5:20. The third column in Table 1 lists the center thickness of Yu's lenses and the interspace distance. *Id.* To determine the "axial distance between an object-side surface of the first lens element and the image-side surface of the fourth lens element … Td," one sums the following values: the center thickness of first lens 11 (0.284 mm), the interspace distance from the first lens 11 to the second lens 12 (0.194 mm), the center thickness of the second lens 12 (0.368 mm), the interspace distance from the second lens 12 to the third lens 13 (0.159 mm), the center thickness of the third lens 13 (0.190 mm), the interspace distance between the third lens 13 and the fourth lens 14 (0.038 mm), and the center thickness of the fourth lens 14 (0.472 mm). *Id.*, 4:51–5:20; Ex.1007 ¶ 114.

TABLE I

First preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Non-adjustable diaphragm 2		∞	−0.03			
First lens 11	Object-side surface 111	1.361	0.284	1.535	56.07	2.19
	Image-side surface 112	−8.119	0.194			

TABLE I-continued

First preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Second lens 12	Object-side surface 121	−2.042	0.368	1.535	56.07	2.05
	Image-side surface 122	−0.760	0.159			
Third lens 13	Object-side surface 131	−0.289	0.190	1.636	23.89	−1.16
	Image-side surface 132	−0.596	0.038			
Fourth lens 14	Object-side surface 141	0.488	0.472	1.535	56.07	1.52
	Image-side surface 142	0.805	0.25			
Filter lens 3	Object-side surface 31	∞	0.21	1.517	64.17	
	Image-side surface 32	∞	0.332			

In Yu's first embodiment, Td equals 1.705 mm, which satisfies the condition "0.5 mm<Td<3.2 mm." Ex.1007 ¶ 114.

Yu also discloses that "HFOV=44°," "f=1.60 mm," "f4=1.52 mm," "f2=2.05 mm," and "f3=-1.16 mm" in the first embodiment. Ex.1003, 4:39–43. Thus:

- Td/tan(HFOV) equals 1.76558 mm, which satisfies the condition "1.0 mm<Td/tan(HFOV)<3.75 mm";
- |f/f4| equals 1.05263, which satisfies the condition "|f/f4|<1.20"; and
- f2/f3 equals -1.76724, which satisfies the condition "f2/f3<-0.65."

Ex.1007 ¶ 115.

Yu's Table 5 shows the "parameters of a third preferred embodiment of the lens assembly." Ex.1003, 8:36–41, 8:48–9:14. The third column in Table 5 lists the center thickness of Yu's lenses and the interspace distance. *Id.* To determine the "axial distance between an object-side surface of the first lens element and the image-side surface of the fourth lens element … Td," one sums the following values: the center thickness of first lens 11 (0.239 mm), the interspace distance from the first lens 11 to the second lens 12 (0.062 mm), the center thickness of the second lens 12 (0.266 mm), the interspace distance from the second lens 12 to the third lens 13 (0.095 mm), the center thickness of the third lens 13 (0.187 mm), the interspace distance between the third lens 13 and the fourth lens 14 (0.092 mm), and the center thickness of the fourth lens 14 (0.429 mm). Ex.1003, 8:48–9:14; Ex.1007 ¶ 116.

TABLE 5

Third preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Non-adjustable diaphragm 2		∞	−0.001			
First lens 11	Object-side surface 111	1.903	0.239	1.535	56.07	2.55
	Image-side surface 112	−4.616	0.062			
Second lens 12	Object-side surface 121	3.029	0.266	1.535	56.07	0.86
	Image-side surface 122	−0.528	0.095			
Third lens 13	Object-side surface 131	−0.184	0.187	1.636	23.89	−0.61
	Image-side surface 132	−0.483	0.092			

TABLE 5-continued

Third preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Fourth lens 14	Object-side surface 141	0.430	0.429	1.535	56.07	0.98
	Image-side surface 142	1.549	0.125			
Filter lens 3	Object-side surface 31	∞	0.210	1.517	64.17	
	Image-side surface 32	∞	0.325			

In Yu's third embodiment, Td equals 1.37 mm, which satisfies the condition "0.5 mm<Td<3.2 mm." Ex.1007 ¶ 116.

Yu also discloses that "HFOV=44°," "f=1.13 mm," "f4=0.98 mm," "f2=0.86 mm," and "f3=-0.61 mm" in the third embodiment. Ex.1003, 8:36–41. Thus:

- Td/tan(HFOV) equals 1.41868 mm, which satisfies the condition "1.0 mm<Td/tan(HFOV)<3.75 mm";
- |f/f4| equals 1.15306, which satisfies the condition "|f/f4|<1.20"; and
- f2/f3 equals -1.40984, which satisfies the condition "f2/f3<-0.65."

Ex.1007 ¶ 117.

Yu discloses Element 1f and renders claim 1 obvious. *Id.* ¶¶ 113–19.

2. Claim 2: "The image capturing lens system of claim 1, wherein the fourth lens element has the object-side surface being convex in a paraxial region thereof."

Yu discloses that "[t]he fourth lens 14 has … an object-side surface [141][3]." Ex.1003, 3:7–13, Fig. 1. Yu's Table 1 lists the radius of curvature of the object-side surface 141 of the fourth lens 14 as 0.488 mm. *Id.*, 5:12–13.

TABLE 1-continued

First preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Second lens 12	Object-side surface 121	−2.042	0.368	1.535	56.07	2.05
	Image-side surface 122	−0.760	0.159			
Third lens 13	Object-side surface 131	−0.289	0.190	1.636	23.89	−1.16
	Image-side surface 132	−0.596	0.038			
Fourth lens 14	Object-side surface 141	0.488	0.472	1.535	56.07	1.52
	Image-side surface 142	0.805	0.25			
Filter lens 3	Object-side surface 31	∞	0.21	1.517	64.17	
	Image-side surface 32	∞	0.332			

The positive radius for the object-side surface 141 discloses a convex object-side surface in the paraxial region. Ex.1007 ¶ 121.

Yu's Fig. 1 shows that the object-side surface 141 is convex because it protrudes outward in the paraxial region. *Id.* ¶¶ 35, 122.

[3] *Supra* note 2.

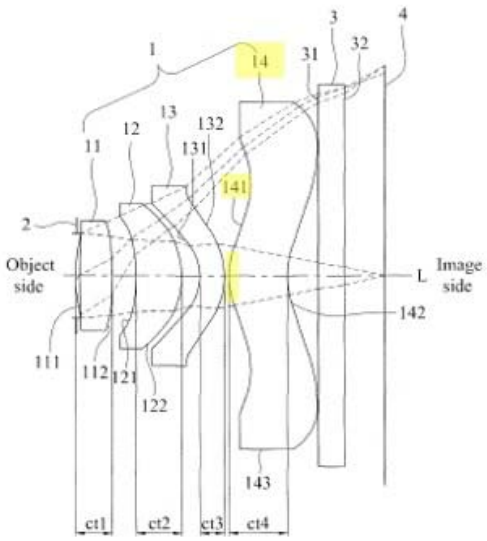


FIG.1

Yu discloses that "the fourth lens element has the object-side surface being convex in a paraxial region" and renders claim 2 obvious. *Id.* ¶¶ 120–23.

3. Claim 3: "The image capturing lens system of claim 2, wherein the focal length of the image capturing lens system is f, a focal length of the first lens element is f1, and the following condition is satisfied: -0.25<f/f1<0.75."

In Yu's first embodiment, "f=1.60 mm" and "f1=2.19 mm." Ex.1003, 4:39–43. Thus, f/f1 equals 0.73059, which satisfies the condition "0.25<f/f1<0.75." Ex.1007 ¶ 125. Yu discloses that "the focal length of the image capturing lens system is f, a focal length of the first lens element is f1, and the following condition is satisfied: -0.25<f/f1<0.75" and renders claim 3 obvious. *Id.* ¶¶ 124–26.

4. Claim 4: "The image capturing lens system of claim 2, wherein the axial distance between the object-side surface of the first lens element and the image-side surface of the

fourth lens element is Td, and the following condition is satisfied: 0.8 mm<Td<2.5 mm."

Section VII.A.1(g) explains that Td equals 1.705 mm in Yu's first embodiment, which satisfies the condition "0.8 mm<Td<2.5 mm." *Id.* ¶ 128. Yu renders claim 4 obvious. *Id.* ¶¶ 127–29.

5. Claim 6: "The image capturing lens system of claim 2, wherein a curvature radius of the object-side surface of the second lens element is R3, a curvature radius of the image-side surface of the second lens element is R4, and the following condition is satisfied: 0.5<(R3+R4)/(R3-R4)<2.5."

Yu's Table 1 lists the radius of curvature for the object-side surface 121 of the second lens 12 ("R3") as -2.042 mm and the radius of curvature of the image-side surface 122 of the second lens 12 ("R4") as -0.760 mm. Ex.1003, 5:4–7.

TABLE 1-continued

First preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Second lens 12	Object-side surface 121	−2.042	0.368	1.535	56.07	2.05
	Image-side surface 122	−0.760	0.159			
Third lens 13	Object-side surface 131	−0.289	0.190	1.636	23.89	−1.16
	Image-side surface 132	−0.596	0.038			
Fourth lens 14	Object-side surface 141	0.488	0.472	1.535	56.07	1.52
	Image-side surface 142	0.805	0.25			
Filter lens 3	Object-side surface 31	∞	0.21	1.517	64.17	
	Image-side surface 32	∞	0.332			

Thus, (R3+R4)/(R3-R4) equals 2.18565, which satisfies the condition "0.5<(R3+R4)/(R3-R4)<2.5," and Yu renders claim 6 obvious. Ex.1007 ¶¶ 130–32.

6. Claim 7: "The image capturing lens system of claim 2, wherein the focal length of the image capturing lens system

is f, and the following condition is satisfied: 0.5 mm<f<2.0 mm."

In Yu's first embodiment, "f=1.60 mm," which satisfies the condition "0.5 mm<f<2.0 mm." Ex.1003, 4:39–44; Ex.1007 ¶ 134. Thus, Yu renders claim 7 obvious. Ex.1007 ¶¶ 133–35.

7. Claim 8: "The image capturing lens system of claim 1, wherein the first lens element has a convex object-side surface in a paraxial region thereof."

Yu discloses that "[t]he first lens 11 … has a convex object-side surface 111." Ex.1003, 2:58–61, Figs. 1, 7. Yu's description of the "convex object-side surface 111" describes the surface in a paraxial region of the first lens 11. Ex.1007 ¶ 137.

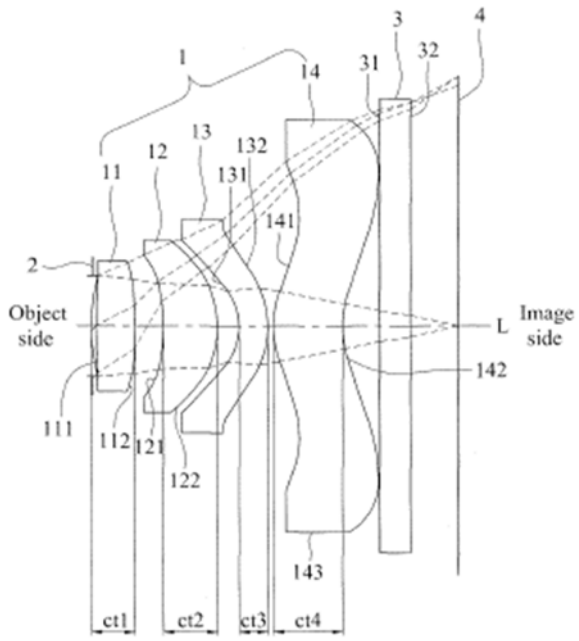


FIG.1

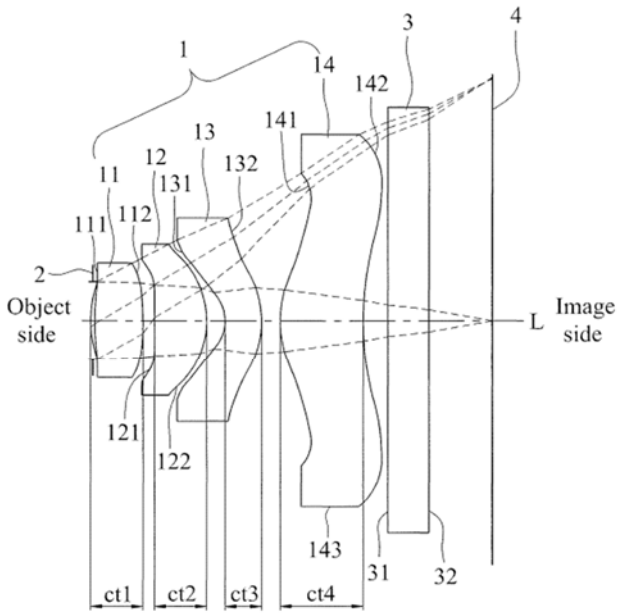


FIG.7

The positive radius for the object-side surface 111 of the first lens 11 in Yu's Tables 1 (first embodiment) and 5 (third embodiment) also discloses a convex object-side surface. *Id.* ¶ 138; Ex.1003, 4:64–65, 8:56–57.

TABLE 1

First preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Non-adjustable diaphragm 2		∞	−0.03			
First lens 11	Object-side surface 111	1.361	0.284	1.535	56.07	2.19
	Image-side surface 112	−8.119	0.194			

TABLE 5

Third preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Non-adjustable diaphragm 2		∞	−0.001			
First lens 11	Object-side surface 111	1.903	0.239	1.535	56.07	2.55
	Image-side surface 112	−4.616	0.062			
Second lens 12	Object-side surface 121	3.029	0.266	1.535	56.07	0.86
	Image-side surface 122	−0.528	0.095			
Third lens 13	Object-side surface 131	−0.184	0.187	1.636	23.89	−0.61
	Image-side surface 132	−0.483	0.092			

Yu discloses that "the first lens element has a convex object-side surface in a paraxial region thereof" and renders claim 8 obvious. *Id.* ¶¶ 136–39.

8. Claim 9: "The image capturing lens system of claim 8, wherein the axial distance between the object-side surface of the first lens element and the image-side surface of the fourth lens element is Td, half of the maximal field of view of the image capturing lens system is HFOV, and the

following condition is satisfied: 1.2 mm<Td/tan(HFOV)<2.75 mm."

Section VII.A.1(g) explains that Td/tan(HFOV) equals 1.76558 mm in Yu's first embodiment, which satisfies the condition "1.2 mm<Td/tan(HFOV)<2.75 mm." *Id.* ¶ 141. Yu renders claim 9 obvious. *Id.* ¶¶ 140–42.

9. Claim 10: "The image capturing lens system of claim 8, wherein a sum of the central thicknesses of the first lens element, the second lens element, the third lens element, and the fourth lens element is ∑CT, the axial distance between the object-side surface of the first lens element and the image-side surface of the fourth lens element is Td, and the following condition is satisfied: 0.80<∑CT/Td<0.95."

Yu's Table 5 shows the "parameters of a third preferred embodiment of the lens assembly." Ex.1003, 8:36–41, 8:48–9:14. The third column in Table 5 lists the center thickness of Yu's lenses and the interspace distance. *Id.* In the third embodiment, the center thickness of the first lens 11 is 0.239 mm, the center thickness of the second lens 12 is 0.266 mm, the center thickness of the third lens 13 is 0.187 mm, and the center thickness of the fourth lens 14 is 0.429 mm. *Id.* Thus, ∑CT equals 1.121 mm. Ex.1007 ¶ 144.

TABLE 5

Third preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Non-adjustable diaphragm 2		∞	−0.001			
First lens 11	Object-side surface 111	1.903	0.239	1.535	56.07	2.55
	Image-side surface 112	−4.616	0.062			
Second lens 12	Object-side surface 121	3.029	0.266	1.535	56.07	0.86
	Image-side surface 122	−0.528	0.095			
Third lens 13	Object-side surface 131	−0.184	0.187	1.636	23.89	−0.61
	Image-side surface 132	−0.483	0.092			

TABLE 5-continued

Third preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Fourth lens 14	Object-side surface 141	0.430	0.429	1.535	56.07	0.98
	Image-side surface 142	1.549	0.125			
Filter lens 3	Object-side surface 31	∞	0.210	1.517	64.17	
	Image-side surface 32	∞	0.325			

Section VII.A.1(g) explains that Td equals 1.37 mm for Yu's third embodiment. Thus, in Yu's third embodiment, ∑CT/Td equals 0.81825, which satisfies the condition "0.80<∑CT/Td<0.95." *Id.* ¶ 145. Yu renders claim 10 obvious. *Id.* ¶¶ 143–46.

10. Claim 11: "The image capturing lens system of claim 8, wherein an Abbe number of the first lens element is V1, and the following condition is satisfied: 45<V1."

The Abbe number of the first lens 11 in Yu's first embodiment is 56.07. Ex.1003, 4:60. Yu discloses that "an Abbe number of the first lens element is V1, and the following condition is satisfied: 45<V1." Ex.1007 ¶ 148. Yu renders claim 11 obvious. *Id.* ¶¶ 147–49.

11. Claim 15

(a) Preamble and Elements 15a–15e

Claim 15's preamble and Elements 15a through 15e are identical to claim 1's preamble and Elements 1a through 1e. *Id.* ¶¶ 150–55. Thus, Sections VII.A.1(a)–(f) explain how Yu discloses claim 15's preamble and Elements 15a through 15e. *Id.*

(b) Element 15f: "an axial distance between an object-side surface of the first lens element and the image-side surface of the fourth lens element is Td, half of a maximal field of view of the image capturing lens system is HFOV, a focal length of the image capturing lens system is f, a focal length of the fourth lens element is f4, a focal length of the third lens element is f3, and the following conditions are satisfied: 0.5 mm<Td<3.2 mm; 1.0 mm<Td/tan(HFOV)<3.75 mm; |f/f4|<1.20; and -2.0<f/f3<-0.95."

Section VII.A.1(g) explains that Td equals 1.705 mm, f equals 1.60 mm, f4 equals 1.52 mm, f3 equals -1.16 mm, Td/tan(HFOV) equals 1.76558 mm, and |f/f4| equals 1.05263 in Yu's first embodiment. Accordingly, f/f3 equals -1.37931. *Id.* ¶ 157. The values of Td, Td/tan(HFOV), |f/f4|, and f/f3 for Yu's first embodiment satisfy each of the conditions in Element 15f: "0.5 mm<Td<3.2 mm; 1.0 mm<Td/tan(HFOV)<3.75 mm; |f/f4|<1.20; and -2.0<f/f3<-0.95." *Id.* Yu discloses Element 15f and renders claim 15 obvious. *Id.* ¶¶ 156–58.

12. Claim 16: "The image capturing lens system of claim 15, wherein an Abbe number of the first lens element is V1, and the following condition is satisfied: 45<V1."

Section VII.A.10 explains that, in Yu's first embodiment, "an Abbe number of the first lens element is V1, and the following condition is satisfied: 45<V1." Yu renders claim 16 obvious. *Id.* ¶¶ 159–61.

13. Claim 17: "The image capturing lens system of claim 15, wherein the focal length of the image capturing lens system is f, a focal length of the first lens element is f1, and the following condition is satisfied: -0.25<f/f1<0.75."

Section VII.A.3 explains that, in Yu's first embodiment, "the focal length of the image capturing lens system is f, a focal length of the first lens element is f1, and the following condition is satisfied: -0.25<f/f1<0.75." Yu renders claim 17 obvious. *Id.* ¶¶ 162–64.

14. Claim 18: "The image capturing lens system of claim 15, wherein a maximal field of view of the image capturing lens system is FOV, and the following condition is satisfied: 80 degrees<FOV<110 degrees."

In Yu's first embodiment, "HFOV=44°." Ex.1003, 4:39–43. "HFOV represents one half of a maximum angle of view of the lens assembly …." *Id.*, 2:13–14. Thus, the "maximal field of view" of Yu's first embodiment is 88 degrees, which satisfies the condition "80 degrees<FOV<110 degrees." Ex.1007 ¶ 166. Yu renders claim 18 obvious. *Id.* ¶¶ 165–67.

15. Claim 19: "The image capturing lens system of claim 15, wherein the axial distance between the object-side surface of the first lens element and the image-side surface of the

fourth lens element is Td, and the following condition is satisfied: 0.8 mm<Td<2.5 mm."

Section VII.A.4 explains that in Yu's first embodiment "the axial distance between the object-side surface of the first lens element and the image-side surface of the fourth lens element is Td, and the following condition is satisfied: 0.8 mm<Td<2.5 mm." Yu renders claim 19 obvious. *Id.* ¶¶ 168–70.

16. Claim 20: "The image capturing lens system of claim 15, wherein a focal length of the second lens element is f2, the focal length of the third lens element is f3, and the following condition is satisfied: f2/f3<-0.75."

Section VII.A.1(g) explains that f2/f3 equals -1.76724 in Yu's first embodiment, which satisfies the condition "f2/f3<-0.75." *Id.* ¶ 172. Yu renders claim 20 obvious. *Id.* ¶¶ 171–73.

17. Claim 5: "The image capturing lens system of claim 2, wherein an f-number of the image capturing lens system is Fno, and the following condition is satisfied: 1.40<Fno≤2.25."

The f-number (Fno) is calculated by dividing the focal length of the lens system by the diameter of the entrance pupil. Ex.1007 ¶ 175. The entrance pupil is the view of the aperture stop as seen through all of the lenses, if any, to the left of the aperture stop. *Id.* In Yu's first embodiment, a non-adjustable diaphragm 2, which is an aperture stop, is physically to left of the first lens 11. *Id.* ¶ 176–78; Ex.1003, 2:7–9, 2:52–54, 3:19–20, 4:62–63, Fig. 1. Because the non-adjustable diaphragm 2 is

physically to the left of the first lens 11, the diameter of its opening is the entrance pupil. Ex.1007 ¶ 178.

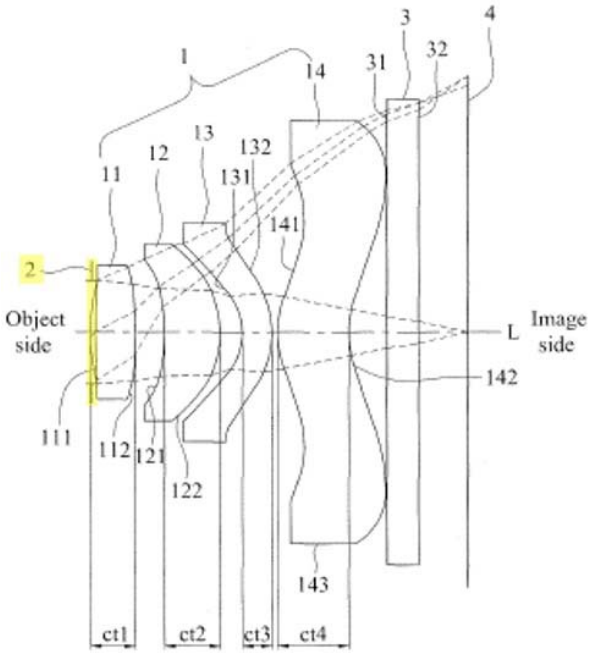


FIG.1

To the extent that Yu does not expressly disclose claim 5's limitation, at the time of the '796 patent, it would have been obvious to a POSITA to start a new lens design based on Yu's first embodiment and adjust the size of the entrance pupil in order to increase the lens system's light-gathering ability. *Id.* ¶¶ 179–82. Lens designers often begin new lens designs with classic designs, and adjust them to meet their current specifications, which include the f-number. *Id.* ¶¶ 54–57, 179–80; Ex.1014, 558–59, 661. The specified f-number can vary depending on the end-use of the lens system. Ex.1007 ¶ 180. The selection of an f-number involves a tradeoff between the light-gathering ability of the lens system and the sharpness of the

resulting image, which is analogous to the tradeoff made by photographers using classic cameras with a manual aperture adjustment who have always had to balance these considerations when taking a picture. *Id.* ¶¶ 180–81. In certain applications, such as photographing a fast moving athletic event, improving the light-gathering ability of the lens system is more important than maintaining the fullest sharpness of the image. *Id.* ¶ 180. Or, as disclosed in U.S. Patent Application Publication No. 2012/0147249 ("Okano"), which was published on June 14, 2012, and is prior art to the '796 patent, a lens assembly with a low f-number may be desired "in order to prevent deterioration of image quality due to noise in photographing in dark places." *Id.*; Ex.1011 ¶ 0005.

To increase the light-gathering ability of Yu's first embodiment, it would have been obvious to increase the size of the entrance pupil. Ex.1007 ¶ 182. A lens designer always considers the size of the entrance pupil because it determines how sensitive the system is to low-light operation. *Id.* The diameter of the opening in Yu's non-adjustable diaphragm 2 defines the entrance pupil in its first embodiment, so a POSITA would know that increasing the diameter of its opening increases the entrance pupil. *Id.* A lens designer considering enlargement of the diameter of the opening in Yu's non-adjustable diaphragm 2 to increase the light-gathering ability of Yu's first embodiment would logically consider how the f-number (Fno) would be affected by opening it up to match the size of Yu's first lens 11, which would be the

maximum increase to the diameter that does not require changing any of the dimensions of the lens elements. *Id.* ¶ 183.

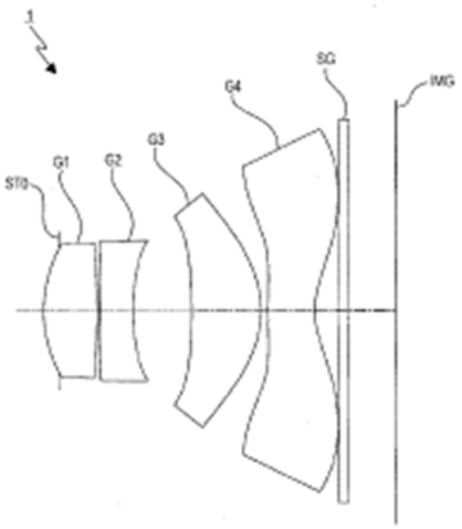
Yu does not expressly disclose the diameter of the first lens 11, but for the purposes of determining how much the diameter of the opening in the non-adjustable diaphragm 2 could be opened up, the information in Yu's Table 1 and Fig. 1 can be utilized. *Id.* ¶ 184. The distance between object-side surface 111 and image-side surface 142 can be measured in a printout of Fig. 1 and compared to the value determined by summing the relevant thickness/interspace values in Yu's Table 1, as discussed in Section VII.A.1(g). *Id.* ¶ 184. Using these two values, it can be determined that 1 mm in Table 1 equals approximately 32.8446 mm in the printed Fig. 1. *Id.* ¶¶ 184–85. Then, by measuring the diameter of the first lens 11 in the printed Fig. 1, it can be determined that its diameter is 0.886 mm. *Id.* ¶ 186. A POSITA would find it obvious and convenient to increase the diameter of the opening in the non-adjustable diaphragm 2 up to this diameter. *Id.*

The focal length of Yu's first embodiment is 1.60 mm. Ex.1003, 2:9–16, 4:39–43. Opening the diameter of the non-adjustable diaphragm 2 to a diameter of 0.886 mm results in an f-number of 1.806, which is within the range of $1.40<Fno\leq2.25$. Ex.1007 ¶ 186. It would have been obvious to a POSITA to increase the diameter of the opening of the non-adjustable diaphragm 2 in Yu's first embodiment to this or a lesser amount to increase the light-gathering ability of the

lens system, depending on the requirements for light-gathering ability and sharpness of the new lens system design. *Id.* ¶¶ 186–87. For example, it would have been obvious to adjust the diameter to between 0.711 mm and 0.886 mm. *Id.* ¶ 187. At the lower end of this range, the f-number of Yu's first embodiment would equal 2.25, which also satisfies the relation $1.40<Fno\leq 2.25$. *Id.* Any diameter in this range renders claim 5 obvious, and the ultimate choice depends on the requirements of the new lens design. *Id.* The first lens 11 could also be enlarged if more light-gathering ability is needed. *Id.*

Lens assemblies with f-numbers in the recited range were known before the '796 patent. *Id.* ¶ 188. For example, Okano discloses "an imaging lens which is suitable for a small sized apparatus such as a digital still camera or mobile phone" that comprises four lenses (G1, G2, G3, G4) with positive, negative, positive, and negative refractive power, respectively. *Id.*; Ex.1011 ¶¶ 0001, 0106, 0013, Fig. 1. The amount of light Okano accepts is directly proportional to the area of its aperture stop STO. Ex.1007 ¶ 188.

FIG.1



Okano's first embodiment has an f-number of 2.2, and it discloses embodiments with f-numbers ranging from 2.1 to 2.6 "to realize a bright optical system." *Id.*; Ex.1011 ¶¶ 0005, 0077–0078, 0112, 0228, 0256–0257, Table 1, Table 23.

TABLE 1

first value example lens data

Si surface number	Ri curvature radius	Di interval	Ndi refractive index	vdi Abbe number
1 (STO)	∞	−0.220	—	—
2	1.833	0.792	1.535	56.3
3	−8.067	0.030	—	—
4	−26.471	0.500	1.635	23.9
5	3.512	0.862	—	—
6	−7.054	1.017	1.535	56.3
7	−1.696	0.100	—	—
8	3.056	0.700	1.535	56.3
9	1.038	0.350	—	—
10	∞	0.150	1.518	64.1
11	∞	0.700	—	—

FNo = 2.2
f = 4.2
2ω = 69.8°

TABLE 23

	First value example	Second value example	Third value example	Fourth value example	Fifth value example	Sixth value example	Seventh value example	Eighth value example	Ninth value example	Tenth value example
Focal length in 35 mm version (mm)	30	28	28	27	31	29	31	30	30	31
FNo	2.2	2.4	2.4	2.4	2.4	2.2	2.4	2.4	2.4	2.4
Total optical length/ Sensor opposing angle	1.7	1.6	1.6	1.5	1.7	1.7	1.7	1.7	1.7	1.7

Another example, WO 2013/125248 ("Sugiyama"), which was published on August 29, 2013, and is prior art to the '796 patent, discloses "a compact, high resolution, wide-angle lens composed of four to six lenses" for a camera. Ex.1013 ¶¶ 0001–0002; Ex.1007 ¶ 189. Sugiyama discloses multiple embodiments having an f-number of 2, 2.2, or 2.4. *E.g.*, Ex.1013 ¶¶ 0021, 0065, 0080. It's lens assemblies are described as having "a bright configuration." *Id.* ¶¶ 0036, 0048, 0061, 0076, 0091.

While there may be some degradation of the sharpness of the image as the diameter of Yu's non-adjustable diaphragm 2 is enlarged, this is acceptable in certain applications. Ex.1007 ¶ 190. Further refinements to the lens system might reduce this degradation, but neither claims 1, 2, nor 5 recite any limitations regarding the quality of the resulting image. *Id.* Adjusting the diameter of the opening in the non-adjustable diaphragm 2 of Yu's first embodiment does not affect the analysis of claims 1 and 2 in Sections VII.A.1 and VII.A.2. *Id.*

Adjusting the diameter of the opening in the non-adjustable diaphragm 2 in Yu's first embodiment would have been obvious to a POSITA because it amounts to

the simple substitution of one known element for another to obtain predictable results, a predictable use of prior art elements according to their established functions, and applying a known technique to a known device to yield predictable results with reasonable expectation of success. *Id.* ¶ 191.

Yu renders claim 5 obvious. *Id.* ¶¶ 174–92.

18. Claim 21

(a) Preamble and Elements 21a–21e

Claim 21's preamble and Elements 21a through 21e are identical to claim 1's preamble and Elements 1a through 1e. *Id.* ¶¶ 193–98. Thus, Sections VII.A.1(a)–(f) explain how Yu discloses claim 21's preamble and Elements 21a through 21e. *Id.*

(b) Element 21f: "an axial distance between the object-side surface of the first lens element and the image-side surface of the fourth lens element is Td, half of a maximal field of view of the image capturing lens system is HFOV, a focal length of the image capturing lens system is f, a focal length of the fourth lens element is f4, an f-number of the image capturing lens system is Fno, and the following conditions are satisfied: 0.5 mm<Td<3.2 mm; 1.0 mm<Td/tan(HFOV)<3.75 mm; |f/f4|<1.20; and 1.40<Fno≤2.25.**

Section VII.A.1(g) explains that Td equals 1.705 mm, f equals 1.60 mm, f4 equals 1.52 mm, Td/tan(HFOV) equals 1.76558 mm, and |f/f4| equals 1.05263 in Yu's first embodiment. The values of Td, Td/tan(HFOV), and |f/f4| for Yu's first embodiment satisfy the first three conditions of Element 21f: "0.5 mm<Td<3.2 mm; 1.0 mm<Td/tan(HFOV)<3.75 mm; |f/f4|<1.20." *Id.* ¶ 200.

Section VII.A.17 explains why Yu's first embodiment renders claim 5 obvious, which recites that "an f-number of the image capturing lens system is Fno, and the following condition is satisfied: 1.40<Fno≤2.25." Yu renders Element 21f and claim 21 obvious. *Id.* ¶¶ 199–202.

19. Claim 22: "The image capturing lens system of claim 21, wherein a focal length of the second lens element is f2, a focal length of the third lens element is f3, and the following condition is satisfied: f2/f3<-0.65."

Section VII.A.1(g) explains that f2/f3 equals -1.76724 in Yu's first embodiment, which satisfies the condition "f2/f3<-0.65." *Id.* ¶ 204. Yu renders claim 22 obvious. *Id.* ¶¶ 203–05.

20. Claim 23: "The image capturing lens system of claim 21, wherein an Abbe number of the first lens element is V1, and the following condition is satisfied: 45<V1."

Section VII.A.10 explains that Yu's first embodiment discloses that "an Abbe number of the first lens element is V1, and the following condition is satisfied: 45<V1." Yu renders claim 23 obvious. *Id.* ¶¶ 206–08.

21. Claim 24: "The image capturing lens system of claim 21, wherein the first lens element has positive refractive power, the focal length of the image capturing lens system is f, a focal length of the first lens element is f1, and the following condition is satisfied: 0.25<f/f1<0.75."

Yu discloses that "[t]he first lens 11 has a positive optical power adjacent to the optical axis L." Ex.1003, 2:58–61. Positive optical power means positive

refractive power. Ex.1007 ¶ 210. Yu's Fig. 1 shows that the first lens 11 has positive refractive power, because it is thicker in the paraxial region. *Id.*

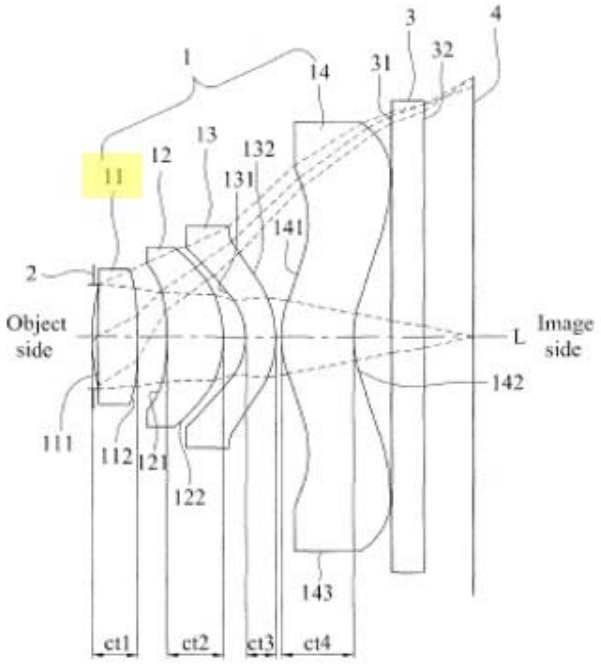


FIG.1

Section VII.A.3 explains that f/f1 equals 0.73059 in Yu's first embodiment, which satisfies the condition "0.25<f/f1<0.75." *Id.* ¶ 211. Yu renders claim 24 obvious. *Id.* ¶¶ 209–12.

22. Claim 25: "The image capturing lens system of claim 21, wherein a maximal field of view of the image capturing lens system is FOV, and the following condition is satisfied: 80 degrees<FOV<110 degrees."

Section VII.A.14 explains that Yu's first embodiment satisfies the condition "80 degrees<FOV<110 degrees." Yu renders claim 25 obvious. *Id.* ¶¶ 213–15.

B. Ground 2: Yamaguchi in View of Yu Renders Claims 1-11, 15-16, and 19-24 Obvious.

Yamaguchi discloses four example embodiments of a pickup lens. Ex.1006 ¶ 0154. The analysis below focuses on Examples 3 and 4. Yamaguchi's Example 4 renders claims 1–11 and 21–24 obvious in view of Yu, and Example 3 renders claims 1, 15–16, and 19–20 obvious in view of Yu.

1. Scaling Yamaguchi is Obvious.

Yamaguchi discloses a lens assembly having an axial distance between the object-side surface of the first lens and the image-side surface of the fourth lens that is greater than recited in challenged claims. Ex.1007 ¶ 216. However, a POSITA would have known that a lens assembly may be scaled up or down in size, while maintaining the same properties, by adjusting all of its dimensions by the same numerical ratio. *Id.* Yu discloses a lens assembly supporting a smaller sensor that has an axial distance within the range. *Id.* In view of Yu, it would have been obvious to scale down Yamaguchi's lens assembly to support a smaller sensor. *Id.*

At the time of the '796 patent, it would have been obvious to a POSITA to reference Yamaguchi's Examples 3 and 4 when beginning the design of a new lens assembly. *Id.* ¶¶ 217–18. Yamaguchi discloses "an image pickup lens" for use with "a CCD type image sensor or a CMOS type image sensor." Ex.1006 ¶ 0002. And Yamaguchi recognized that the "miniaturization" of devices and "the miniaturization and the dense arrangement of pixels" necessitated "the further miniaturization of an

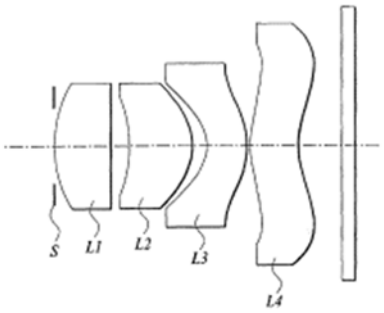
image pickup lens." *Id.* ¶¶ 0004–0005. Thus, Yamaguchi discloses "an image pickup lens which is composed of a plurality of lenses and is miniaturized." *Id.* ¶ 0008.

Yamaguchi discloses a four-lens lens assembly with the refractive power of the lenses arranged positive, positive, negative, and then positive or negative. *Id.* ¶¶ 0009–0010. For Examples 3 and 4, Yamaguchi discloses standard lens data in Table 9 (Example 3) and Table 13 (Example 14), an expression defining the aspherical surfaces, and the aspherical coefficients in Table 10 (Example 3) and Table 14 (Example 4). *Id.* ¶¶ 0155–0164, 0179–0180, 0186–0187; Ex.1007 ¶¶ 220–21. With this information, a POSITA could use these examples as the starting point for a new design. Ex.1007 ¶¶ 219–22.

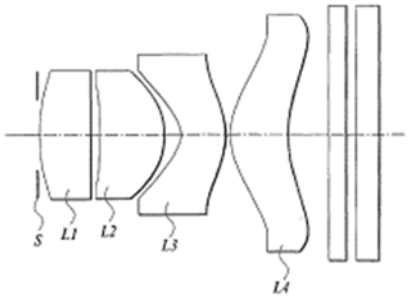
Yu's first embodiment is another design that would have been available at the time of the '796 patent. *Id.* ¶ 223. Yu discloses "a four-piece imaging lens assembly which has compact and thin dimensions." Ex.1003, 1:12–14, 1:41–44. The refractive power of the lenses in Yu's lens assembly is positive, positive, negative, and positive. *Id.*, 1:46–2:4, 2:58–3:18. Yu discloses standard lens data for its first embodiment in Table 1, an equation describing the aspheric surfaces, and the aspherical coefficients in Table 2. *Id.*, 4:21–32, Tables 1–2; Ex.1007 ¶¶ 225–27.

Yamaguchi's and Yu's lens assemblies are similar. Ex.1007 ¶ 228. Both are four-lens designs, have similar arrangements of lens refractive powers, and are

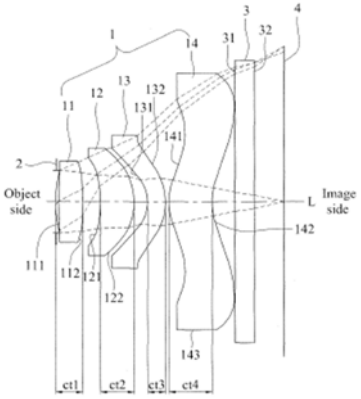
intended for use in small electronic products. *Id.*; Ex.1003, 1:16–19, 1:46–2:3; Ex.1006 ¶ 0002, 0004–0005, 0008–0010, 0105–0106, 0149, 0227.



Yamaguchi Fig. 8 (Example 3)



Yamaguchi Fig. 10 (Example 4)



Yin Fig. 1 (first embodiment)

A goal of Yamaguchi's invention is to miniaturize the pickup lens to address the need for further miniaturization. Ex.1006 ¶¶ 0005, 0008. One measure of the pickup lens's length is the axial distance between the object-side surface of the first lens element and the image-side surface of the fourth lens element. Ex.1007 ¶ 229. This can be calculated by summing the D values in Yamaguchi's Table 9 (Example 3) and 13 (Example 4) for surfaces 1–7. *Id.* The length is 5.56 mm in Example 3 and 4.57 mm in Example 4. *Id.*

TABLE 9

(Example 3)
f = 5.309 mm, fB = 0.511 mm, F = 2.88, 2Y = 6.48 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.00		
1	3.227	1.27	1.69680	55.5
2	−87.050	0.44		
3	−3.364	1.40	1.52500	56.0
4	−1.626	0.35		
5	−1.021	0.90	1.58300	30.0
6	−2.147	0.10		
7	2.462	1.10	1.52500	56.0
8	2.283	1.00		
9	∞	0.30	1.51633	64.1
10	∞			

TABLE 13

(Example 4)
f = 3.952 mm, fB = 0.437 mm, F = 2.88, 2Y = 4.76 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.05		
1	3.913	0.93	1.69680	55.5
2	346.379	0.18		
3	−20.920	1.20	1.52500	56.0
4	−1.410	0.32		
5	−0.566	0.80	1.58300	30.0
6	−1.702	0.10		
7	1.248	1.04	1.52500	56.0
8	2.707	0.75		
9	∞	0.30	1.51633	64.1
10	∞	0.20		
11	∞	0.40	1.51633	64.1
12	∞			

Similarly, Yu discloses a lens assembly "developed toward a trend of being compact and having thin dimensions" driven by "continuous improvement of electronic products, [and] a tendency toward compact design." Ex.1003, 1:19–24. The same axial distance can be calculated for Yu's first embodiment using Table 1 by summing the thickness/interspace values for the object-side surface 111 through the object-side surface 141, and it equals 1.705 mm. Ex.1007 ¶ 230.

TABLE I

First preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Non-adjustable diaphragm 2		∞	−0.03			
First lens 11	Object-side surface 111	1.361	0.284	1.535	56.07	2.19
	Image-side surface 112	−8.119	0.194			

TABLE I-continued

First preferred embodiment

Component/ Surface		Radius of curvature	Thickness/ Interspace	Refractive index	Abbe number	Focal length (mm)
Second lens 12	Object-side surface 121	−2.042	0.368	1.535	56.07	2.05
	Image-side surface 122	−0.760	0.159			
Third lens 13	Object-side surface 131	−0.289	0.190	1.636	23.89	−1.16
	Image-side surface 132	−0.596	0.038			
Fourth lens 14	Object-side surface 141	0.488	0.472	1.535	56.07	1.52
	Image-side surface 142	0.805	0.25			
Filter lens 3	Object-side surface 31	∞	0.21	1.517	64.17	
	Image-side surface 32	∞	0.332			

Yu's distance is 30.67% of Yamaguchi's Example 3 and 37.31% of Yamaguchi's Example 4. *Id.* ¶ 231. Yu's reduced dimensions means that it focuses on a smaller sensor. *Id.* Reduced sensor size is a long-known trend in photography, and smaller sensors require smaller lens assemblies. *Id.* ¶¶ 232–33; Ex.1003, 1:19–24; Ex.1006 ¶ 0005. A range of sensors sizes would have been known to a POSITA at the time of the '796 patent, as demonstrated by the range supported by Yamaguchi's Examples 3 and 4 and Yu's first embodiment. Ex.1007 ¶ 233.

> A lens prescription can be scaled to any desired focal length simply by multiplying all of its dimensions by the same constant. All of its linear aberration measures will then be scaled by the same factor.

Ex.1016, 96. Ten-plus years elapsed between the designs of Yamaguchi and Yu, so the smaller dimensions of Yu's design are expected in light of the trend toward smaller designs. Ex.1007 ¶ 233.

It would have been obvious at the time of the '796 patent to start with Yamaguchi's Example 3 or 4 and then adjust the design to support a smaller sensor. *Id.* ¶ 234. A POSITA would know that a geometric lens design may be scaled easily and as necessary to make the design useful for a larger or smaller sensor by scaling all of the dimensions by the same numerical ratio, and the aspheric coefficients by that ratio raised to the appropriate power. *Id.* This scaling is so common and important that it is incorporated as function in software. *Id.*; Ex.1008, 29–31; Ex.1009, 247; Ex.1010, 227–28. Since Yu's first embodiment is 30.67% the size of Yamaguchi's Example 3 and 37.31% of Yamaguchi's Example 4, it would have been obvious to scale the dimensions of Yamaguchi's examples by the same or a lesser amount. Ex.1007 ¶ 235. For example, it would have been obvious to scale the dimensions of Yamaguchi's Example 3 to 40% of their original size and Example 4 to 49% of their original size. *Id.* Doing so changes Example 3's axial distance to 2.224 mm and Example 4's axial distance to 2.2393 mm. *Id.* After scaling, the refractive index and Abbe numbers of the lenses, the angles at which

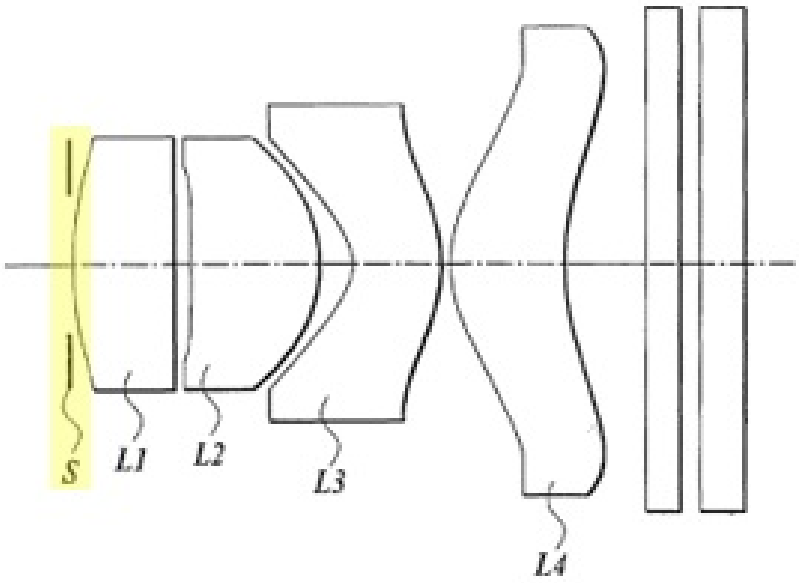
light rays are refracted at each lens, the f-number, and the HFOV remain unchanged. *Id.* The lens focal lengths scale by the same factor, but the optical aberrations will remain optically corrected. *Id.*

This scaling amounts to the application of a known technique to a known device ready for improvement to yield predictable results and would have been obvious to try with a reasonable expectation of success. *Id.* ¶ 236. Further there are express teachings in both references regarding smaller sensors requiring smaller lens assemblies. *Id.*; Ex.1003, 1:19–24; Ex.1006 ¶ 0005.

2. Adjusting Yamaguchi's F-Number is Obvious.

The f-number of a lens system equals the focal length divided by the entrance pupil diameter. Ex.1007 ¶ 238. Yamaguchi discloses "a stop," which "has a function for determining the F number of the whole image pickup lens." Ex.1006 ¶¶ 0127, 0129. In Example 4, it is to the left of the first lens L1, so the diameter of its opening is the entrance pupil of the lens system. *Id.* ¶ 0186, Fig. 10; Ex.1007 ¶¶ 238–240.

FIG.10



The f-number of Yamaguchi's Example 4 is 2.88. Ex.1006 ¶¶ 0157, 0186.

TABLE 13

(Example 4)
f = 3.952 mm, fB = 0.437 mm, F = 2.88, 2Y = 4.76 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.05		
1	3.913	0.93	1.69680	55.5
2	346.379	0.18		
3	−20.920	1.20	1.52500	56.0
4	−1.410	0.32		
5	−0.566	0.80	1.58300	30.0
6	−1.702	0.10		
7	1.248	1.04	1.52500	56.0
8	2.707	0.75		
9	∞	0.30	1.51633	64.1
10	∞	0.20		
11	∞	0.40	1.51633	64.1
12	∞			

At the time of the '796 patent, it would have been obvious to increase the size of the diameter of the opening in the stop S in Yamaguchi's Example 4 and reduce the f-number. Ex.1007 ¶ 241. As discussed in Section VII.A.17, it is common for

lens designers to adjust classic designs to satisfy present design specifications, which include the f-number. *Id.* ¶ 242. As discussed in Section VII.A.17, there is a tradeoff when selecting an f-number between light-gathering ability and sharpness, but in certain applications, light-gathering ability is more important than maintaining the fullest sharpness of the image. *Id.* Also, a low f-number may be desired "in order to prevent the deterioration of image quality due to noise in photographing in dark places." *Id.*; Ex.1011 ¶ 0005. The tradeoff between light-gathering and sharpness has been known as long as photographers have used classic cameras with manual aperture adjustment. Ex.1007 ¶ 243.

To increase the light-gathering ability of Yamaguchi's Example 4, increasing the entrance pupil size is an obvious starting point. *Id.* ¶ 244. A lens designer always considers the size of the entrance pupil because it determines the how sensitive the system will be for low-light operation. *Id.* Yamaguchi discloses that "the stop S has a function for determining an F number of the whole image pickup lens." Ex.1006 ¶ 0129. Increasing the diameter of the opening in Yamaguchi's stop S increases the entrance pupil because it is to the left of the first lens in Example 4. Ex.1007 ¶ 244.

Yamaguchi discloses that Example 4's focal length is 3.952 mm, so the diameter of the opening in the stop is 1.372 mm. Ex.1006 ¶ 0155, 0186; Ex.1007 ¶¶ 245–46.

TABLE 13

(Example 4)
f = 3.952 mm, fB = 0.437 mm, F = 2.88, 2Y = 4.76 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.05		
1	3.913	0.93	1.69680	55.5
2	346.379	0.18		
3	−20.920	1.20	1.52500	56.0
4	−1.410	0.32		
5	−0.566	0.80	1.58300	30.0
6	−1.702	0.10		
7	1.248	1.04	1.52500	56.0
8	2.707	0.75		
9	∞	0.30	1.51633	64.1
10	∞	0.20		
11	∞	0.40	1.51633	64.1
12	∞			

Increasing the opening by 28.3% to 1.76 mm changes the f-number to 2.245. Ex.1007 ¶ 246. Such a slight modification would have been obvious and typical in the design process at the time of the '796 patent. *Id.* Section VII.A.17 explained that lens assemblies with f-numbers in the recited range of claims 5 and Element 21f, such as Okano (Ex.1011) and Sugiyama (Ex.1013), were known before the '796 patent. *Id.* ¶ 247. Scaling the dimensions of Yamaguchi's Example 4 to support a smaller sensor, as discussed in Section VII.B.1, does not affect the f-number because the focal length and entrance pupil scale by the same factor. *Id.* ¶ 248.

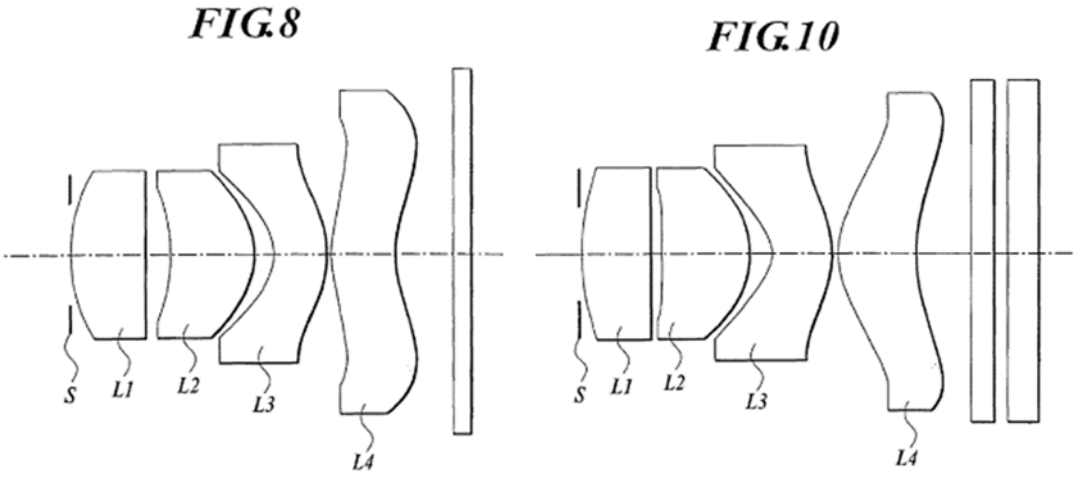
While enlarging the diameter of the opening in stop S may degrade sharpness, this is acceptable in certain applications. *Id.* ¶ 249. Further refinements to the lens system might reduce this degradation, but the '796 patent's claims do not recite any limitations regarding image quality. *Id.*

Adjusting the diameter of the opening in the stop S in Yamaguchi's Example 4 amounts to the simple substitution of one known element for another to obtain predictable results, a predictable use of prior art elements according to their established functions, and applying a known technique to a known device to yield predictable results with reasonable expectation of success. *Id.* ¶ 250.

3. Claim 1

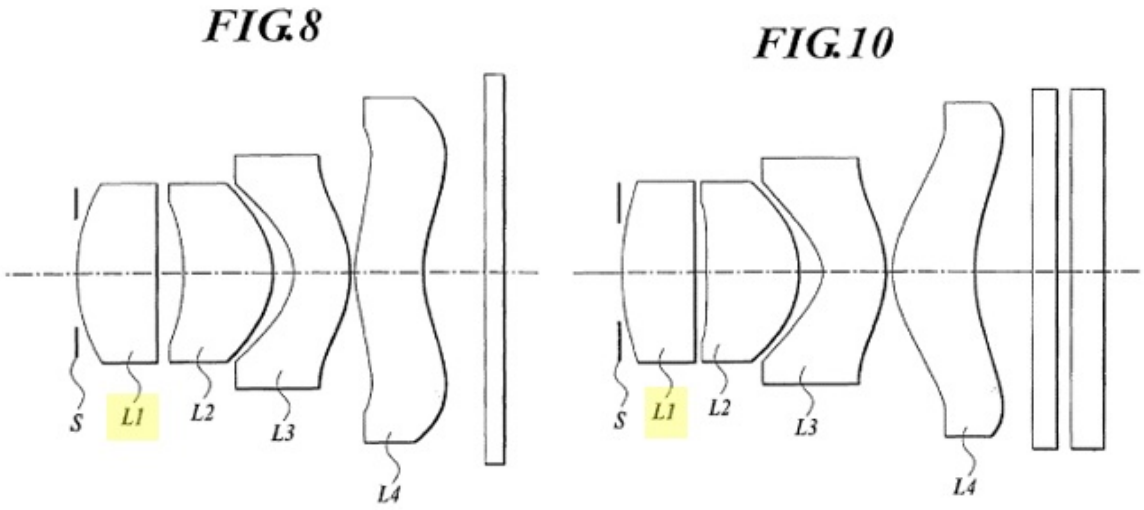
(a) Preamble

Yamaguchi discloses "an image pickup lens comprising four lenses arranged in an order of a first lens, a second lens, a third lens, and a fourth lens from an object side." Ex.1006 ¶¶ 0002, 0008–0009, 0011, 0051, 0059. Figs. 8 (Example 3) and 10 (Example 4) show section views of "a small-sized image pickup lens." *Id.* ¶¶ 0115, 0117. To the extent the preamble is limiting, Yamaguchi's pickup lens is "[a]n image capturing lens system." Ex.1007 ¶¶ 251–52.



(b) Element 1a

In order from the object side to the image side, Yamaguchi's pickup lens comprises first a "first lens L1." Ex.1006 ¶ 0191, Figs. 8, 10. Yamaguchi discloses that "the first lens has positive refractive power." *Id.* ¶¶ 0010, 0052. Yamaguchi's first lens L1 is a "first lens element having refractive power." Ex.1007 ¶¶ 253–54.



(c) Element 1b

After the first lens L1, from the object side to image side in Yamaguchi's pickup lens is a "second lens L2." Ex.1006 ¶ 0191, Figs. 8, 10. Yamaguchi discloses that "the second lens has … positive refractive power." *Id.* ¶ 0010. Figs. 8 (Example 3) and 10 (Example 4) show that the second lens L2 has positive refractive power, because it is thicker in the paraxial region. Ex.1007 ¶ 256.

FIG.8

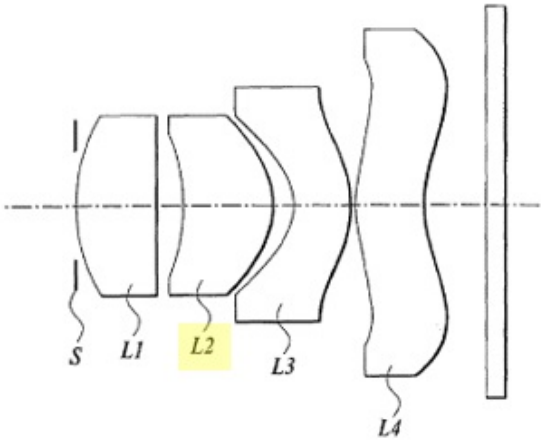
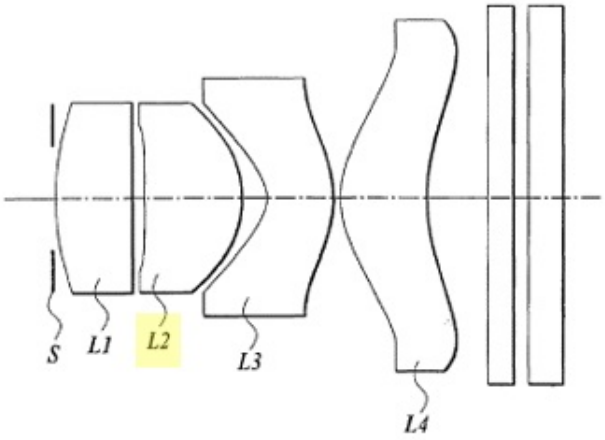


FIG.10



Tables 9 (Example 3) and 13 (Example 4) list the radius of curvature (R) for the lens surfaces. Ex.1006 ¶¶ 0154, 0159, 0179, 0186. The radius of the image-side surface of the second lens L2 (4) is -1.626 mm in Example 3 and -1.410 mm in Example 4, which denotes a convex surface in the paraxial region, as shown in Figs. 8 and 10. *Id.* ¶¶ 0179, 0186; Ex.1007 ¶ 257.

TABLE 9

(Example 3)
f = 5.309 mm, fB = 0.511 mm, F = 2.88, 2Y = 6.48 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.00		
1	3.227	1.27	1.69680	55.5
2	−87.050	0.44		
3	−3.364	1.40	1.52500	56.0
4	−1.626	0.35		
5	−1.021	0.90	1.58300	30.0
6	−2.147	0.10		
7	2.462	1.10	1.52500	56.0
8	2.283	1.00		
9	∞	0.30	1.51633	64.1
10	∞			

TABLE 13

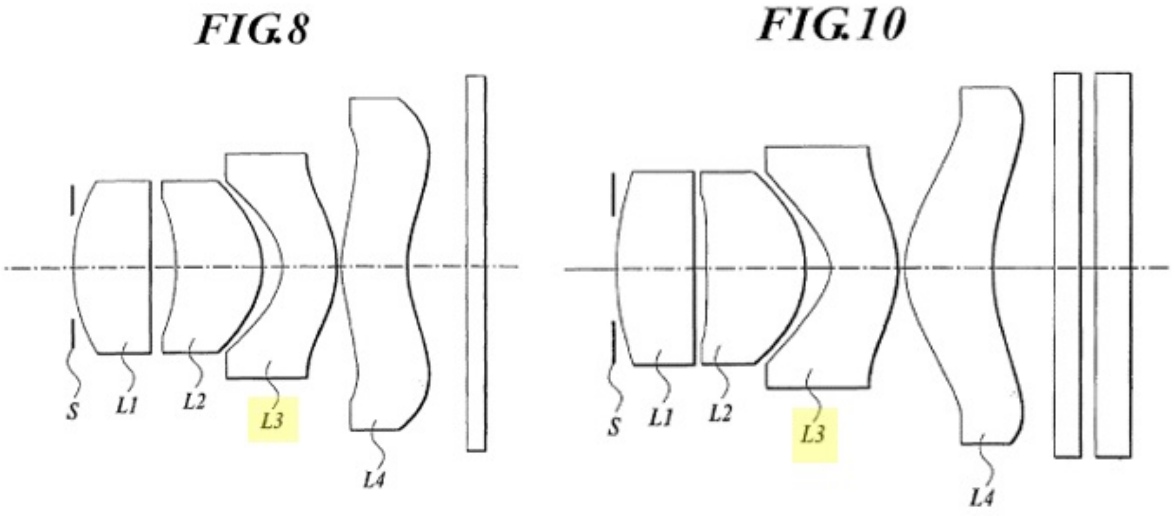
(Example 4)
f = 3.952 mm, fB = 0.437 mm, F = 2.88, 2Y = 4.76 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.05		
1	3.913	0.93	1.69680	55.5
2	346.379	0.18		
3	−20.920	1.20	1.52500	56.0
4	−1.410	0.32		
5	−0.566	0.80	1.58300	30.0
6	−1.702	0.10		
7	1.248	1.04	1.52500	56.0
8	2.707	0.75		
9	∞	0.30	1.51633	64.1
10	∞	0.20		
11	∞	0.40	1.51633	64.1
12	∞			

Yamaguchi's second lens L2 is a "second lens element with positive refractive power having a convex image-side surface in a paraxial region thereof." Ex.1007 ¶¶ 255–57.

(d) Element 1c

After the second lens L2, from the object side to image side in Yamaguchi's pickup lens is a "third lens L3." Ex.1006 ¶ 0191, Figs. 8, 10. Yamaguchi discloses that "the third lens has negative refractive power and has a concave surface facing toward the object side to be formed in a meniscus shape." *Id.* ¶ 0010. A meniscus-shaped lens has a convex surface on one side and a concave surface on the other, so the image-side surface of the third lens L3 is convex in the paraxial region. Ex.1007 ¶ 259.



Figs. 8 and 10 show that the third lens L3 has negative refractive power, because it is thinner in the paraxial region. *Id.* They also show that the object-side surface of the third lens L3 is concave because it protrudes inward and the image-side surface is convex because it protrudes outward. *Id.* ¶¶ 35, 259.

Tables 9 and 13 list a negative radius of curvature (-1.021 mm in Example 3 and -0.566 mm in Example 4) for the object-side surface of the third lens L3 (5) and a negative radius of curvature (-2.147 mm in Example 3 and -1.702 mm in Example 4) for the image-side surface of the third lens L3 (6), which confirms that the object-side is concave in the paraxial region and the image-side is convex in the paraxial region. *Id.* ¶ 260; Ex.1006 ¶¶ 0179, 0186.

TABLE 9

(Example 3)
f = 5.309 mm, fB = 0.511 mm, F = 2.88, 2Y = 6.48 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.00		
1	3.227	1.27	1.69680	55.5
2	−87.050	0.44		
3	−3.364	1.40	1.52500	56.0
4	−1.626	0.35		
5	−1.021	0.90	1.58300	30.0
6	−2.147	0.10		
7	2.462	1.10	1.52500	56.0
8	2.283	1.00		
9	∞	0.30	1.51633	64.1
10	∞			

TABLE 13

(Example 4)
f = 3.952 mm, fB = 0.437 mm, F = 2.88, 2Y = 4.76 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.05		
1	3.913	0.93	1.69680	55.5
2	346.379	0.18		
3	−20.920	1.20	1.52500	56.0
4	−1.410	0.32		
5	−0.566	0.80	1.58300	30.0
6	−1.702	0.10		
7	1.248	1.04	1.52500	56.0
8	2.707	0.75		
9	∞	0.30	1.51633	64.1
10	∞	0.20		
11	∞	0.40	1.51633	64.1
12	∞			

Yamaguchi's third lens L3 is "a third lens element with negative refractive power having a concave object-side surface in a paraxial region thereof and a convex image-side surface in a paraxial region thereof." Ex.1007 ¶¶ 258–60.

(e) Element 1d

After the third lens L3, from the object side to image side in Yamaguchi's pickup lens is a "fourth lens L4." Ex.1006 ¶ 0191, Figs. 8, 10. Yamaguchi discloses that "the fourth lens has … positive or negative refractive power and has a convex surface facing toward the object side to be formed in the meniscus shape." *Id.* ¶ 0010. A meniscus-shaped lens has a convex surface on one side and a concave surface on the other, so the image-side surface of the fourth lens L4 is concave in the paraxial region. Ex.1007 ¶ 262. Figs. 8 and 10 show that the image-side surface of the fourth lens L4 is concave because it protrudes inward. *Id.* ¶¶ 35, 262.

FIG.8

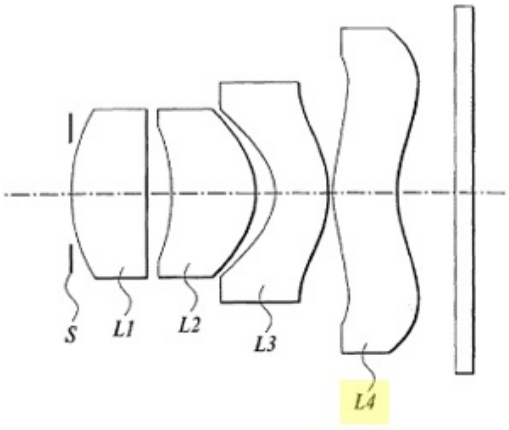
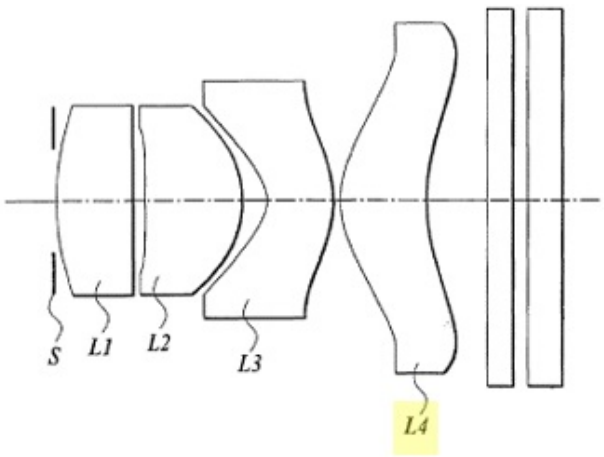


FIG.10



Tables 9 (Example 3) and 13 (Example 4) list a positive radius for the image-side surface of the fourth lens L4 (8), which confirms that the surface is concave in the paraxial region. *Id.* ¶ 263; Ex.1006 ¶¶ 0179, 0186.

TABLE 9

(Example 3)
f = 5.309 mm, fB = 0.511 mm, F = 2.88, 2Y = 6.48 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.00		
1	3.227	1.27	1.69680	55.5
2	−87.050	0.44		
3	−3.364	1.40	1.52500	56.0
4	−1.626	0.35		
5	−1.021	0.90	1.58300	30.0
6	−2.147	0.10		
7	2.462	1.10	1.52500	56.0
8	2.283	1.00		
9	∞	0.30	1.51633	64.1
10	∞			

TABLE 13

(Example 4)
f = 3.952 mm, fB = 0.437 mm, F = 2.88, 2Y = 4.76 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.05		
1	3.913	0.93	1.69680	55.5
2	346.379	0.18		
3	−20.920	1.20	1.52500	56.0
4	−1.410	0.32		
5	−0.566	0.80	1.58300	30.0
6	−1.702	0.10		
7	1.248	1.04	1.52500	56.0
8	2.707	0.75		
9	∞	0.30	1.51633	64.1
10	∞	0.20		
11	∞	0.40	1.51633	64.1
12	∞			

Yamaguchi's fourth lens L4 is "a fourth lens element with refractive power having a concave image-side surface in a paraxial region." Ex.1007 ¶¶ 262–63.

Yamaguchi discloses that "the image side surface of the fourth lens is formed in the aspherical surface shape satisfying the formulas (14), (15) and (16)." Ex.1006

¶¶ 0054–0056, 0062. This is visible in Figs. 8 and 10. Ex.1007 ¶ 264. Yamaguchi discloses a version of this formula using "a rectangular coordinate system" and lists the aspheric coefficients in Tables 10 (Example 3) and 14 (Example 4). Ex.1006 ¶¶ 0163–0165, 0180, 0187. Tables 10 and 14 show that the object- (7) and image-side (8) surfaces of the fourth lens L4 are aspheric in Examples 3 and 4 because they provide aspheric coefficients for those surfaces. *Id.* ¶¶ 0180, 0187; Ex.1007 ¶ 264.

TABLE 10

Coefficients of aspherical surface

Third surface

K = −3.69470
A4 = −2.00408 × 10^{-2}
A6 = 5.93561 × 10^{-3}
A8 = 5.22016 × 10^{-4}
A10 = −2.38137 × 10^{-4}

Fourth surface

K = −8.46375 × 10^{-1}
A4 = −2.02564 × 10^{-2}
A6 = 1.62756 × 10^{-2}
A8 = −4.14965 × 10^{-3}
A10 = 6.66591 × 10^{-4}

Fifth surface

K = −8.10560 × 10^{-1}
A4 = 6.31710 × 10^{-2}
A6 = 4.14530 × 10^{-4}
A8 = 4.30470 × 10^{-5}
A10 = −2.38210 × 10^{-5}
A12 = 3.81300 × 10^{-4}

Sixth surface

K = −4.69690 × 10^{-1}
A4 = 1.50160 × 10^{-2}
A6 = 9.94400 × 10^{-3}
A8 = −2.33050 × 10^{-3}
A10 = 3.92580 × 10^{-4}
A12 = −2.86340 × 10^{-5}

Seventh surface

K = −8.06986
A4 = −1.22203 × 10^{-2}
A6 = −1.10253 × 10^{-3}
A8 = 2.97022 × 10^{-4}
A10 = −1.61617 × 10^{-5}
A12 = −1.33104 × 10^{-6}

Eight surface

K = −4.95420
A4 = −1.49047 × 10^{-2}
A6 = 7.29589 × 10^{-4}
A8 = −2.84963 × 10^{-4}
A10 = 4.02284 × 10^{-5}
A12 = −2.14994 × 10^{-6}

TABLE 14-continued

Coefficients of aspherical surface

A10 = −1.69526 × 10^{-1}
A12 = 5.93581 × 10^{-2}

Fourth surface

K = −3.64290
A4 = −7.87313 × 10^{-2}
A6 = −8.13418 × 10^{-2}
A8 = 6.89382 × 10^{-2}
A10 = −1.35061 × 10^{-2}
A12 = −1.46313 × 10^{-3}

Fifth surface

K = −2.20465
A4 = −1.19476 × 10^{-1}
A6 = 1.02295 × 10^{-1}
A8 = −4.96877 × 10^{-2}
A10 = 3.08960 × 10^{-2}
A12 = −8.23237 × 10^{-3}

Sixth surface

K = −1.11107
A4 = 3.10033 × 10^{-2}
A6 = 2.14144 × 10^{-2}
A8 = −2.26865 × 10^{-3}
A10 = −1.88014 × 10^{-3}
A12 = 4.46605 × 10^{-4}

Seventh surface

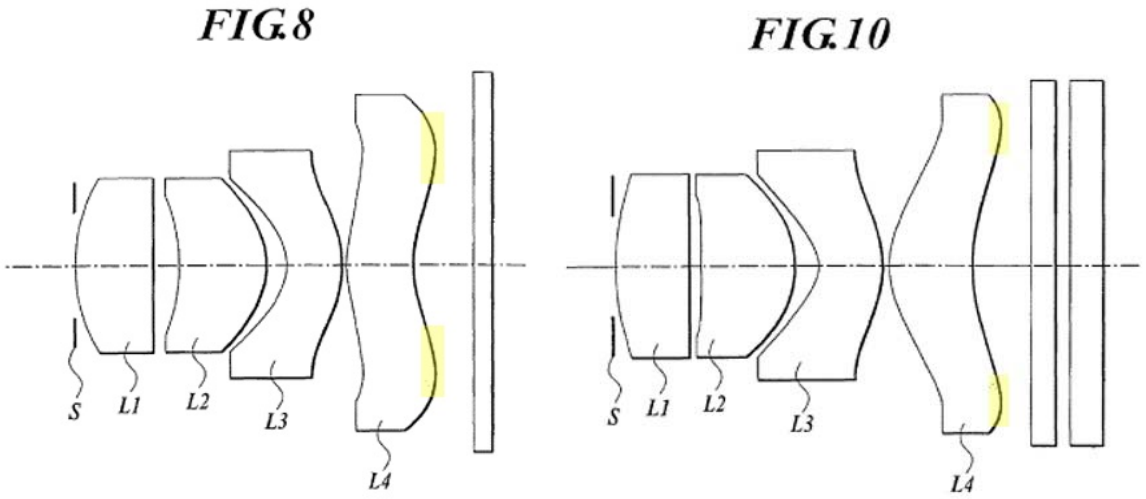
K = −4.23704
A4 = −8.16271 × 10^{-4}
A6 = 1.75735 × 10^{-3}
A8 = −1.91328 × 10^{-3}
A10 = 4.88327 × 10^{-4}
A12 = −5.69413 × 10^{-5}

Eighth surface

K = −8.14983 × 10^{-1}
A4 = −2.99336 × 10^{-2}
A6 = 4.55187 × 10^{-3}
A8 = −1.39696 × 10^{-3}
A10 = 1.81788 × 10^{-4}
A12 = −1.40282 × 10^{-5}

Yamaguchi's fourth lens L4 is "a fourth lens element … wherein both of an object-side surface and the image-side surface of the fourth lens element are aspheric." Ex.1007 ¶ 264.

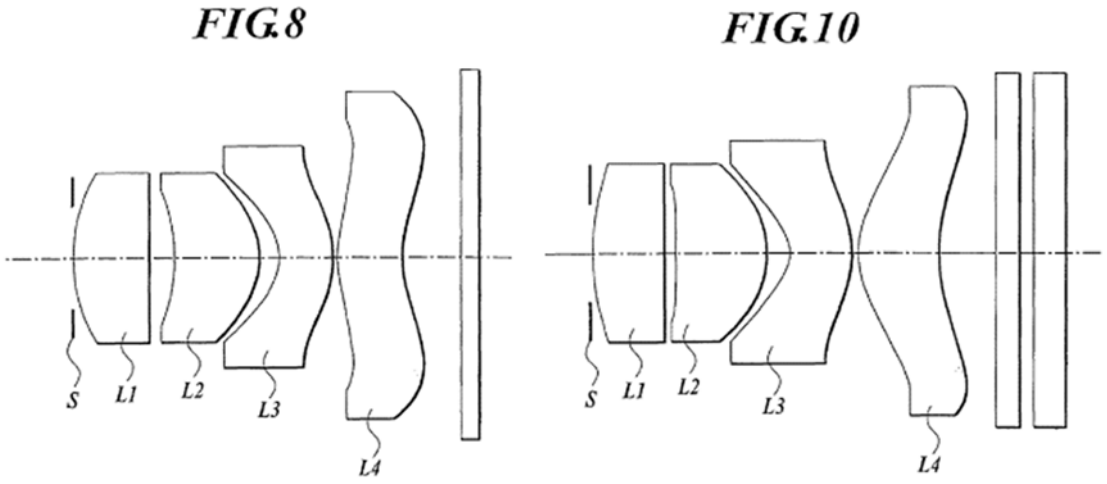
Figs. 8 and 10 show the shape of the fourth lens L4 in Yamaguchi's Examples 3 and 4. Ex.1006 ¶¶ 0182, 0184, 0189, 0191. They show that the image-side surface of the fourth lens L4 has "has at least one convex shape in an off-axis region," which is highlighted below. Ex.1007 ¶ 265.



Yamaguchi's fourth lens L4 is "a fourth lens element … wherein … the image-side surface of the fourth lens element has at least one convex shape in an off-axis region thereof." *Id.* Yamaguchi's fourth lens L4 is the "fourth lens element" of Element 1d. *Id.* ¶¶ 261–66.

(f) Element 1e

Yamaguchi discloses that its pickup lens "has a total of four lens elements with refractive power," i.e., the first lens L1, second lens L2, third lens L3, and fourth lens L4 discussed above. *E.g.*, Ex.1006 ¶¶ 0009–0010, Figs. 8, 10. There are no additional lens elements with refractive power. Ex.1007 ¶ 268. Yamaguchi discloses Element 1e. *Id.* ¶¶ 267–68.



(g) Element 1f

Yamaguchi's Tables 9 (Example 3) and 13 (Example 4) list the "interval between refractive surfaces" (D). Ex.1006 ¶¶ 0154, 0160, 0179, 0186. To determine the "axial distance between an object-side surface of the first lens element and the image-side surface of the fourth lens element … Td," one sums the D values for Surface Nos. 1–7, which equals 5.56 mm in Example 3 and 4.57 mm in Example 4. *Id.* ¶¶ 0179, 0186; Ex.1007 ¶ 270.

Section VII.B.1 explains why it would have been obvious to scale the dimensions of Yamaguchi's pickup lens. Ex.1007 ¶ 271. Yamaguchi's Example 3 can be scaled to 40% of its original size, such that Td equals 2.224 mm, and Yamaguchi's Example 4 can be scaled to 49% of its original size, such that Td equals 2.2393 mm. *Id.* Both values satisfy the condition "0.5 mm<Td<3.2 mm." *Id.*

Yamaguchi discloses 2Y, which "denotes the length of a diagonal line on an effective image screen" for each embodiment. Ex.1006 ¶¶ 0015, 0022, 0073, 0158. In Example 3, "2Y = 6.48 mm." *Id.* ¶ 0179. Thus, Y is 3.24 mm. Ex.1007 ¶ 272. For Example 3, "f = 5.309 mm," where f is the "focal length of the whole image pickup lens." Ex.1006 ¶¶ 0154–0155, 0179. HFOV for Example 3 can be calculated because Y/f = tan(HFOV). Ex.1007 ¶ 272. HFOV equals atan(3.24 mm/5.309 mm), which equals 31.396 degrees. *Id.* ¶ 273. HFOV remains the same when the dimensions of the pickup lens are scaled. *Id.* Accordingly, Td/tan(HFOV) when Example 3 is scaled equals 3.644 mm and satisfies the condition "1.0 mm<Td/tan(HFOV)<3.75 mm." *Id.*

In Example 4, "2Y = 4.76 mm." Ex.1006 ¶ 0186. Thus, Y is 2.38 mm. Ex.1007 ¶ 274. For Example 4, "f = 3.952 mm." Ex.1006 ¶ 0186. Performing the same calculations, HFOV for Example 4 equals atan(2.38 mm/3.952 mm), which equals 31.057 degrees. Ex.1007 ¶ 274. This remains unchanged when the dimensions are scaled. *Id.* Accordingly, Td/tan(HFOV) when Example 4 is scaled equals 3.7184 mm and satisfies the condition "1.0 mm<Td/tan(HFOV)<3.75 mm." *Id.*

In Yamaguchi's Example 3, "f = 5.309 mm." Ex.1006 ¶ 0179. The other focal lengths can be calculated using the data in Table 9: f2 equals 4.6932 mm, f3 equals -4.7323 mm, and f4 equals 53.6144 mm. Ex.1007 ¶¶ 275–76.

In Yamaguchi's Example 4, "f = 3.952 mm." Ex.1006 ¶ 0186. Using the data in Table 13: f2 equals 2.8201 mm, f3 equals -1.9639 mm, and f4 equals 3.5414 mm. Ex.1007 ¶ 277.

Using the values of f and f4 above, |f/f4| equals 0.099 in Example 3 and 1.116 in Example 4, which both satisfy the condition "|f/f4|<1.20." *Id.* ¶ 278. Using the values of f2 and f3 above, f2/f3 equals -0.9917 in Example 3 and -1.436 in Example 4, which both satisfy the condition "f2/f3<-0.65." *Id.* These ratios are unaffected when the dimensions of the pickup lens are scaled. *Id.*

Yamaguchi in view of Yu renders Element 1f and claim 1 obvious. *Id.* ¶¶ 269–80.

4. Claim 2

Yamaguchi discloses that "the fourth lens … has a convex surface facing toward the object side." Ex.1006 ¶ 0010, Fig. 10. Yamaguchi's Table 13 (Example 4) lists the radius of the object-side surface of the fourth lens L4 (7) as 1.248 mm. *Id.* ¶ 0186. The positive radius for the object-side surface of the fourth lens L4 discloses a convex object-side surface in the paraxial region. Ex.1007 ¶ 282.

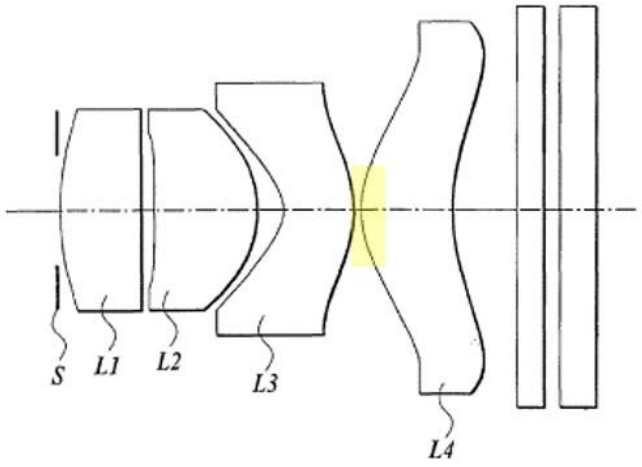
TABLE 13

(Example 4)
f = 3.952 mm, fB = 0.437 mm, F = 2.88, 2Y = 4.76 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.05		
1	3.913	0.93	1.69680	55.5
2	346.379	0.18		
3	−20.920	1.20	1.52500	56.0
4	−1.410	0.32		
5	−0.566	0.80	1.58300	30.0
6	−1.702	0.10		
7	1.248	1.04	1.52500	56.0
8	2.707	0.75		
9	∞	0.30	1.51633	64.1
10	∞	0.20		
11	∞	0.40	1.51633	64.1
12	∞			

Yamaguchi's Fig. 10 shows that the object-side surface of the fourth lens L4 is convex because it protrudes outward in the paraxial region. *Id.* The convex shape of this surface is unaffected when the dimensions of the pickup lens are scaled. *Id.*

FIG.10



Yamaguchi discloses that "the fourth lens element has the object-side surface being convex in a paraxial region," and Yamaguchi in view of Yu renders claim 2 obvious. *Id.* ¶¶ 281–83.

5. Claim 3

In Yamaguchi's Example 4, "f=3.952 mm." Ex.1006 ¶ 0186. Using the data in Table 13 (Example 4), f1 can be calculated and equals 5.6984 mm. Ex.1007 ¶¶ 285–86. Using these values, f/f1 equals 0.6935 in Example 4, which satisfies the condition "-0.25<f/f1<0.75." *Id.* ¶ 286. This ratio is unaffected when the dimensions of the pickup lens are scaled. *Id.* Yamaguchi in view of Yu renders claim 3 obvious. *Id.* ¶¶ 284–87.

6. Claim 4

Section VII.B.3(g) explains that Td equals 2.2393 mm when the dimensions of Yamaguchi's Example 4 are scaled, which satisfies the condition "0.8 mm<Td<2.5 mm." *Id.* ¶ 289. Yamaguchi in view of Yu renders claim 4 obvious. *Id.* ¶¶ 288–90.

7. Claim 5

As explained in Section VII.B.2, it would have been obvious to enlarge the entrance pupil of Example 4 of Yamaguchi's pickup lens. As explained in that section, enlarging it by 28.3% to 1.76 mm changes the f-number to 2.245, which satisfies the condition "1.40<Fno≤2.25." *Id.*¶ 292. Yamaguchi in view of Yu renders claim 5 obvious. *Id.* ¶¶ 291–93.

8. Claim 6

Yamaguchi's Table 13 (Example 4) lists the radius of the object-side surface (3) of the second lens L2 ("R3") as -20.920 mm and the radius of the image-side surface (4) of the second lens L2 ("R4") as -1.410 mm. Ex.1006 ¶ 0186.

TABLE 13

(Example 4)
f = 3.952 mm, fB = 0.437 mm, F = 2.88, 2Y = 4.76 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.05		
1	3.913	0.93	1.69680	55.5
2	346.379	0.18		
3	−20.920	1.20	1.52500	56.0
4	−1.410	0.32		
5	−0.566	0.80	1.58300	30.0
6	−1.702	0.10		
7	1.248	1.04	1.52500	56.0
8	2.707	0.75		
9	∞	0.30	1.51633	64.1
10	∞	0.20		
11	∞	0.40	1.51633	64.1
12	∞			

With these numbers, (R3+R4)/(R3-R4) equals 1.1445, which satisfies the condition "0.5<(R3+R4)/(R3-R4)<2.5." Ex.1007 ¶ 295. This ratio is unaffected when the dimensions of the pickup lens are scaled. *Id.* Yamaguchi in view of Yu renders claim 6 obvious. *Id.* ¶¶ 294–96.

9. Claim 7

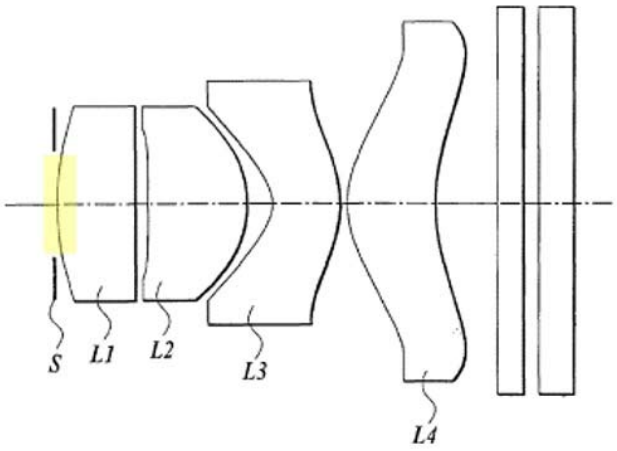
In Yamaguchi's Example 4, "f = 3.952 mm." Ex.1006 ¶ 0186. This focal length scales proportionally to the other dimensions of Yamaguchi's Example 4. Ex.1007 ¶ 298. When Example 4 is scaled to 49% of its original size, as discussed in Sections VII.B.1 and VII.B.3(g), f also scales to 49% of its original value, so that

it equals 1.9365 mm, which satisfies the condition "0.5 mm<f<2.0 mm." *Id.* Yamaguchi in view of Yu renders claim 7 obvious. *Id.* ¶¶ 297–99.

10. Claim 8

Yamaguchi discloses that "the first lens … has a convex surface facing toward the object side." Ex.1006 ¶ 0010, Fig. 10; Ex.1007 ¶ 301.

FIG. 10



Yamaguchi's Table 13 (Example 4) lists the radius of the object-side surface of the first lens L1 (1) as 3.913 mm, which denotes a convex object-side surface in a paraxial region of the first lens L1. *Id.* ¶ 302; Ex.1006 ¶ 0186. The shape of this surface remains convex when the dimensions of the pickup lens are scaled. Ex.1007 ¶ 303.

TABLE 13

(Example 4)
f = 3.952 mm, fB = 0.437 mm, F = 2.88, 2Y = 4.76 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.05		
1	3.913	0.93	1.69680	55.5
2	346.379	0.18		
3	−20.920	1.20	1.52500	56.0
4	−1.410	0.32		
5	−0.566	0.80	1.58300	30.0
6	−1.702	0.10		
7	1.248	1.04	1.52500	56.0
8	2.707	0.75		
9	∞	0.30	1.51633	64.1
10	∞	0.20		
11	∞	0.40	1.51633	64.1
12	∞			

Yamaguchi discloses that "the first lens element has a convex object-side surface in a paraxial region thereof," and Yamaguchi in view of Yu renders claim 8 obvious. *Id.* ¶¶ 300–304.

11. Claim 9

Section VII.B.3(g) explains that Td equals 4.57 mm and HFOV equals 31.057 degrees in Yamaguchi's Example 4. Thus, Td/tan(HFOV) equals 7.5886 mm. *Id.* ¶ 306. Section VII.B.1 explains that it would have been obvious to scale the dimensions of Yamaguchi's pickup lens. When the dimensions of Example 4, including Td, are scaled, the value of HFOV remains the same. *Id.* Accordingly, when the dimensions of Yamaguchi's Example 4 are scaled down, the value of Td/tan(HFOV) will be scaled down proportionally. *Id.*

It would have been obvious to a POSITA to further scale Yamaguchi's Example 4 to 36% of its original size, which would result in Td equaling 1.6452 mm. *Id.* ¶ 307. The value of Td/tan(HFOV) for this scaled version of Yamaguchi's Example 4 is 2.732 mm, which satisfies the condition "1.2 mm<Td/tan(HFOV)<2.75 mm." *Id.* ¶ 308. This further scaling does not change the prior analysis for claims 1 or 8. *Id.* ¶¶ 309–12. The surface shapes remain convex or concave, the lens refractive powers remain the same, and surfaces that are aspheric remain aspheric no matter how much Example 4 is scaled. *Id.* ¶¶ 309–11. Td equals 1.6452 mm, which satisfies Element 1f's condition "0.5 mm<Td<3.2 mm." *Id.* ¶ 312. Td/tan(HFOV) equals 2.732 (1.6452 mm/tan(31.057°)), which satisfies Element 1f's condition "1.0 mm<Td/tan(HFOV)<3.75 mm." *Id.* ¶¶ 274, 312. The ratios |f/f4| and f2/f3 remain the same with further scaling and still satisfy Element 1f's conditions "|f/f4|<1.20" and "f2/f3>-0.65." *Id.* ¶ 312. Yamaguchi in view of Yu renders claim 9 obvious. *Id.* ¶¶ 305–13.

12. Claim 10

Yamaguchi's Table 13 lists the "interval between refractive surfaces" (D) for Example 4. Ex.1006 ¶¶ 0154, 0160, 0186. Section VII.B.3(g) explains that Td equals 4.57 mm for Yamaguchi's Example 4. Table 13 lists the center thickness of the first lens L1 as 0.93 mm, the center thickness of the second lens L2 as 1.20 mm,

the center thickness of the third lens L3 as 0.80 mm, and the center thickness of the fourth lens L4 is 1.04 mm. *Id.* ¶ 0186.

TABLE 13

(Example 4)
f = 3.952 mm, fB = 0.437 mm, F = 2.88, 2Y = 4.76 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.05		
1	3.913	0.93	1.69680	55.5
2	346.379	0.18		
3	−20.920	1.20	1.52500	56.0
4	−1.410	0.32		
5	−0.566	0.80	1.58300	30.0
6	−1.702	0.10		
7	1.248	1.04	1.52500	56.0
8	2.707	0.75		
9	∞	0.30	1.51633	64.1
10	∞	0.20		
11	∞	0.40	1.51633	64.1
12	∞			

Using these numbers, ∑CT equals 3.97 mm. Ex.1007 ¶ 316. Thus, ∑CT/Td equals 0.8687, which satisfies the condition "0.80<∑CT/Td<0.95." *Id.* This ratio is unaffected when the dimensions of the pickup lens are scaled. *Id.* Thus, Yamaguchi in view of Yu renders claim 10 obvious. *Id.* ¶¶ 314–17.

13. Claim 11

The Abbe number of the first lens L1 in Yamaguchi's Example 4 is 55.5. Ex.1006 ¶¶ 0154, 0162, 0186. This number is unaffected when the dimensions of Yamaguchi's Example 4 are scaled. Ex.1007 ¶ 319.

TABLE 13

(Example 4)
f = 3.952 mm, fB = 0.437 mm, F = 2.88, 2Y = 4.76 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.05		
1	3.913	0.93	1.69680	55.5
2	346.379	0.18		
3	−20.920	1.20	1.52500	56.0
4	−1.410	0.32		
5	−0.566	0.80	1.58300	30.0
6	−1.702	0.10		
7	1.248	1.04	1.52500	56.0
8	2.707	0.75		
9	∞	0.30	1.51633	64.1
10	∞	0.20		
11	∞	0.40	1.51633	64.1
12	∞			

Yamaguchi discloses that "an Abbe number of the first lens element is V1, and the following condition is satisfied: 45<V1," and Yamaguchi in view of Yu renders claim 11 obvious. *Id.* ¶¶ 318–20.

14. Claim 15

(a) Preamble and Elements 15a–15e

Claim 15's preamble and Elements 15a through 15e are identical to claim 1's preamble and Elements 1a through 1e. *Id.* ¶¶ 321–26. Thus, Sections VII.B.3(a)–(f) explain how Yamaguchi in view of Yu renders obvious claim 15's preamble and Elements 15a through 15e. *Id.*

(b) Element 15f

Section VII.B.3(g) explains why it would have been obvious to scale the dimensions of Yamaguchi's Example 3 such that the values of Td, Td/tan(HFOV),

and |f/f4| satisfy the first three conditions of Element 15f: "0.5 mm<Td<3.2 mm; 1.0 mm<Td/tan(HFOV)<3.75 mm; |f/f4|<1.20."

Yamaguchi discloses that "f = 5.309 mm" for Example 3. Ex.1006 ¶ 0179. Section VII.B.3(g) explains that f3 equals -4.7323 mm in Example 3. Accordingly, f/f3 equals -1.122 in Example 3, which satisfies the condition "-2.0<f/f3<-0.95." Ex.1007 ¶ 329. This ratio is unaffected when the dimensions of the pickup lens are scaled. *Id.*

Yamaguchi in view of Yu renders claim 15 obvious. *Id.* ¶¶ 327–30.

15. Claim 16

In Yamaguchi's Example 3, the Abbe number of the first lens L1 is "55.5." Ex.1006 ¶¶ 0154, 0162, 0179. This number is unaffected when the dimensions of Yamaguchi's Example 3 are scaled. Ex.1007 ¶ 332.

TABLE 9

(Example 3)
f = 5.309 mm, fB = 0.511 mm, F = 2.88, 2Y = 6.48 mm

Surface No.	R (mm)	D (mm)	Nd	vd
stop	∞	0.00		
1	3.227	1.27	1.69680	55.5
2	−87.050	0.44		
3	−3.364	1.40	1.52500	56.0
4	−1.626	0.35		
5	−1.021	0.90	1.58300	30.0
6	−2.147	0.10		
7	2.462	1.10	1.52500	56.0
8	2.283	1.00		
9	∞	0.30	1.51633	64.1
10	∞			

Yamaguchi discloses that "an Abbe number of the first lens element is V1, and the following condition is satisfied: 45<V1," and Yamaguchi in view of Yu renders claim 16 obvious. *Id.* ¶¶ 331–33.

16. Claim 19

Section VII.B.3(g) explains that Td equals 2.224 mm when Yamaguchi's Example 3 is scaled to 40% of its original size. This satisfies the condition "0.8 mm<Td<2.5 mm." *Id.* ¶ 335. Yamaguchi in view of Yu renders claim 19 obvious. *Id.* ¶¶ 334–36.

17. Claim 20

Section VII.B.3(g) explains that f2/f3 equals -0.9917 in Yamaguchi's Example 3 and that this ratio is unaffected when the dimensions of the pickup lens are scaled. *Id.* ¶ 338. This satisfies the condition "f2/f3<-0.75." *Id.* Yamaguchi in view of Yu renders claim 20 obvious. *Id.* ¶¶ 337–39.

18. Claim 21

(a) Preamble and Elements 21a–21e

Claim 21's preamble and Elements 21a through 21e are identical to claim 1's preamble and Elements 1a–1e. *Id.* ¶¶ 340–45. Thus, Sections VII.B.3(a)–(f) explain how Yamaguchi in view of Yu renders claim 21's preamble and Elements 21a through 21e obvious. *Id.*

(b) Element 21f

Section VII.B.3(g) explains why it would have been obvious to scale the dimensions of Yamaguchi's Example 4 such that the values of Td, Td/tan(HFOV), and |f/f4| for satisfy the first three conditions of Element 21f: "0.5 mm<Td<3.2 mm; 1.0 mm<Td/tan(HFOV)<3.75 mm; |f/f4|<1.20."

Section VII.B.7 explains why it would have been obvious to enlarge the opening in the stop in Yamaguchi's Example 4 such that the f-number (Fno) equals 2.245, which satisfies the condition "1.40<Fno≤2.25." *Id.* ¶ 348.

Yamaguchi in view of Yu renders claim 21 obvious. *Id.* ¶¶ 346–49.

19. Claim 22

Section VII.B.3(g) explains that f2/f3 equals -1.436 in the scaled version of Yamaguchi's Example 4, which satisfies the condition "f2/f3<-0.65." *Id.* ¶ 351. Yamaguchi in view of Yu renders claim 22 obvious. *Id.* ¶¶ 350–52.

20. Claim 23

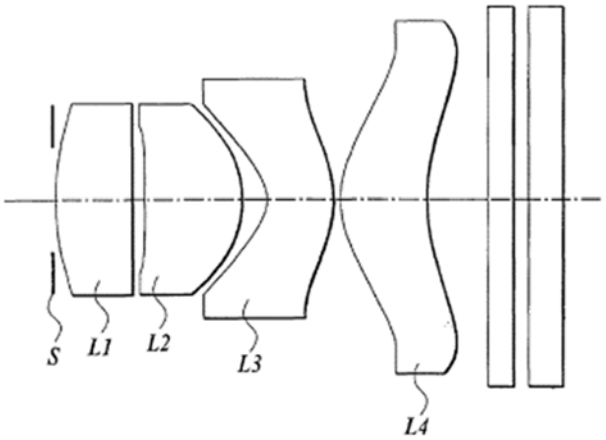
Section VII.B.13 explains that Yamaguchi's Example 4 discloses that "an Abbe number of the first lens element is V1, and the following condition is satisfied: 45<V1." Yamaguchi in view of Yu renders claim 23 obvious. *Id.* ¶¶ 353–55.

21. Claim 24

Yamaguchi discloses that "the first lens has positive refractive power." Ex.1006 ¶¶ 0010, 0052. Yamaguchi's Fig. 10 (Example 4) shows that the first lens L1 has positive refractive power, because it is thicker in the paraxial region.

Ex.1007 ¶ 357. The positive refractive power of a lens is unaffected when the dimensions of the pickup lens are scaled. *Id.*

FIG.10



Section VII.B.5 explains that f/f1 equals 0.6935 in Yamaguchi's Example 4, and that this is unaffected when the dimensions of the pickup lens are scaled. This satisfies the condition "0.25<f/f1<0.75, " and Yamaguchi in view of Yu renders claim 24 obvious. *Id.* ¶¶ 356–59.

VIII. Factors Counseling Against Discretionary Denial Under 35 U.S.C. § 314(a)

As noted in the mandatory notices submitted herewith, Petitioner and Patent Owner are currently parties to a pending district court matter in the Eastern District of Texas where this patent is at issue. Petitioner is timely filing its Petition months before the 35 U.S.C. § 315(b) statutory bar date in October 2020. The timeline for the district court matter is currently unclear. A motion to transfer the case to the Northern District of California is pending (*In re HP Inc.*, No. 20-140 (Fed. Cir.)). Should that motion be granted, the trial timeline will be significantly delayed, likely

well beyond any date for a Final Written Decision in these matters. No date has been set for a district court trial in Texas. Certain pre-trial conferences are preliminarily scheduled for 2021, but those dates are likely to shift based on the current state of discovery. This is especially true because of travel restrictions, where three of the parties to the district court matter are Taiwanese corporations whose representatives are currently unable to travel to the United States. The district court matter remains in the preliminary stage. Only one deposition has been taken so far, and that deposition was of a third party (i.e., not a party to this PTAB matter) on the topic of the motion to transfer. No inventors or party witnesses have been deposed regarding technical issues, infringement, validity, or damages. No *Markman* hearing has occurred, and no claim construction briefs have been filed as yet. Further, to the extent that trial is instituted in these matters, Petitioner agrees not to pursue the combinations of references in unpatentability grounds detailed herein in the trial court proceeding for purposes of invalidity, eliminating any risk of overlap between the unpatentability/invalidity grounds raised in this Petition and the parallel proceeding. The ’796 patent has not previously been challenged by any party at the PTAB. And further the strength of these petitions, where all features of several claims are taught or suggested by single references, counsels in favor of instituting trial.

IX. Mandatory Notices

A. Real Parties-in-Interest

The real party-in-interest is HP Inc.

B. Related Matters

The '796 patent is involved in the following pending litigation that may affect, or be affected by, a decision in this proceeding: *Largan Precision Co. v. Ability Opto-Electronics Tech. Co.*, No. 4:19-cv-00696-ALM (E.D. Tex.). An IPR petition for the '796 patent was previously filed by Ability Opto-Electronics Technology Co., Ltd. as IPR2020-01339, and has been instituted. Petitioner now seeks to join this IPR proceeding based on the same grounds and on the same challenged claims.

C. Service Information

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Pursuant to 37 C.F.R. § 42.10(b), a Power of Attorney accompanies this Petition. HP consents to electronic service by email at the addresses above.

X. Fees

The undersigned representative of HP authorizes the Board to charge the $19,750 petition fee for twenty-two claims, as well as any additional fees, to Deposit Account 504524, ref: 19740-0010. Twenty-two claims are being reviewed, so $24,000 in post institution fees are due for a total of $43,750.

Date: March 9, 2021

By: /Sasha G. Rao/

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CERTIFICATE OF SERVICE

The undersigned hereby certifies that a copy of the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 8,988,796, including all exhibits and the Power of Attorney, will be served on March 9, 2021, via overnight delivery directed to the attorney of record for the '796 patent at the following address:

Morris, Manning & Martin, LLP
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3343 Peachtree Road, NE
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An electronic courtesy copy is also being served to litigation counsel via secure file transfer at:

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Date: March 9, 2021 /Sasha G. Rao/
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CERTIFICATE OF WORD COUNT (37 C.F.R. § 42.24(a))

I, the undersigned, do hereby certify that the attached Petition, including footnotes, contains 13,481 words, as measured by the Word Count function of Microsoft Word. This is less than the limit of 14,000 words as specified by 37 C.F.R. § 42.24(a)(i).

Date: March 9, 2021

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APPENDIX OF EXHIBITS

EXHIBIT NO.	TITLE
1001	U.S. Patent No. 8,988,796 ("'796 patent")
1002	File history of the '796 patent
1003	U.S. Patent No. 9,097,860 ("Yu")
1004	File history of Yu
1005	Certified translation of Taiwan Application No. 102131525
1006	U.S. Patent Application Publication No. 2004/0012861 ("Yamaguchi")
1007	Declaration of William T. Plummer, Ph.D.
1008	Code V Introductory User's Guide, Code V 9.7 (October 2006)
1009	OSLO Optics Reference, Version 6.1 (2001)
1010	ZEMAX Optical Design Program User's Guide (August 1, 2006)
1011	U.S. Patent Application Publication No. 2012/0147249 ("Okano")
1012	WO 2013/125248 A1 ("Sugiyama")

EXHIBIT NO.	TITLE
1013	Certified translation of WO 2013/125248 A1 (“Sugiyama”)
1014	Arthur Cox, A System of Optical Design (1964)
1015	Warren J. Smith, Modern Optical Engineering (3d ed. 2000)
1016	Warren J. Smith, Modern Lens Design (2d ed. 2005)
1017	Warren J. Smith, Modern Optical Engineering (2d ed. 1990)