Paper No. 12

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

COREPHOTONICS, LTD.,
Patent Owner.

Case No. IPR2020-00878
U.S. Patent No. 10,330,897

PATENT OWNER'S RESPONSE

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Cases

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PATENT OWNER'S EXHIBIT LIST

Exhibit No	*Description*
2001	Declaration of Tom D. Milster, Ph.D.
2002	Curriculum Vitae of Tom D. Milster, Ph.D.
2003	Deposition transcript of José Sasián, January 22, 2021
2004	José Sasián, Introduction to Lens Design (2019)
2005	Peter Clark, "Mobile platform optical design," Proc. SPIE 9293, International Optical Design Conference 2017, 92931M (17 December 2014)
2006	Symmons and Schaub, *Field Guide to Molded Optics* (2016)
2007	G. Beall, "By Design: Part design 106 – Corner radiuses," *Plastics Today* (199)
2008	*Handbook of Optics*, 2nd ed., vol. 2 (1995)
2009	Declaration of José Sasián in IPR2019-00030

I. INTRODUCTION

Patent Owner Corephotonics, Ltd. submits this response to the Petition (Paper 2) filed by Apple Inc., requesting *inter partes* review of U.S. Patent No. 10,330,897 (Ex. 1001, '897 patent). This response addresses Grounds 2–4 of this IPR, alleging that claims 2, 3, 5, 6, 8, 16, 18, 19, 21–24, and 30 of the '897 patent are obvious, based on modifications to lens designs found in Ogino (Ex. 1005) and in Chen (Ex. 1020). Corephotonics submits that the arguments presented herein and the additional evidence submitted, such as the testimony from Patent Owner's expert witness Dr. Tom Milster (Ex. 2001), along with the very references cited by Apple and textbook written by its expert, demonstrate that a POSITA would not have made the modifications to these lenses proposed by Apple. Apple has failed to establish obviousness of these challenged claims and that Apple's grounds 2–4 should be rejected.

II. SUMMARY OF ARGUMENT

Apple's obviousness arguments show that Dr. Sasián—a lens designer of exceptional ability who has taught lens design for decades and written textbooks on the subject—was able to, years after the effective filing date of Corephotonics' patent claims and with those patent claims in front of him, make enough modifications to prior art lens designs that the results satisfy the challenged claims. The resulting lenses are presented with impressive-looking computer simulation results, purporting to show that at least on paper the lenses would be functional.

It could hardly be otherwise. Any valid patent claim must be enabled. It must be within the skill of even a journeyman designer to construct the claimed invention after reading the patent. It may be that a claim to a new chemical compound or protein sequence can be implemented using entirely routine chemistry or biology techniques once you have seen the claim. That does not make it obvious. As the Federal Circuit stated in *Belden*, establishing obviousness requires more than simply showing that a designer ***could have made*** specific changes to the prior art. It also requires showing that they ***would have been motivated to make*** those specific changes. Apple's obviousness arguments fail to meet this fundamental requirement of obviousness.

Apple's petition reflects a backwards approach to obviousness. Apple found an example in the prior art, Ogino Example 5, that it believed met all of the elements of the independent claims of the '897 patent. But it had a problem: Ogino Example 5 clearly does not satisfy the limitations of numerous dependent claims. So, Apple asked: how would a designer who was motivated to satisfy the missing limitation have modified that design?

Motivation cannot be found in the challenged claims. It must be found in the prior art and the knowledge of a POSITA at the time. Would a POSITA have been motivated to change Ogino Example 5 in the ways proposed? The evidence emphatically says they would not.

For both grounds 2 and 3, Apple proposes a motivation to modify Ogino Example 5 to reduce its "f-number," either to a value cited in other prior art or to the value of another Ogino lens example. But this is not a well-reasoned motivation. Ogino Example 5 has by far the largest f-number of any example in Ogino. As Corephotonics' expert Dr. Milster explains and as common sense dictates, a POSITA who desired a lens with a small f-number would have chosen to start with an Ogino lens that already had a small f-number, indeed that already had the f-number values that Apple contends the POSITA would have been motivated to achieve. Apple provides no reasoned explanation that a POSITA would have chosen Ogino's lens with the ***largest*** f-number as a starting point to achieve a lens with a ***small*** f-number.

A POSITA might reasonably expect that there is a reason that Ogino Example 5 has a large f-number and that difficulties would be encountered if they tried to reduce it. Dr. Sasián's analysis shows that such fears would have been realized. As explained further below, reducing the f-number requires making the first lens in Ogino larger. Dr. Sasián's work shows that stretching Ogino's Example 5 to achieve the f-number Apple says a POSITA would have been motivated to achieve results in an unmanufacturable "paper lens," something that works as a computer simulation but cannot be built using practical means and would not work right even if it could be built.

A POSITA would have recognized that this modification to Ogino was unmanufacturable because it violates the rules of thumb and manufacturing tolerances set forth in two of the very prior art references that Apple relies on, Bareau and Beich, as well as in textbooks and references works by Dr. Sasián, Dr. Milster, and others. Whatever a POSITA would have been motivated to do to modify the Ogino lens, they would not have been motivated to use the impractical and unmanufacturable design proposed by Dr. Sasián for ground 2.

Apple proposed design for ground 3 suffers from some of the same problems. Once again, the purported motivation makes little rational sense. If the goal was an f-number equal to the f-number in a different Ogino example, why wouldn't the POSITA simply use that other Ogino example? Apple provides no reasoned justification for starting with the largest f-number lens in Ogino if the goal was the f-number of the smallest f-number lens.

But more fundamentally, Apple and its expert provide no rationale for why Dr. Sasián modified the Ogino Example 5 lens in a particular way, or even ***how*** he did that modification. For example, an entire claim limitation—the "convex image-side surface" limitation of claims 8 and 24—required changing the sign of one of the parameters of the Ogino design. Making this change, from concave to convex, required disregarding one of the features that Ogino describes and claims as a defining characteristic of its invention: the meniscus shape of its first lens. Dr. Sasián cites to no prior art reference that suggests making this change from concave to convex, does not explain in his declaration the process that resulted in this change, and could not remember during his deposition how that change happened. At most, Apple's evidence on ground 3 goes to what a POSITA ***could have*** done, not what they ***would have been motivated*** to do.

Apple's arguments for ground 4 suffer from many of the same basic flaws as ground 2. The Chen patent does not disclose the ratio required by claims

16 and 30 or the lens diameter values that would allow one to calculate that ratio. So, Apple shows that a POSITA ***could have*** chosen a value that satisfied the claim limitation, in a "paper lens." As with ground 2, Dr. Sasián's ground 4 would not work in practice, based on the limits of manufacturability taught in the very prior art references Apple relies on, in Dr. Sasián textbook, and in other references discussed below. Further, as Dr. Milster shows, any practical implementation of the Chen lens, taking into account the limits of manufacturability, would not have satisfied the challenged claims. A POSITA would not have been motivated to implement Chen's lens design in the impractical, unmanufacturable way proposed by Apple. Indeed, the fact that the best arguments Apple was able to find, with the benefit of hindsight, depend on such unrealistic lens designs suggests that the inventions claimed in the '897 patent are, in fact, non-obvious.

For these reasons, and as explained further below, each of Apple's proposed modifications lacks the motivation that is legally required to establish obviousness, and each of Apple's obviousness grounds should be rejected.

III. OVERVIEW OF THE ’897 PATENT

The ’897 patent is concerned with designs for a “miniature telephoto lens assembly” of a kind suitable for use in mobile phones and other portable electronic products. (Ex. 1001, ’897 patent at 1:26–30.) The example designs shown in the ’897 patent utilize five plastic lens elements, each having a complex aspheric shape:

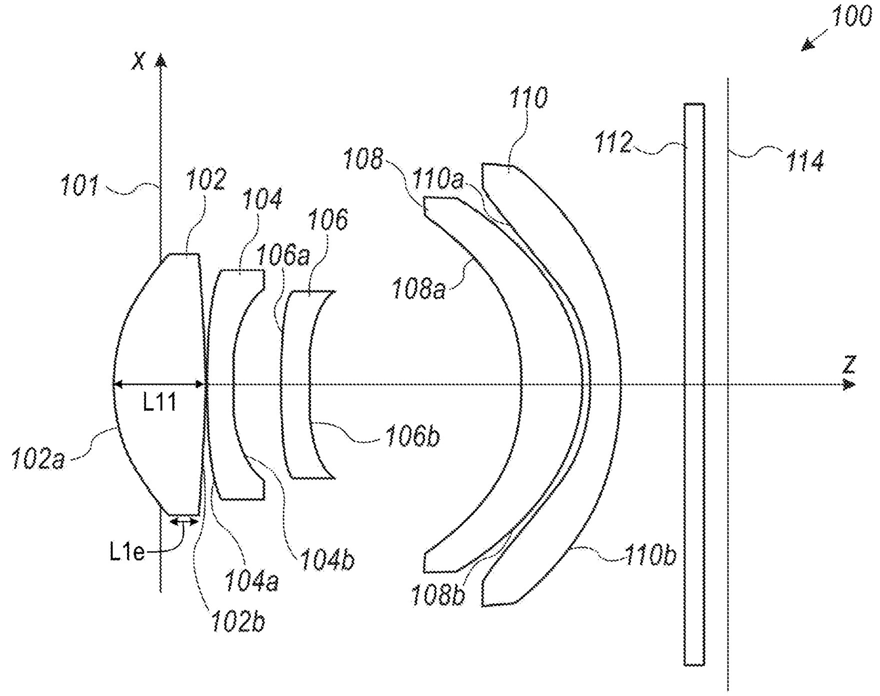


FIG. 1A

(Ex. 2001, Milster Decl., ¶ 36.)

The use of these multiple lens elements with aspheric shapes makes possible a lens that produces a high-quality image, by minimizing chromatic aberrations and other optical aberrations that would blur or distort the image. (Ex. 1001, ’897 patent at 2:22–34, 2:51–57; Ex. 2001, Milster Decl., ¶ 37.)

These multi-lens systems with aspheric lens surfaces have a vast range of possible designs. For example, the design in figure 1A from the ’897 patent requires several dozen numerical parameters to define the shapes, locations, and properties of its lens elements:

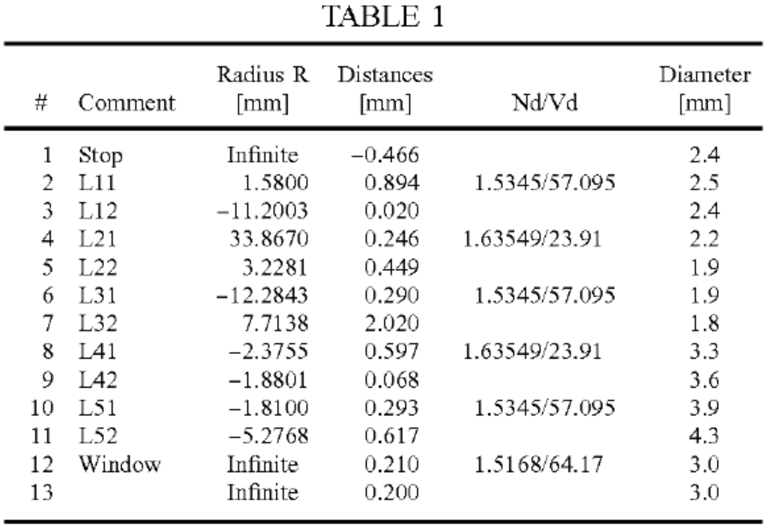


TABLE 1

#	Comment	Radius R [mm]	Distances [mm]	Nd/Vd	Diameter [mm]
1	Stop	Infinite	−0.466		2.4
2	L11	1.5800	0.894	1.5345/57.095	2.5
3	L12	−11.2003	0.020		2.4
4	L21	33.8670	0.246	1.63549/23.91	2.2
5	L22	3.2281	0.449		1.9
6	L31	−12.2843	0.290	1.5345/57.095	1.9
7	L32	7.7138	2.020		1.8
8	L41	−2.3755	0.597	1.63549/23.91	3.3
9	L42	−1.8801	0.068		3.6
10	L51	−1.8100	0.293	1.5345/57.095	3.9
11	L52	−5.2768	0.617		4.3
12	Window	Infinite	0.210	1.5168/64.17	3.0
13		Infinite	0.200		3.0

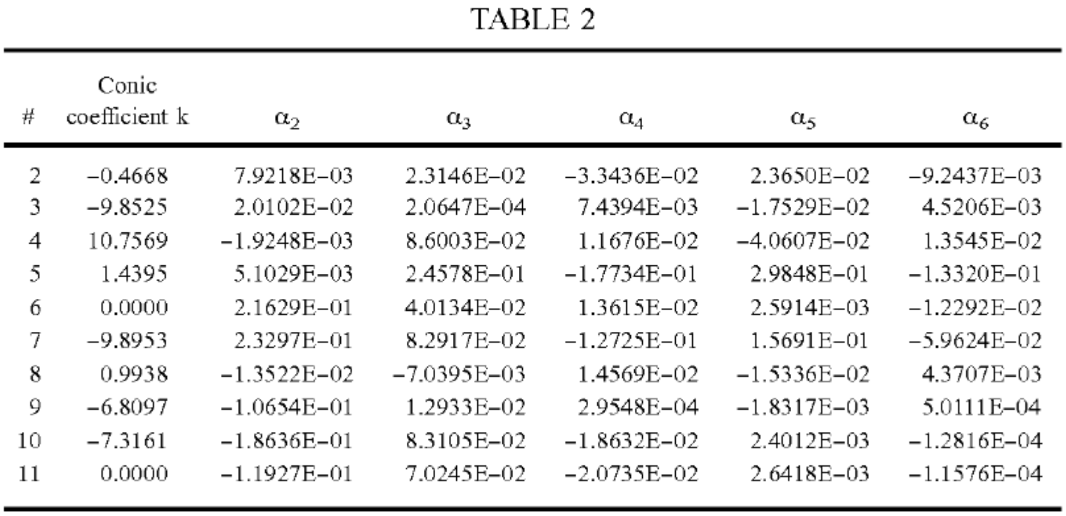


TABLE 2

#	Conic coefficient k	α_2	α_3	α_4	α_5	α_6
2	−0.4668	7.9218E−03	2.3146E−02	−3.3436E−02	2.3650E−02	−9.2437E−03
3	−9.8525	2.0102E−02	2.0647E−04	7.4394E−03	−1.7529E−02	4.5206E−03
4	10.7569	−1.9248E−03	8.6003E−02	1.1676E−02	−4.0607E−02	1.3545E−02
5	1.4395	5.1029E−03	2.4578E−01	−1.7734E−01	2.9848E−01	−1.3320E−01
6	0.0000	2.1629E−01	4.0134E−02	1.3615E−02	2.5914E−03	−1.2292E−02
7	−9.8953	2.3297E−01	8.2917E−02	−1.2725E−01	1.5691E−01	−5.9624E−02
8	0.9938	−1.3522E−02	−7.0395E−03	1.4569E−02	−1.5336E−02	4.3707E−03
9	−6.8097	−1.0654E−01	1.2933E−02	2.9548E−04	−1.8317E−03	5.0111E−04
10	−7.3161	−1.8636E−01	8.3105E−02	−1.8632E−02	2.4012E−03	−1.2816E−04
11	0.0000	−1.1927E−01	7.0245E−02	−2.0735E−02	2.6418E−03	−1.1576E−04

(Ex. 1001, ’897 patent, col. 4; Ex. 2001, Milster Decl., ¶ 38.)

The ’897 patent provides examples of lens designs and their corresponding numerical parameters, and it also teaches and claims sets of conditions and relationships among the parameters that help to make a lens system with high performance characteristics. The resulting lens designs are thin and compact, appropriate for use in mobile devices, and they offer a large focal length (and thus a large degree of image magnification) for their physical size. (Ex. 1001, ’897 patent at 2:6–21; Ex. 2001, Milster Decl., ¶ 39.)

The lens designs in the ’897 patent are also manufacturable, meaning that they have shapes that can be successfully and repeatably manufactured using the techniques of plastic injection molding that are commonly used for mobile device camera lenses. The ’897 patent designs avoid features such as overly narrow lens edges that make a lens difficult or impossible to manufacture. (Ex. 1001, ’897 patent at 2:35–50; Ex. 2001, Milster Decl., ¶ 40.)

One of the parameters of a lens design that is discussed in the ’897 patent and claimed in certain claims is the “f-number” or “F#.” As Dr. Milster explains, the f-number is a property of a lens that relates to how bright the image formed by the lens is. (*Id.*, ¶ 41.) A lens that forms brighter images is sometimes referred to as a “faster” lens, because for a given image sensor (or a given type of film) and focal length, the minimum amount of time required to capture an image varies inversely with the brightness of the image. (*Id.*) For a single thin lens, the f number is equal to the focal length of the lens divided by the diameter of the lens:

$$f - number = \frac{f}{diameter}$$

(Ex. 1016, Walker at 59; Ex. 2001, Milster Decl., ¶ 41.)

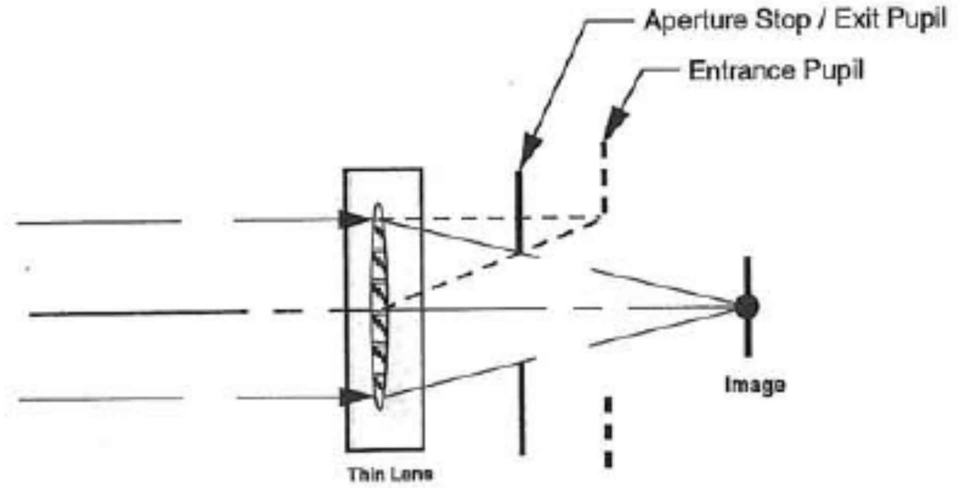
The diameter of the lens determines how much total light is collected per unit time by the lens from a given scene. (Ex. 2001, Milster Decl., ¶ 42.) Under certain approximations, doubling the diameter increases the amount of light collected by a factor of four. (*Id.*) The focal length determines the image size on the sensor and thus determines the size of the distribution area of the collected light. (*Id.*) Doubling the focal length increases the area illuminated in the image by a factor of four and reduces the intensity of the light in any given part of the image by a factor of four. (*Id.*) So, if both the diameter and focal length are doubled, then the effects approximately cancel out, and the brightness of the image at the sensor is left unchanged, although the image is larger. (*Id.*) In other words, it is the ratio of the focal length and the diameter that most strongly effects the image brightness. (*Id.*)

Because the diameter is in the denominator, a smaller f-number corresponds to a brighter image for a fixed focal length. In more complicated lens systems with multiple lens elements, such as those at issue in this IPR, the amount of light collected no longer depends on the diameter of a single lens (or of a single lens surface), and the effective focal length (EFL) is a function of the lens elements and their spacings. (*Id.*, ¶ 43.) One definition of f-number for such systems instead uses the diameter of the "entrance pupil" (EPD), meaning that the formula is changed to:

$$f\text{-}number = \frac{EFL}{diameter} = \frac{EFL}{EPD}$$

(Ex. 1003, Sasián Decl. at 58–39; Ex. 2001, Milster Decl., ¶ 43.)

The concept of the "entrance pupil" is illustrated in the following drawing from Figure 4-2 of Walker:



(Ex. 1016, Walker, p. 61; Ex. 2001, Milster Decl., ¶ 44.)

As shown here, the entrance pupil reflects the size of the bundle of rays parallel to the optical axis of the lens that can enter the lens, travel through the aperture stop, and reach the image plane. Explained another way, the entrance pupil "is the image of the aperture stop as seen when looking from the object side of the lens." (Ex. 1016, Walker, p. 60; Ex. 2001, Milster Decl., ¶ 45.)

IV. LEGAL STANDARDS

The petitioner has the burden to clearly set forth the basis for its challenges in the petition. *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir.2016) (citing 35 U.S.C. § 312(a)(3) as "requiring IPR petitions to identify 'with particularity ... the evidence that supports the grounds for the challenge to each claim'"). The burden of persuasion "never shifts to the patentee." *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015).

A petitioner may not rely on the Board to substitute its own reasoning to remedy the deficiencies in a petition. *SAS Inst., Inc. v. Iancu*, 138 S. Ct. 1348, 1355 (2018) ("Congress chose to structure a process in which it's the petitioner, not the Director, who gets to define the contours of the proceeding."); *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1381 (Fed. Cir. 2016) (rejecting the Board's reliance on obviousness arguments that "could have been included" in the petition but were not, and holding that the Board may not "raise, address, and decide unpatentability theories never presented by the petitioner and not supported by the record evidence"); *Ariosa Diagnostics v. Verinata Health, Inc.*, 805 F.3d 1359, 1367 (Fed. Cir. 2015) (holding that "a challenge can fail even if different evidence and arguments might have led to success"); *Wasica Finance GMBH v. Continental Auto. Systems*, 853 F.3d 1272, 1286 (Fed. Cir. 2017) (holding that new arguments in a reply brief are "foreclosed by statute, our precedent, and Board guidelines").

The petitioner cannot satisfy its burden of proving obviousness by employing "mere conclusory statements." *Magnum*, 829 F.3d at 1380. As the Federal Circuit has explained, "obviousness concerns whether a skilled artisan not only *could have made* but *would have been motivated to make* the combinations or modifications of prior art to arrive at the claimed invention." *Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1073 (Fed. Cir. 2015); *Hulu, LLC v. Sound View Innovactions, LLC*, Case No. IPR2018-00582, Paper 34 at 21–22 (Aug. 5, 2019) (informative).

V. LEVEL OF ORDINARY SKILL IN THE ART (POSITA)

In his declaration, Dr. Sasián offers his opinion that a person having ordinary skill in the art ("POSITA"):

> would include someone who had, at the priority date of the '897 Patent, (i) a Bachelor's degree in Physics, Optical Sciences, or equivalent training, as well as (ii) approximately three years of experience in designing multi-lens optical systems. Such a person would have had experience in analyzing, tolerancing, adjusting, and optimizing multi-lens systems for manufacturing, and would have been familiar with the specifications of lens systems and their fabrication. In addition, a POSITA would have known how to use lens design software such as Code V, Oslo, or Zemax, and would have taken a lens design course or had equivalent training.

(Ex. 1003, Sasián Decl., ¶¶ 19–20.) Corephotonics' expert Dr. Milster has applied the same definition of ordinary skill in his analysis. (Ex. 2001, Milster Decl., ¶ 19.)

The '897 patent claims priority by a series of continuations to an application that was filed on January 30, 2017 and issued as U.S. Patent No. 9,857,568. (Ex. 1001, '897 patent at 1:5–10.) The '897 patent also claims priority by a series of continuations and continuations-in-part to a provisional patent application that was filed on July 4, 2013. (Ex. 1001, '897 patent at 1:5–12.)

In his declaration, Dr. Sasián appears to assume that the relevant effective filing date for assessing the level of skill in the art is July 4, 2013. (Ex. 1003, Sasián Decl., ¶¶ 18–21.) The only claims that Dr. Sasián contends have a January 30, 2017 priority date are claims 16 and 30. (Ex. 1003, Sasián Decl., ¶ 33.) Apple and Dr. Sasián do not appear to dispute that the challenged claims other than claims 16 and 30 have an effective filing date of July 4, 2013. For the purposes of evaluating the level of skill in the art, Dr. Milster has considered the level of skill in the art as of January 30, 2017 for claims 16 and 30, and as of July 4, 2013 for the other challenged claims, and this response does the same. (Ex. 2001, Milster Decl., ¶ 23.) However, none of the arguments set forth herein would change if one assumed a July 4, 2013 date for claims 16 and 30 or a January 30, 2017 for any of the other claims. (*See id.*)

VI. CLAIM CONSTRUCTION

Apple's petition applies two claim constructions for terms that the Board has previously construed in IPRs concerning U.S. Patent No. 9,402,032 and 9,568,712, patents to which the '897 patent claims priority:

> Effective Focal Length (EFL): "the focal length of a lens assembly."
>
> Total Track Length (TTL): "the length of the optical axis spacing between the object-side surface of the first lens element and one of: an electronic sensor, a film sensor, and an image plane corresponding to either the electronic sensor or a film sensor."

(Paper 2 at 7–8; IPR2018-01140, Paper 37 at 10–18.) The Board also adopted these same constructions in IPR2019-00030 concerning the '568 patent, which contains the same specification as the '897 patent. (IPR2019-00030, Paper 32 at 8, 14–15.)

The Board's Institution Decision applied these constructions, but invited the parties to address the proper construction of "Total Track Length," in light of a different construction for this term proposed by Apple in IPR2020-00877. (Paper 7 at 8–9.)

Corephotonics does not believe that any dispute between the parties in this IPR depends on the construction of EFL, TTL, or of any other claim term. Accordingly, Corephotonics submits that the Board should refrain from construing any terms in the patent for the purposes of this proceeding.

VII. PRIOR ART REFERENCES

A. Ogino

Ogino issued on September 8, 2015 as U.S. Patent No. 9, 128,267. (Ex. 2015.) Apple contends that Ogino has an effective filing date of March 29, 2013, based upon the filing date of the corresponding Japanese patent application. (Petition at 9.)

As described in Ogino's abstract, its invention is a system of five lenses with a particular set of shapes:

> An imaging lens substantially consists of, in order from an object side, five lenses of a first lens that has a positive refractive power and has a meniscus shape which is convex toward the object side, a second lens that has a biconcave shape, a third lens that has a meniscus shape which is convex toward the object side, a fourth lens that has a meniscus shape which is convex toward the image side; and a fifth lens that has a negative refractive power and has at least one inflection point on an image side surface. Further, the following conditional expression (1) is satisfied.
>
> $1.4<f/f1<4$ (1)

(Ex. 1005, Ogino, Abstract.)

This same set of shapes and conditions is described as the "imaging lens of the present invention" in Ogino's "Summary of the Invention" section. (Ex. 1005, Ogino at 2:1–16; Ex. 2001, Milster Decl., ¶ 51.)

Ogino describes six examples of this basic system, each of which has this same pattern of shapes:

> As in the first embodiment, the imaging lenses according to the second to sixth embodiments of the present invention substantially consist of, in order from the object side, five lenses of: the first lens L1 that has a positive refractive power and has a meniscus shape which is convex toward the object side; the second lens L2 that has a biconcave shape; the third lens L3 that has a meniscus shape which is convex toward the object side; the fourth lens L4 that has a meniscus shape which is convex toward the image side; and the fifth lens L5 that has a negative refractive power and has at least one inflection point on an image side surface.

(Ex. 1005, Ogino at 13:5–16.)

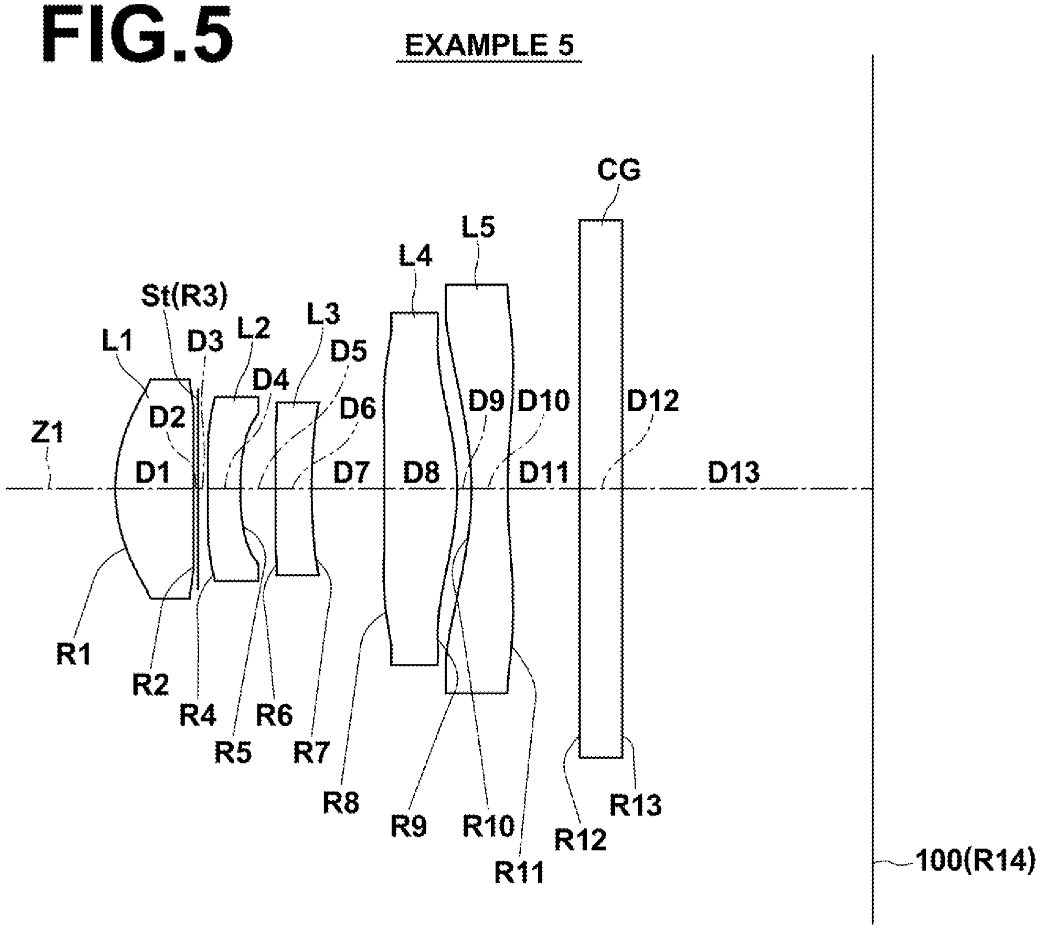
Ogino explains the reasons for using each of these shapes, for example in lines 7:28–8:42. For example:

> As shown in the embodiments, by making the first lens L1, which is a lens closest to the object, have a positive refractive power and have a meniscus shape which is convex toward the object side in the vicinity of the optical axis, the position of the rear side principal point of the first lens L1 can be set to be close to the object, and thus it is possible to appropriately reduce the total length.

(Ex. 1005, Ogino at 7:31–37; Ex. 2001, Milster Decl., ¶ 53.)

Apple's grounds utilizing Ogino are all based on Ogino's "Example 5" or modifications to that example. (Ex. 1003, Sasián Decl., ¶¶ 46, 51, 61.) The lens elements of Example 5 are shown in Ogino, Figure 5:

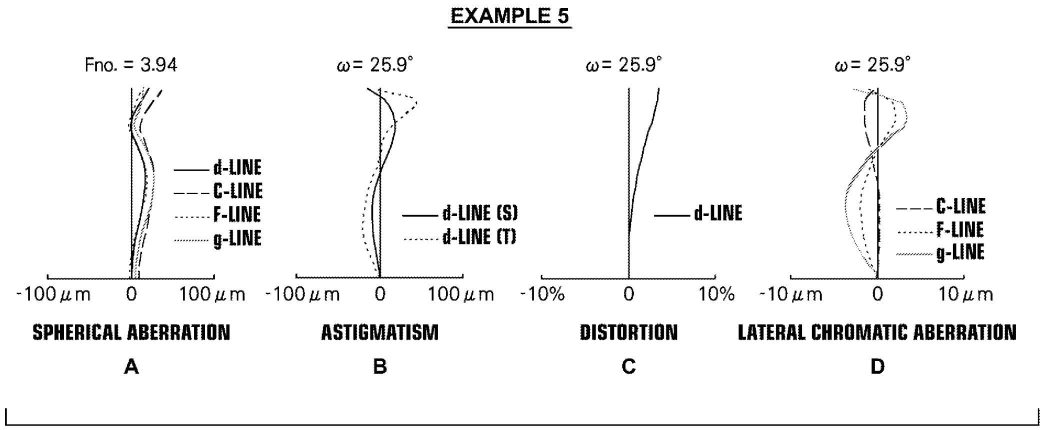
FIG.5



(Ex. 1005, Ogino, Figure 5; Ex. 2001, Milster Decl., ¶ 54.)

Figure 12 of Ogino provides certain optical characteristics of Example 5, including its f-number of 3.94 and half-angle of view ω=25.9°:

FIG.12



(Ex. 1005, Ogino, Figure 12; Ex. 2001, Milster Decl., ¶ 55.)

The lens prescription for Example 5 is given in Ogino Tables 9 and 10:

TABLE 9

EXAMPLE 5
f = 5.956, Bf = 2.438, TL = 5.171

Si	Ri	Di	ndj	νdj
*1	1.12444	0.546	1.54488	54.87
*2	252.97534	0.030		
3 (APERTURE STOP)	∞	0.069		
*4	−18.78836	0.227	1.63351	23.63
*5	2.25616	0.243		
*6	506.45581	0.253	1.63351	23.63
*7	4.36560	0.506		
*8	−99.83715	0.506	1.63351	23.63
*9	−1.70702	0.100		
*10	−2.17464	0.253	1.54488	54.87
*11	3.61429	0.500		
12	∞	0.300	1.51633	64.14
13	∞	1.740		
14	∞			

*ASPHERIC SURFACE

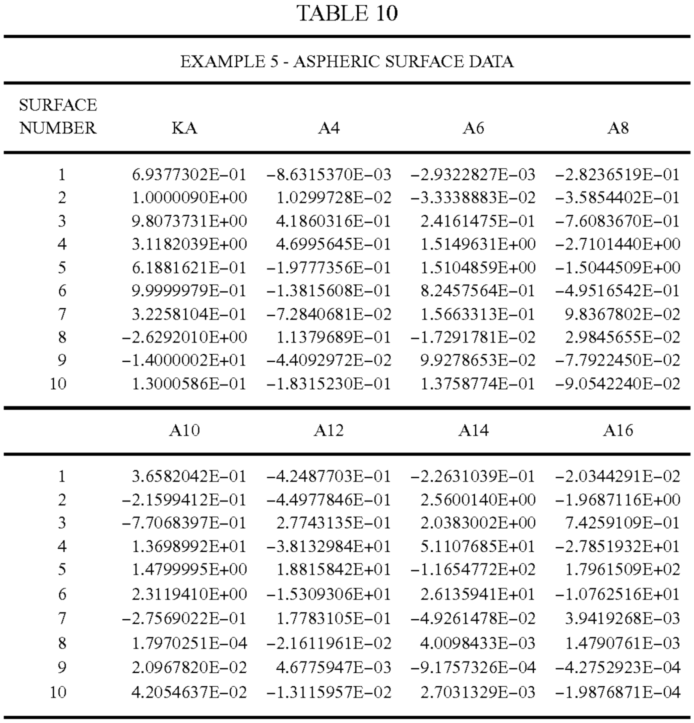


TABLE 10

EXAMPLE 5 - ASPHERIC SURFACE DATA

SURFACE NUMBER	KA	A4	A6	A8
1	6.9377302E−01	−8.6315370E−03	−2.9322827E−03	−2.8236519E−01
2	1.0000090E+00	1.0299728E−02	−3.3338883E−02	−3.5854402E−01
3	9.8073731E+00	4.1860316E−01	2.4161475E−01	−7.6083670E−01
4	3.1182039E+00	4.6995645E−01	1.5149631E+00	−2.7101440E+00
5	6.1881621E−01	−1.9777356E−01	1.5104859E+00	−1.5044509E+00
6	9.9999979E−01	−1.3815608E−01	8.2457564E−01	−4.9516542E−01
7	3.2258104E−01	−7.2840681E−02	1.5663313E−01	9.8367802E−02
8	−2.6292010E+00	1.1379689E−01	−1.7291781E−02	2.9845655E−02
9	−1.4000002E+01	−4.4092972E−02	9.9278653E−02	−7.7922450E−02
10	1.3000586E−01	−1.8315230E−01	1.3758774E−01	−9.0542240E−02

	A10	A12	A14	A16
1	3.6582042E−01	−4.2487703E−01	−2.2631039E−01	−2.0344291E−02
2	−2.1599412E−01	−4.4977846E−01	2.5600140E+00	−1.9687116E+00
3	−7.7068397E−01	2.7743135E−01	2.0383002E+00	7.4259109E−01
4	1.3698992E+01	−3.8132984E+01	5.1107685E+01	−2.7851932E+01
5	1.4799995E+00	1.8815842E+01	−1.1654772E+02	1.7961509E+02
6	2.3119410E+00	−1.5309306E+01	2.6135941E+01	−1.0762516E+01
7	−2.7569022E−01	1.7783105E−01	−4.9261478E−02	3.9419268E−03
8	1.7970251E−04	−2.1611961E−02	4.0098433E−03	1.4790761E−03
9	2.0967820E−02	4.6775947E−03	−9.1757326E−04	−4.2752923E−04
10	4.2054637E−02	−1.3115957E−02	2.7031329E−03	−1.9876871E−04

(Ex. 1005, Ogino, column 21; Ex. 2001, Milster Decl., ¶ 56.)

B. Bareau

Bareau is an article by Jane Bareau and Peter P. Clark, titled "The Optics of Miniature Digital Camera Modules." (Ex. 1012.) Dr. Sasián states that this was presented at an International Optical Design Conference in June 2006 and that it was published in SPIE Proceedings Vol. 6342 "a few months after the conference." (Ex. 1003, Sasián Decl., ¶ 47.)

Apple does not rely on any detailed lens design from Bareau or any teachings of how a lens designer would create a detailed lens design. (Ex. 2001, Milster Decl., ¶ 58.) Rather, Apple and Dr. Sasián rely on Bareau listing an f-number of 2.8 in its “typical lens specifications for a ¼″ sensor format.” (Ex. 1003, Sasián Decl., ¶¶ 51–53; Ex. 1012, Bareau at 3–4; Ex. 2001, Milster Decl., ¶ 58.)

Other parts of Bareau illustrate an important point relevant to this IPR: the fact that you can simulate a lens design in lens design software such as Zemax does not mean that you can build that design. (Ex. 2001, Milster Decl., ¶ 59.) As Bareau explains:

> Layout drawings can be very misleading. Many times we find ourselves surprised when the mechanical layout of a lens barrel that looked reasonable on paper turns out to be very difficult or impossible to fabricate. Tabs on a barrel that appear substantial in a drawing, are found to be too flimsy to function on the actual part, sharp edges on molded stops don’t fill completely because the features are too small.

(Ex. 1012, Bareau at 1; Ex. 2001, Milster Decl., ¶ 59.)

Bareau explains aspects of the shape and size of lens elements, be they made out of plastic or glass, that are particularly problematic when producing miniature lenses like those at issue in this IPR:

> Scaling down such a lens will result in a system that is unmanufacturable. If the design includes molded plastic optics, a scaled down system will result in element edge thicknesses shrinking to the point where the flow of plastic is affected. For glass elements, the edge thicknesses will become too thin to be fabricated without chipping.

(Ex. 1012, Bareau at 1; Ex. 2001, Milster Decl., ¶ 60.)

Bareau explains that the issue of "geometric tolerances," including both in the size and shape of individual lens elements and their alignment within the overall system, "proves to be the greatest challenge of producing these lenses." (Ex. 1012, Bareau at 3; Ex. 2001, Milster Decl., ¶ 61.)

Bareau further explains that there are limits to achievable shapes in miniature lenses. For molded lenses, these limits arise from the properties of the lens material, both in liquid form and in solid form, and from the techniques used to make the mold inserts that the lens parts are formed in. According to Bareau:

> Plastic injection molded optics have minimum edge thicknesses, minimum center thicknesses and range of acceptability for their center to edge thickness ratio that must be met in order that they can be molded. Additionally, the maximum slope that can be diamond-turned in mold inserts and measured in either the lens or the mold is around 45 degrees.

(Ex. 1012, Bareau at 8; Ex. 2001, Milster Decl., ¶ 62.)

As Bareau explains, similar limitations apply to glass lens elements: "Traditional glass lenses have similar types of requirements but with different values." (Ex. 1012, Bareau at 8; Ex. 2001, Milster Decl., ¶ 63.) In molded glass lenses, "surfaces with inflections can only be used under very limited circumstances and flanges can only be formed in a restricted range of shapes, no sharp corners or abrupt changes in slope are allowed." (Ex. 1012, Bareau at 8; Ex. 2001, Milster Decl., ¶ 63.)

C. Kingslake

Kingslake is a text by Rudolf Kingslake titled "Optics in Photography." (Ex. 1013.) The copyright page contains a copyright date of 1992. (Ex. 1013 at 2.) Apple cites to only a single page from this textbook, page 104. (Ex. 1013 at 3.)

This page contains the beginning of Kingslake's chapter 6, titled "The Brightness of Images." (Ex. 1013.) The only portions of Kingslake that Apple or Dr. Sasián actually quotes are from the first paragraph of this chapter:

> The relation between the aperture of a lens and brightness of the image produced by it on the photographic emulsion is often misunderstood, yet it is of the greatest importance to the photographer who wishes to make the best use of the equipment. The ***tremendous efforts of lens designers and manufacturers*** that have been devoted to the production of lenses of extremely high relative aperture are an indication of the need that exists for brighter images and "faster" lenses.

(Ex. 1013, p. 104 (emphasis added).)

This paragraph refers to "brighter" and "faster" lenses, which as explained above correspond to lenses with smaller f-numbers. (Ex. 2001, Milster Decl., ¶ 67.) Brighter or faster lenses have advantages, in that they are able to capture an image of a given scene with a shorter exposure (which may be desirable for fast-moving scenes) or to capture a lower-light scene with the same exposure duration. (*Id.*)

However, simply because a property is desirable, does not make it easy to achieve. (*Id.*, ¶ 68.) As Kingslake says, creating lenses with small f-number has required "tremendous efforts of lens designers and manufacturers." (Ex. 1013, Kingslake, p. 104) It requires more than simply deciding to have larger diameters of lenses and apertures. (Ex. 2001, Milster Decl., ¶ 68.)

D. Chen

The Chen patent issued as U.S. Patent No. 10,324,273 on June 18, 2019 and claims priority to a Chinese patent application filed August 29, 2016. (Ex. 1020, Chen.) It describes "an optical imaging lens set of five lens elements for use in mobile phones, in cameras, in tablet personal computers, or in personal digital assistants." (Ex. 1020, Chen at 1:17–19.)

Apple's and Dr. Sasián's obviousness arguments based on Chen are based on a modification of Chen's Example 1, which is shown in Chen Figure 6:

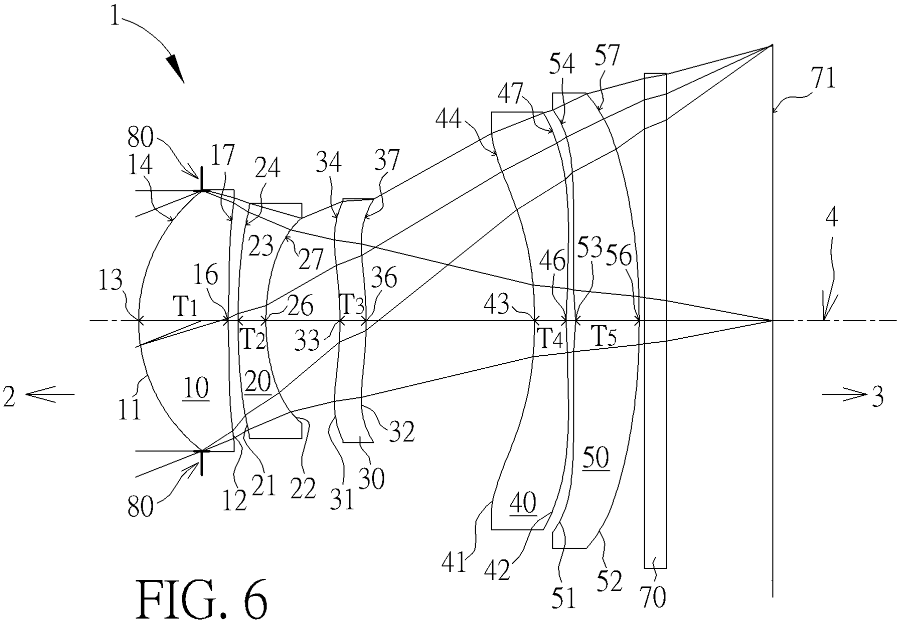


FIG. 6

(Ex. 1020, Chen, Figures 6 and 24, 2:62–63, 8:42–10:12; Ex. 2001, Milster Decl., ¶ 70.)

According to Chen, this lens system has an effective focal length of 6.582 mm (Ex. 1020, Chen, Figure 42) and a TTL of 6.0187 mm (Ex. 1020, Chen at 10:9.) According to Chen, "[g]enerally speaking," each of the five lens elements in this system may be made of "transparent plastic material." (Ex. 1020, Chen at 7:11–22.)

Chen also illustrates an important point concerning lens ray trace diagrams produced using lens design software, such as Chen's figure 6. (Ex. 2001, Milster Decl., ¶ 72.) The lens design software is concerned with the optically clear aperture of the lens element that light passes through and that bend that light to form an image. (*Id.*) The ray trace diagrams generated by software such as Zemax show those parts of the lens elements. (*Id.*) But a physical lens element (as opposed to one simulated in software) extends beyond the shape drawn by the lens design software at the maximum diameter of where the light passes through the lens. (*Id.*) This is illustrated by Chen Figure 1, which shows "extension parts" E that are part of the lens outside of the light bending portion:

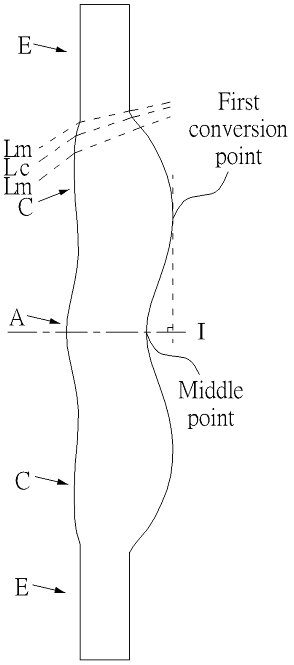


FIG. 1

(Ex. 1020, Figure 1; Ex. 2001, Milster Decl., ¶ 72.)

The extension parts in this lens element appear to serve as flanges for mounting the lens element, like those described in Bareau. (Ex. 1012, Bareau at 8; Ex. 2001, Milster Decl., ¶ 73.)

E. Iwasaki

The Iwasaki patent issued as U.S. Patent No. 9,678,310 on June 13, 2017, and it claims priority to a Japanese patent application filed March 25, 2013. (Ex. 1009.) It describes an "imaging lens . . . constituted essentially by four or more lenses." (Ex. 1009, Iwasaki, Abstract.)

The only aspect of Iwasaki that Apple and Dr. Sasián rely on is the 0.145 mm cover glass used in Iwasaki's examples 1 and 2. (Ex. 1003, Sasián Decl., ¶¶ 72–74; Ex. 1009, Iwasaki, Tables 1 and 3; Ex. 2001, Milster Decl., ¶ 75.)

F. Beich

Beich is a paper titled "Polymer Optics: A manufacturer's perspective on the factors that contribute to successful programs," which lists William S. Beich and Nicholas Turner as its authors. (Ex. 1007, Beich at 1.) According to a statement on its first page, it was published in the Proceedings of SPIE in 2010. (Ex. 1007, Beich at 1.)

Beich discusses various considerations and rules of thumb that relate to the manufacturability of lenses using injection molding methods. According to Dr. Sasián "a POSITA looking to implement optical element specifications using injection molding methods would look to Beich for guidance on limitations and parameters that affect lens manufacturability." (Ex. 1003, Sasián Decl., ¶ 78; Ex. 2001, Milster Decl., ¶ 77.)

Beich explains that the "unique nature of injection molding demands a very disciplined approach during the component design and development phase." (Ex. 1007, Beich at 2.) The paper describes aspects of the injection molding process, such as the "runner system" of channels that convey molten plastic into the mold insert through the sides of the lens. (Ex. 1007, Beich at 6.) Beich explains that "[o]ptics with extremely thick centers and thin edges are very challenging to mold," and it provides a set of "rules of thumb," including that the center thickness to edge thickness ratio for a lens element should be less than "3:1" and that the lens diameter tolerance is ±0.020 mm. (Ex. 1007, Beich at 7; Ex. 2001, Milster Decl., ¶ 78.)

VIII. ARGUMENT

A. Ground 2 – Claims 2, 5, 6, 18, and 21–23 Are Not Obvious over Ogino in view of Bareau

According to Dr. Sasián, Ogino Example 5 satisfies each of the elements of claims 1 and 17 of the ’897 patent. Dependent claims 2, 5, 6, 18, and 21–23 each add the requirement that f-number be less than 2.9, or in the case of claim 23 that the f-number equal 2.8. But, Ogino Example 5 has an f-number of 3.94. Ogino Figure 12. (Ex. 2001, Milster Decl., ¶ 79.)

Dr. Sasián shows how Ogino Example 5 ***could*** be modified using the Zemax software, to reduce the f-number while leaving all the other characteristics of Example 5 that Apple relies on to satisfy claims 1 and 17 unchanged. However, the fact that Dr. Sasián, a highly skilled and well-regarded lens designer with decades of experience who literally “wrote the book” on the subject could modify Ogino Example 5 in this way in 2020, with the claims of the ’897 patent in front of him, does not demonstrate that a lens designer of merely ordinary skill ***would*** have thought to follow this approach in 2013. (Ex. 2001, Milster Decl., ¶ 80)

Bareau suggests that a lens with f-number of 2.8 was desirable for use in a miniature digital camera in 2013. But Bareau also shows that lenses with f-number 2.8 were already commercially available years earlier, in 2006. Ogino itself describes other lenses with f-numbers of 2.45, 2.46, 2.47, 2.64, 3.04. (Ex. 1005, Figures 8–11, 13.) If a POSITA looking at Ogino felt that an f-number of 3.94 was not suitable for their particular application and wanted an f-number of 2.8 instead, that person would naturally look to one of Ogino's other designs, with f-number closer to 2.8, or to one of the hundreds of other miniature lens designs available in the patent literature or in the market. (Ex. 2001, Milster Decl., ¶ 81.) Dr. Sasián provides no explanation for why a POSITA would pick Ogino Example 5, the Ogino lens that is farthest from this desired f-number and modify it dramatically as Dr. Sasián proposes. (*Id.*)

Further, the result of Dr. Sasián's modification to Ogino Example 5 does not satisfy all of the "typical lens specifications" from Bareau. (*Id.*, ¶ 82) Bareau's table of specifications lists a field of view "FOV" of 60 degrees, but Bareau suggests that larger angles such as 66 degrees are also "typical." (Ex. 1012, Bareau at 3.) The unmodified Ogino Example 5 has a half-angle field of view ω=25.9°, or a full field of view of approximately 52°. (Ex. 2001, Milster Decl., ¶ 82.) Dr. Sasian's modifications reduced the field of view to "+/-20°," i.e., to a full field of view of 40°. (Ex. 1003, Sasián Decl. at 104 and figures on 105 and 106; Ex. 2001, Milster Decl., ¶ 82.) Dr. Sasián does not explain why a POSITA seeking to modify Ogino Example 5 based upon the specification in Bareau would do so in a way that allowed it to satisfy one of Bareau's specifications but that moved it further away from Bareau's other specifications. (*Id.*)

Dr. Sasián does point to a patent by Parulski (Ex. 1014) as an example of a cell phone with both wide and narrow angle lenses, but Parulski does not specify any f-number for its narrow angle lenses. (Ex. 2001, Milster Decl., ¶ 83.) Nothing cited by Dr. Sasián suggests that an f-number of 2.8 was desirable in the context of a narrower-angle lens, and nothing suggests that a POSITA would have been motivated to modify Ogino example 5 to reduce both the f-number and the field of view. (*Id.*)

Even if there were some evidence that a POSITA would have considered the result of the modifications that Dr. Sasián performs to Ogino Example 5 to be desirable, he does not show that a POSITA would have actually followed the approach that he describes. (Ex. 2001, Milster Decl., ¶ 84.) In modifying Ogino Example 5, Dr. Sasián kept the number of lens elements, the powers of the lens elements, their thicknesses, and their spacings unchanged, except for a small change to the thickness of the first lens element. (Ex. 1003, Sasián Decl. at 104; Ex. 2001, Milster Decl., ¶ 84.) He made the small change in thickness of the first lens element, from 0.546 mm (Ex. 1005, Ogino Table 9) to 0.600 mm (Ex. 1003, Sasián Decl. at 107) by hand. (Ex. 2003, Sasián Depo. at 24:14–25:10.) By keeping these parameters (nearly) unchanged, Dr. Sasián ensured that the values of EFL, TTL, lens powers, and lens gaps needed to satisfy other claim elements remained unchanged. (Ex. 2001, Milster Decl., ¶ 84.)

In other words, in modifying Ogino Example 5, Dr. Sasián changed the one parameter by hand that needed to be changed to satisfy the claims, the f-number, while forcing the other parameters to stay (nearly) the same, so that the other parameters of the claims did not change. (Ex. 2001, Milster Decl., ¶ 85.)

This approach is a natural approach if the goal is to modify Ogino to satisfy the '897 patent claims, but it is not the approach that a POSITA would actually follow. (Ex. 2001, Milster Decl., ¶ 86.) A lens design such as Ogino Example 5 is defined by more than 100 numerical parameters, shown in tables 9 and 10 of Ogino. (*Id.*) There are a vast number of ways that various combinations of these parameters could be varied. (*Id.*) Further, entire lens elements can be added or removed, substantially increasing the space of available designs. (*Id.*) The section of Dr. Sasián's lens design textbook that discusses using lens design software describes 20 “well-known techniques for modifying and improving a lens” for purposes such as to decrease the f-number. (Ex. 2004, Sasián at 133–134; Ex. 2001, Milster Decl., ¶ 86.) Following these “well-known” techniques might very well have led a POSITA to change Ogino Example 5 in a direction very different from what Dr. Sasián proposes, in a way that did not satisfy any of the claims of the ’897 patent. (Ex. 2001, Milster Decl., ¶ 86.)

But more fundamentally, a POSITA looking at Ogino and seeking to meet the specifications of Bareau would have seen that there were already lens designs in Ogino that nearly did so, such as Example 6, with its f-number of 2.64 and field of view of 2×29.8° = 59.6°. (Ex. 1005, Ogino, Figure 13; Ex. 2001, Milster Decl., ¶ 87.) They would not have been motivated to instead look to modifying Example 5, just to obtain a lens that was ***further*** from Bareau’s specifications than Example 6. (*Id.*)

In addition, a POSITA would have recognized that the lens design that Dr. Sasián created was not manufacturable. (Ex. 2001, Milster Decl., ¶ 88.) That is, the lens has a shape that lens design software such as Zemax will happily perform ray trace calculations on, but that is extremely difficult to construct in a useful physical lens. (*Id.*)

Dr. Sasián has previously offered the opinion that a POSITA would know that the lenses described in Ogino would most likely be made of injection-molded plastic. Specifically, Dr. Sasián noted that:

> While Ogino does not specifically indicate that its lens elements can be plastic, a POSITA would recognize that the index of refraction and Abbe number of the lens elements specified in Example 6 of Ogino are within the range of values of plastic materials used for cell phone lenses.
>
> Further lens elements of the sizes and asphericities described in Ogino would preferably be made of plastic via injection molding processes. See Ex.1019, p.34.14 (pdf p.80). A POSITA would also recognize that when designing lens elements for crafting via injection molding, a number of manufacturing realities apply that all promote maximizing the thickness of the lens element at the edge.

(Ex. 2009, IPR2019-00030 Sasián Decl. at 69; Ex. 2001, Milster Decl., ¶ 89.)

While this earlier statement of Dr. Sasián relates to Ogino Example 6, it applies similarly to Ogino Example 5. (Ex. 2001, Milster Decl., ¶ 90.) For example, the indices of refraction and Abbe numbers for the materials used in Example 5 are the same as those in Example 6 (Ex. 1005, Ogino, Tables 9, 11), indicating that the same plastic materials were used in both examples. (Ex. 2001, Milster Decl., ¶ 90.)

A POSITA would understand that a lens intended for use in a compact camera for a mobile device like Ogino (Ex. 1005, Ogino at 1:7–15) would be made using injection molded plastic. (Ex. 2001, Milster Decl., ¶ 91.) For example, Bareau states that in miniature digital camera modules: "The ***majority of these lenses are all-plastic*** although some incorporate one glass element (usually the front element) for the advantages of high-index refraction and color correction." (Ex. 1012, Bareau at 8.) (Ogino Example 5 does not follow the minority approach of a different non-plastic material for the first lens, as the first and fifth lens both use the same material, Ex. 1005, Ogino, Table 9 (Ex. 2001, Milster Decl., ¶ 91).) Likewise, Clark (one of the authors of the Bareau article) writing about mobile device camera lenses in 2014 wrote: "Conventional lens designs are multi-element injection molded plastic lenses assembled in a plastic barrel, as they were in 2006." (Ex. 2005, Clark at 3; Ex. 2001, Milster Decl., ¶ 91.)

To the extent that glass were used in a lens design such as Ogino's, it would also be molded, as molding is the practical approach to making aspheric lenses, such as those in Ogino:

> One of the primary advantages of molded optics has always been the use of aspheric surfaces. Aspheric surfaces are simply surfaces that are not spherical. Historically, ***most optical surfaces have been spherical (or flat) due to ease of fabrication and testing with the exception of molded optics***. Aspheric surfaces have long been the standard in molded optics, regardless of process, again due to ease of manufacture. The mold manufacturing process is well suited to aspheric manufacturing, and

> only having to cut a small number of molds to make a large quantity of optics made an increase in tooling cost trivial when amortized over a molding run.

(Ex. 2006, Symmons at 6; Ex. 2001, Milster Decl., ¶ 92.)

Dr. Milster has written a chapter in the Handbook of Optics which contains a section on molded glass and plastic optics. (Ex. 2008, Handbook of Optics, Section 7.5.) As he explains there:

> Molded lenses become especially attractive when one is designing an application that requires aspheric surfaces. Conventional techniques for polishing and grinding lenses tend to be time-expensive and do not yield good piece-to-piece uniformity. Direct molding, on the other hand, eliminates the need for any grinding or polishing.

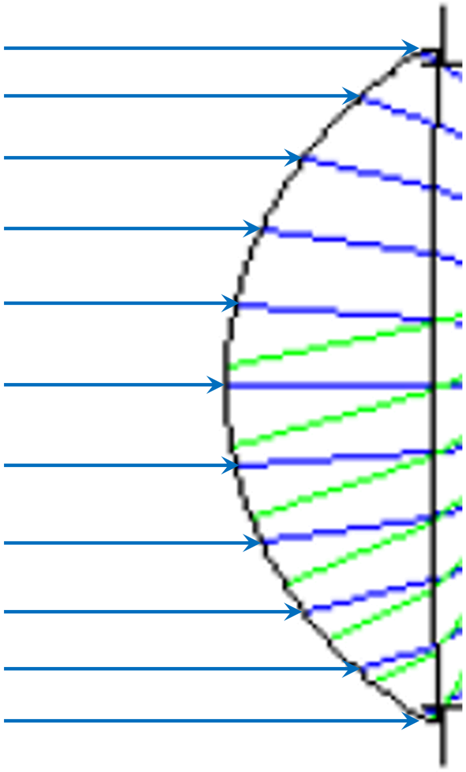
(Ex. 2008, Handbook of Optics, at 7.5–7.6; Ex. 2001, Milster Decl., ¶ 93.)

The modified lenses discussed by Dr. Sasián have the same indices of refraction and Abbe number as in Ogino’s example 5, indicating that these modified lenses would use the same (likely plastic) materials as Ogino. (Ex. 1003, Sasián Decl. at 107, 111; Ex. 1005, Ogino, Table 9; Ex. 2001, Milster Decl., ¶ 94.)

The main manufacturability problems with Dr. Sasián’s f-number 2.8 modification of Ogino concerns the edges of the first lens element:

(Ex. 1003, Sasián Decl. at 107; Ex. 2001, Milster Decl., ¶ 95.)

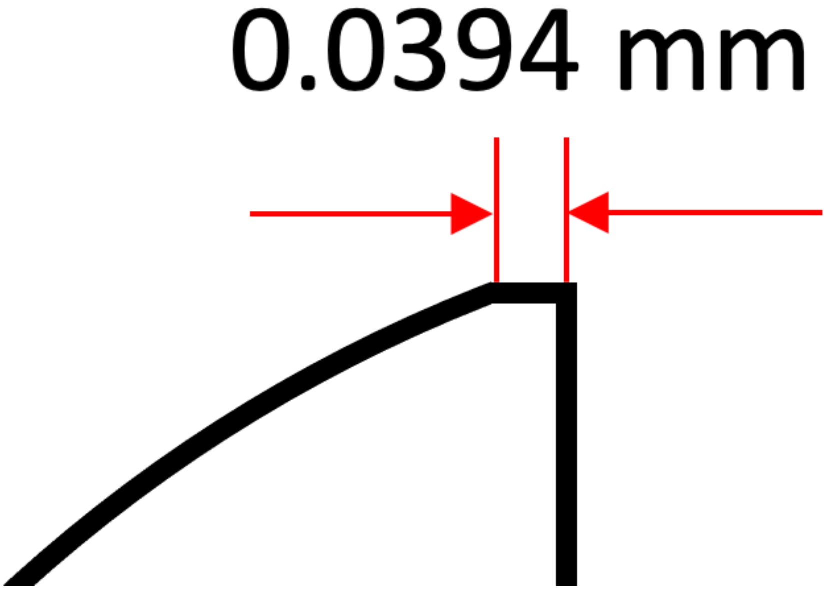
The left surface of this of this excerpt is the object side surface of the first lens. (Ex. 2001, Milster Decl., ¶ 96.) The blue rays of this drawing are the rays of the bundle that defines the entrance pupil. (*Id.*) As the following drawing illustrates, the light forming these blue rays enters as a bundle of parallel rays from the left before being bent by the lens front surface:

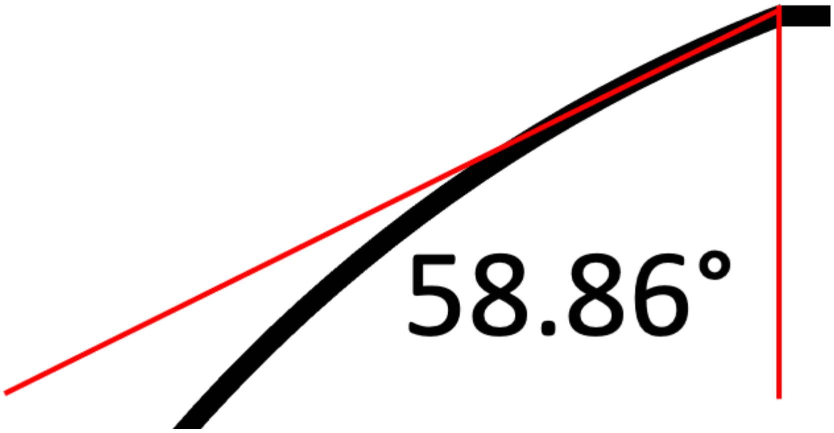


(Ex. 2001, Milster Decl., ¶ 96.)

The entrance pupil diameter (part of the formula for f-number) is the diameter of this bundle of rays, which in turn is nearly the full diameter of the object-side lens surface in this drawing. (Ex. 2001, Milster Decl., ¶ 97.) In other words, this lens element needs to be at least the diameter shown here in order to achieve the f-number = 2.8 that Dr. Sasián sought to obtain. (*Id.*) Put another way, the clear aperture of the first surface needs to be at least as large as shown in this drawing to achieve the f-number Dr. Sasián sought. (*Id.*)

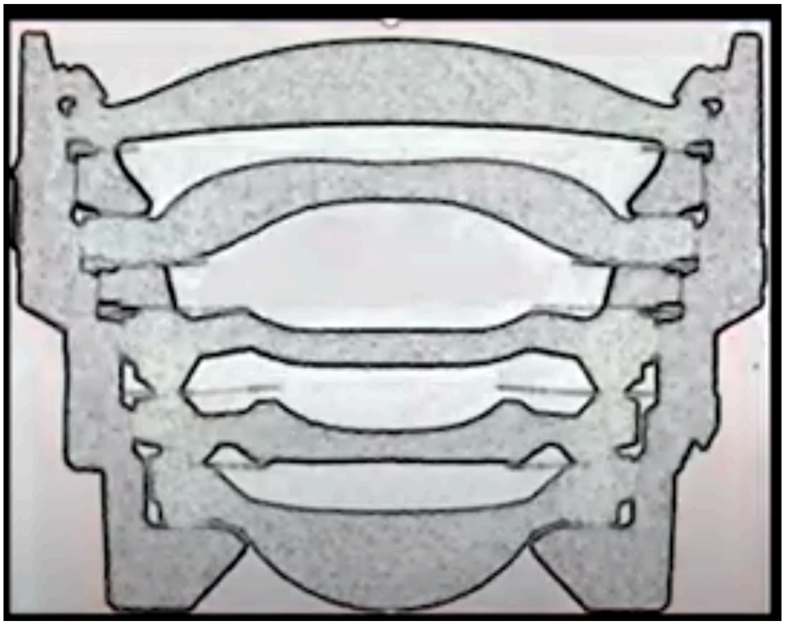
The resulting shape has a very narrow edge and a large slope at that edge. According to Dr. Milster's calculations, the edge thickness is only 0.0394 mm (or 39.4 microns), and the slope is 58.86°:





(Ex. 2001, Milster Decl., ¶ 98, Appx. § XI.A.)

This edge thickness of 39.4 µm (microns) is roughly half the width of a typical human hair, commonly taken to be 75 µm.[1] (Ex. 2001, Milster Decl., ¶ 99.) This is not the edge of a realistic, practical lens. (*Id.*) To see why, it is useful to see an actual commercial lens, as in the following X-ray CT image that Dr. Milster had taken as part of his work prior to this IPR[2]:



(Ex. 2001, Milster Decl., ¶ 99.)

This lens has five plastic elements (gray), with air gaps (white) between them. (Ex. 2001, Milster Decl., ¶ 100.) The bottom of this picture is the object

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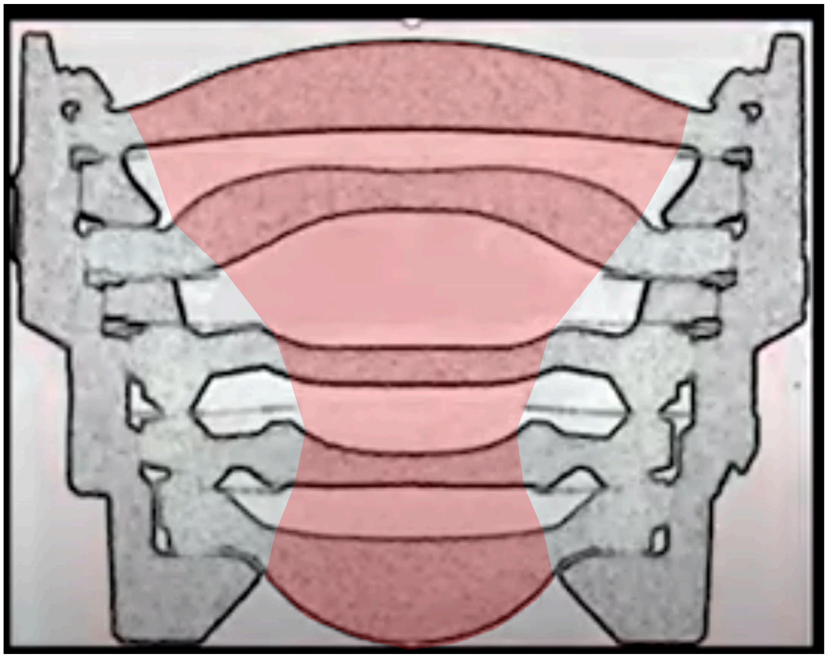
[1] https://en.wikipedia.org/wiki/Hair%27s_breadth

[2] A YouTube video of this work is available at https://www.youtube.com/watch?v=E8nE8aBSiJQ.

side, and the top is the image side. (*Id.*) The portion of the lens that light actually passes through is (very) roughly shown in the red shading below:

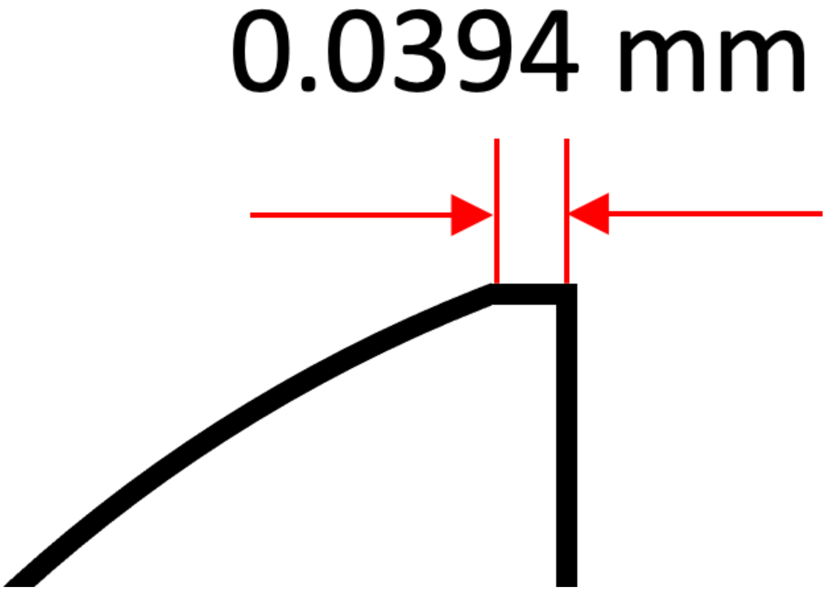


(Ex. 2001, Milster Decl., ¶ 100.)

The thin black structures protruding from left and right are baffles. (*Id.*, ¶ 101.) There are two important things to note concerning the lens elements in this design. (*Id.*) First, each element has a thick mounting flange at its edge, to mount it physically to the roughly cone-shaped lens barrel. (*Id.*) Second, the smoothly curved surfaces in the center of each lens element extend beyond the "clear aperture" where light actually passes through the lens. (*Id.*) Parts of the curved surfaces are in the shadow of the baffles. (*Id.*) In other words, the curved portions of the lens elements are "oversized" relative to their clear apertures. (*Id.*)

Zemax's ray traces are only concerned with the parts of the lens elements that bend light, i.e., with their clear apertures. (*Id.*, ¶ 102.) The oversized portions and the mounting portions of the lenses are not included in the Zemax designs from Dr. Sasián. (*Id.*) But a POSITA would understand they need to be there in the actual lens. (*Id.*)

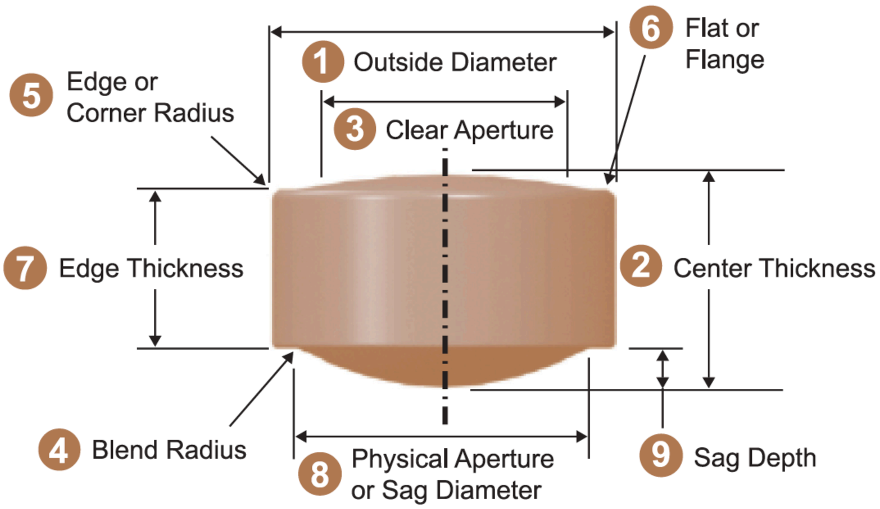
Oversizing is necessary because a lens cannot be made with perfectly sharp corners and edges. (*Id.*, ¶ 103.) In molded lenses, one reason for this is surface tension of the lens material. (*Id.*) If one attempted to inject plastic or glass into a mold with sharp corners such as shown in the Zemax drawing, the liquid would not fill the corners, but would rather form a rounded surface, which would bend light differently than the ideal shape in Zemax:



(Ex. 2001, Milster Decl., ¶ 103.)

In addition, there are limits to the ability to make molds with such sharp corners in the first place, as the diamond-tipped tools typically used to make them have a finite width and are not infinitely sharp. (*Id.*, ¶ 104)

As explained in the Field Guide to Molded Optics, actual molded lenses have rounded corners:



> ❺ **Edge radius** or **corner radius** (R_c)
>
> The radius on the outside diameter due to volumetric molding.

(Ex. 2006, Symmons, pp. 87–88; Ex. 2001, Milster Decl., ¶ 105.)

Even if the surface tension and other limitations of injection molding were not a factor, practical lenses will have rounded or chamfered corners rather than sharp 90° corners, regardless of the technology used to make them. (Ex. 2001, Milster Decl., ¶ 106.) As Dr. Sasián notes in his textbook, "[i]t is imperative that a bevel, or protective chamfer, is specified to avoid the lens edge easily chipping." (Ex. 2004, Sasián at 112; Ex. 2001, Milster Decl., ¶ 106.)

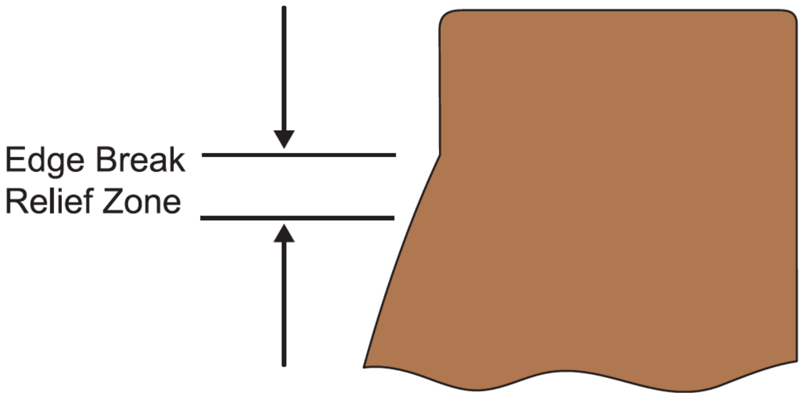
A sharp corner is mechanically much weaker than a rounded or chamfered corner. (Ex. 2001, Milster Decl., ¶ 107.) For example, a Plastics Today article by Glenn Beall explains that a corner with a 0.02-inch radius of curvature can withstand 8 times the impact load of a corner with a 0.01-inch radius of curvature. (Ex. 2007, Beall.) Making extremely sharp corners without chipping the lens is difficult regardless of the manufacturing technique used. (Ex. 2001, Milster Decl., ¶ 107.)

A practical lens design would use an edge shape that permitted oversizing and rounded corners. The importance of oversizing is explained in the Handbook of Optics:

> Surface-tension effects may play a significant role in the accuracy to which a precision optical surface may be molded. Particularly in areas of the part where the ratio of surface area / volume is locally high (corners, edges), surface tension may create nonuniform shrinkage which propagates inward into the clear aperture, resulting in an edge rollback condition similar to that which is familiar to glass opticians. . . . ***These phenomena provide motivation to oversize optical elements, if possible, to a dimension considerably beyond the clear apertures***. A buffer region, or an integrally molded flange provides the additional benefit of harmlessly absorbing optical inhomogeneities which typically form near the injection gate.

(Ex. 1019, Handbook of Optics, Vol. 2 at 34.16; Ex. 2001, Milster Decl., ¶ 108.)

The Field Guide suggests oversizing of around 4-10% for molded plastics:



> Because of the impact of edge break, molders will require the CA size to be smaller than the full optical surface that is molded. The amount of edge relief will depend on the part size, but one millimeter or more in the radial direction is desired for parts of approximately 10 to 25 mm in diameter.
>
> This much relief is often impractical for smaller parts, where it would be a substantial portion of their diameter. In this case, the edge break relief zone will need to scale down with the part size.

(Ex. 2006, Symmons at 103; Ex. 2001, Milster Decl., ¶ 109.)

Dr. Sasián's textbook indicates that even greater degrees of oversizing, 10-20%, are common for traditional polished glass lenses: "A common surface polishing problem is to have the very edge of the surface turned down.

To overcome this figuring problem, there is a tendency to specify a lens diameter larger, say 10–20% larger, than the clear aperture." (Ex. 2004, Sasián at 111; Ex. 2001, Milster Decl., ¶ 110.)

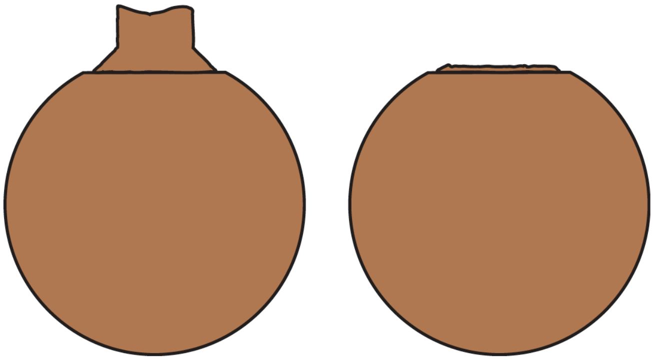
The problem with Dr. Sasián's first modified lens is that the first lens shape leaves no room to oversize or to have rounded or chamfered corners. Given the 0.0394 mm edge thickness and 58.86° slope, the diameter could be increased by less than 0.030 mm before the edge thickness reached zero, i.e., less than 3%. (Ex. 2001, Milster Decl., ¶ 111.) And that assumes that an edge thickness of zero were possible, which it is not. (*Id.*)

These problems are further compounded by the finite precision of manufacturing techniques. (*Id.*, ¶ 112.) For example, the Beich paper cited by Dr. Sasián provides "rules of thumb" for part tolerances of "± 0.020 mm" for center thickness and diameter, "< 0.020 mm" for the "S1 to S2 Displacement," i.e., the displacement between the halves of the mold forming the front and back surfaces of the lens, and "< 0.010 mm" for "wedge," i.e., the difference in edge thickness from one side of the lens to the other. (Ex. 1007, Beich at 7; Ex. 2001, Milster Decl., ¶ 112.) Tolerances for glass molding are similar. (Ex. 2006, Symmons at 95; Ex. 2001, Milster Decl., ¶ 112.) As the Field Guide notes, "high repeatability from component to component" is an advantage of molded lenses over other techniques, so other techniques have tolerance issues as well. (Ex. 2006, Symmons at 2; Ex. 2001, Milster Decl., ¶ 112.)

The presence of center thickness variation and "wedge" in the molded parts makes the tiny edge thickness more problematic. (Ex. 2001, Milster Decl., ¶ 113.) A Zemax edge thickness of 0.039 mm becomes a thickness ranging from perhaps 0.015 mm to 0.065 mm in practice. (*Id.*)

Manufacturing tolerances add up. (Ex. 2001, Milster Decl., ¶ 114.) For example, the semi-diameter of the first lens object side in the f-number 2.8 modification of Ogino is 1.0175 mm, while the aperture stop has a semi-diameter of 0.9751 mm, for a difference of only 0.0424 mm. (*Id.*) If the lens diameter has a variation of ± 0.020 mm, the lens has a position offset of 0.020 mm, and the aperture stop (likely made by molding or punching) has similar tolerances, these four variances add under the root sum square rule to yield an error that goes as the square root of the number of errors. (*Id.*; Ex. 2004, Sasián at 116–117.) Even if the first lens is slightly oversized, these additive errors can easily lead to a situation where there is an open gap between the first lens and the aperture, allowing light to leak through and adding a diffuse haze to the image, something that is highly undesirable. (Ex. 2001, Milster Decl., ¶ 114.)

The less-than-hair's-width edge of the first lens causes at least two further problems. (Ex. 2001, Milster Decl., ¶ 115.) First, as explained in Symmons, the injected liquid comes into the mold via runners from the side. (*Id.*) After the part is formed, these now-solid runners must be removed: "It is then cut from the runner/gate system in a process known as degating. The degating process is not perfect and results in residual material being left on the edge of the part. This remaining plastic is called gate vestige." (Ex. 2006, Symmons at 100.) This means that the edge has to be thick enough to provide room for the liquid to flow into the mold and also needs to have space outside the clear aperture to accommodate the imperfect cut of the gate vestige:



(Ex. 2006, Symmons at 100; Ex. 2001, Milster Decl., ¶ 115.)

Bareau recognizes this problem when it refers to "element edge thicknesses shrinking to the point where the flow of plastic is affected." (Ex. 1012, Bareau at 1; Ex. 2001, Milster Decl., ¶ 116.) The tiny edge thickness of Dr.

Sasián's modified lens simply does not have enough room to allow for proper flow of the liquid or to accommodate runners and degating. (Ex. 2001, Milster Decl., ¶ 116.)

The microscopic edge also poses a major problem for mounting the lens element. (Ex. 2001, Milster Decl., ¶ 117.) Any extension or flange of this lens must have at least a portion that is as thin as the edge thickness of the clear aperture, i.e., 0.0394 mm. (*Id.*) Such thin flanges will be difficult to form and regardless of how they are made will be vulnerable to chipping and cracking. Indeed, the Field Guide refers to an injection molded plastic lens with a minimum thickness of "on the order of a few hundred microns" as "extremely small." (Ex. 2006, Symmons 102; Ex. 2001, Milster Decl., ¶ 117.) Dr. Sasián proposes a minimum thickness of a few tens of microns, roughly a factor of ten thinner than what the Field Guide considers "extremely small." (Ex. 2001, Milster Decl., ¶ 117.)

These many issues with thin lens edges lead to a rule of thumb in the Beich paper, which Dr. Sasián himself cites as something that a POSITA would be motivated to follow: the "Center Thickness to Edge Thickness Ratio" should be less than 3:1. (Ex. 1007, Beich at 7; Ex. 1003, Sasián Decl., ¶ 78.) Dr. Sasián's textbook gives a similar rule of thumb, saying "the ratio of lens central thickness to edge thickness should be larger than 3.2." (Ex. 2004, Sasián at 194.) Dr. Milster's chapter in the Handbook of Optics likewise says to use "a center/edge thickness ration less than 3." (Ex. 2008, Handbook of Optics at 7.11.) By contrast, Dr. Sasián's design has a ratio of 0.6 mm / 0.039375 mm = 15.238, far outside the range of what a POSITA would consider manufacturable. (Ex. 2001, Milster Decl., ¶ 118.)

While that rule of thumb applies to plastic lenses, a POSITA would recognize that the tiny edge thickness is similarly problematic for glass lenses. (Ex. 2001, Milster Decl., ¶ 119.) For example, the Field Guide states that "Very small edge thicknesses (<0.4 mm) should be avoided, as these lenses become very difficult to handle and can chip easily." (Ex. 2006, Symmons at 90; Ex. 2001, Milster Decl., ¶ 119.) This chipping issue is not unique to molded glasses, but will also apply to glass lenses formed other ways. Bareau recognizes this as a general problem for glass lenses when it warns that "[f]or glass elements, the edge thicknesses will become too thin to be fabricated without chipping." (Ex. 1012, Bareau at 1; Ex. 2001, Milster Decl., ¶ 119.) A POSITA would recognize that the edge of Dr. Sasián's lens (0.0394 mm) is too small by a factor of ten for a glass lens. (Ex. 2001, Milster Decl., ¶ 119.)

Also problematic for molded glass is the steep slope of the modified lens, 58.86°. (Ex. 2001, Milster Decl., ¶ 120.) As the Field Guide states:

> The slope of a lens surface should be kept less than 55 deg for PGM. High slopes create difficultly in mold manufacture and testing. Very steep surfaces can be difficult to manufacture and difficult to measure. Precision diamond grinding is limited to just under 55 deg, but the maximum angle varies based on final geometry and manufacturer. Many surface profilometers cannot measure surfaces this steep and begin to lose accuracy at high angles.

(Ex. 2006, Symmons at 94; Ex. 2001, Milster Decl., ¶ 120.)

While this discussion appears in the section on glass molding, each of these problems applies equally to molding plastic and indeed to almost any manufacturing technique. (Ex. 2001, Milster Decl., ¶ 121.) For example, Bareau states that for plastic molding, "the maximum slope that can be diamond-turned in mold inserts and measured in either the lens or the mold is around 45 degrees." (Ex. 1012, Bareau at 8; Ex. 2001, Milster Decl., ¶ 121.) A POSITA would recognize that the 58.86° slope in Dr. Sasián's modified lens is not practical. (Ex. 2001, Milster Decl., ¶ 121.)

As this section shows, the first lens in Dr. Sasián's f-number 2.8 modification of Ogino requires unrealistic manufacturing tolerances, poses practical difficulties in manufacturing, will be vulnerable to chipping and cracking, and will suffer from significant optical defects. (*Id.*, ¶ 122.) A POSITA who had read Dr. Milster's chapter or Dr. Sasián's book would recognize that it violates manufacturing rules of thumb. (*Id.*)

Both the '897 patent and Ogino depict lenses of the type of the POSITA would actually consider manufacturable, with curved surfaces that are oversized beyond the clear apertures and with relatively thick edges that facilitate accurate manufacture and mounting:

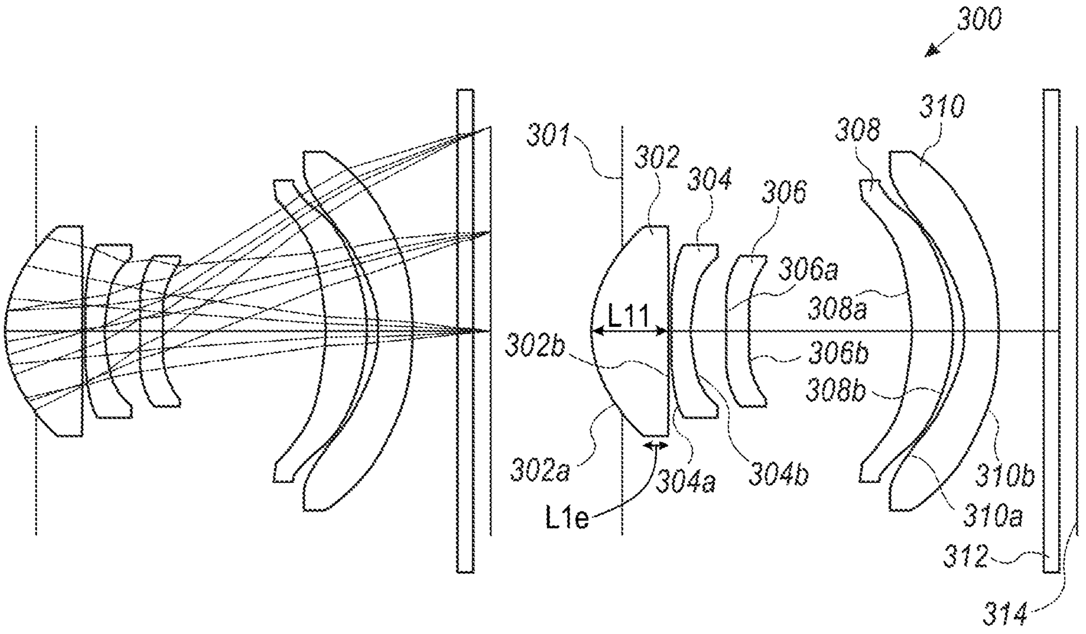
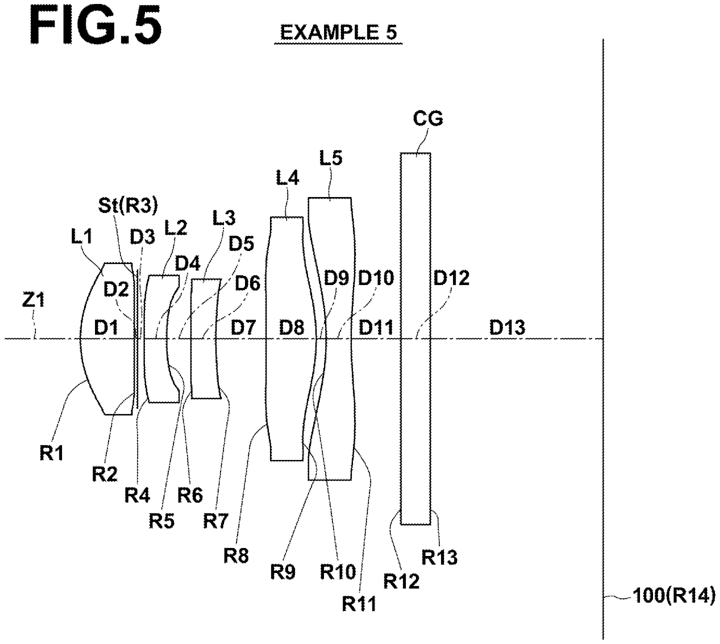


FIG. 3A

FIG.5



(Ex. 1001, ’897 patent, Figure 3A; Ex. 1005, Ogino, Figure 5; Ex. 2001, Milster Decl., ¶ 123.)

As noted above, the POSITA would not be motivated to reduce the f-number of Ogino Example 5 in the first place, because Ogino has multiple other lens designs that would be more suitable. (Ex. 2001, Milster Decl., ¶ 124.) But, as Dr. Milster explains, “if a POSITA did attempt to modify Example 5, and the best that they could achieve was this unmanufacturable design, unsuitable for use in mobile devices of the type addressed by Ogino and Bareau, the POSITA would wisely have abandoned the effort.” (*Id.*)

B. Ground 3 – Claims 3, 8, 19, and 24 Are Not Obvious over Ogino in view of Bareau and Kingslake

Apple and Dr. Sasián propose a further modification to Ogino Example 5 to satisfy the limitations of claims 3, 8, 19, and 24. These claims add two limitations that are not satisfied by the first modification to Ogino: an image-side surface diameter between 2.3 mm and 2.5 mm for the first lens element (claims 3 and 19) and a convex image-side surface (claims 8 and 24). (Ex. 2001, Milster Decl., ¶ 125.)

The image-side surface diameter of the first lens element in the first modification of Ogino is 2×0.98943 = 1.97886 mm, outside the range required by claims 3 and 19. (Ex. 2001, Milster Decl., ¶ 126.) This image-side surface is also concave, as shown by the positive value of the radius of curvature (252.97534) in Dr. Sasián's lens prescription. (Ex. 1003, Sasián Decl. at 107; Ex. 2001, Milster Decl., ¶ 126.) The fact that the first lens element has a concave image-side surface is a feature of every example in Ogino and is described by Ogino as a defining feature of its invention. (Ex. 2001, Milster Decl., ¶ 126.)

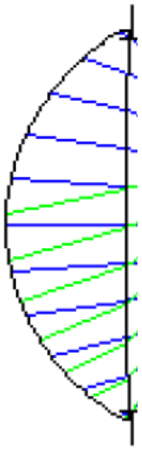
Ogino explains that its invention uses a first lens that "has a positive refractive power and has a meniscus shape which is convex toward the object side." (Ex. 1005, Ogino, Abstract, 13:5:10.) Ogino explains its reason for including this feature:

> by making the first lens L1, which is a lens closest to the object, have a positive refractive power and have a meniscus shape which is convex toward the object side in the vicinity of the optical axis, the position of the rear side principal point of the first lens L1 can be set to be close to the object, and ***thus it is possible to appropriately reduce the total length***

(Ex. 1005, Ogino at 7:31–37; Ex. 2001, Milster Decl., ¶ 127.)

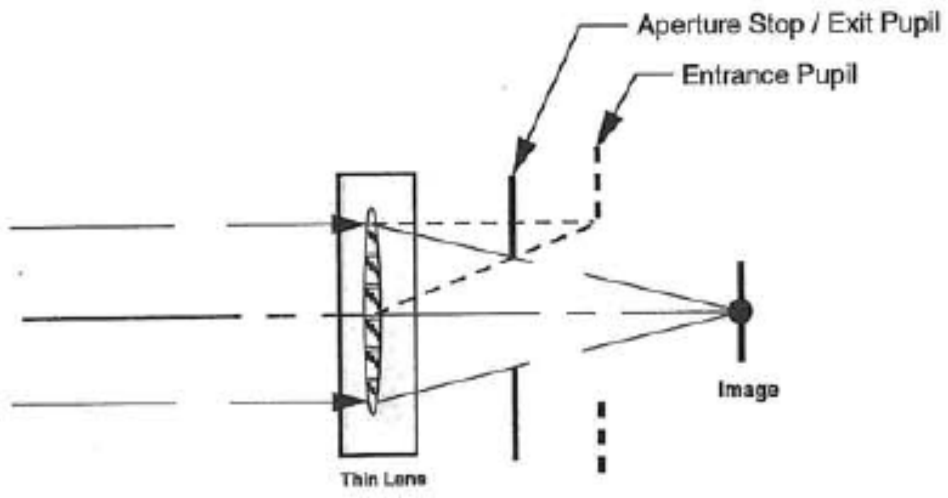
A "meniscus" shape is one that is convex on one side and concave on the other, meaning that a meniscus lens that is convex toward the object side necessarily is concave toward the image side. (Ex. 2001, Milster Decl., ¶ 128.) Dr. Sasián explains how the meniscus lens convex toward the object side in each of Ogino's examples has a concave image-side surface in his analysis of claim 6. (Ex. 1003, Sasián Decl. at 63–66; Ex. 2001, Milster Decl., ¶ 128.)

So, in order to satisfy these limitations of claims 3, 8, 19, and 24, Dr. Sasián had to substantially change the shape of the first lens element, making it much larger, and changing the image side from concave to convex, among other changes:



(Ex. 1003, Sasián Decl. at 104 and 108; Ex. 2001, Milster Decl., ¶ 129.) Indeed, every single parameter of this lens element was changed except for the lens material. (Ex. 2003, Sasián Depo. at 48:15–24; Ex. 2001, Milster Decl., ¶ 129.)

If the goal is to increase the image-side surface diameter to be greater than 2.3 mm, that can be done in Zemax (or similar software) by increasing the entrance pupil diameter, as increasing the size of the bundle of rays entering the first lens element more-or-less mechanically requires that the first lens element, including its image-side surface, become larger:



(Ex. 1016, Walker, p. 61; Ex. 2001, Milster Decl., ¶ 130.)

Likewise, if the goal is to make the image-side surface convex, that can be done by hand. (Ex. 2001, Milster Decl., ¶ 131.) But the fact that these changes are possible does not explain ***why*** a POSITA would make these specific changes, out of all the many parameters of the design they could change. (*Id.*)

Dr. Sasián's declaration and testimony are very unclear on what process he used, let alone why he used that process. (Ex. 2001, Milster Decl., ¶ 132.) The result of his changes has an image-side surface diameter of 2×1.17086 ≈ 2.34 mm and a convex image-side surface. (Ex. 1003, Sasián Decl. at 108; Ex. 2001, Milster Decl., ¶ 132.) The stated reason for the modifications was to further reduce f-number below 2.8. (Ex. 1003, Sasián Decl., ¶¶ 61–64.) Dr.

Sasián cites general statements suggesting lower f-numbers are desirable, but the only specific f-numbers that he points to that are less than 2.8 are the f-numbers in example 1–3 and 6 of Ogino. (Ex. 1003, Sasián Decl., ¶ 62; Ex. 2001, Milster Decl., ¶ 132.)

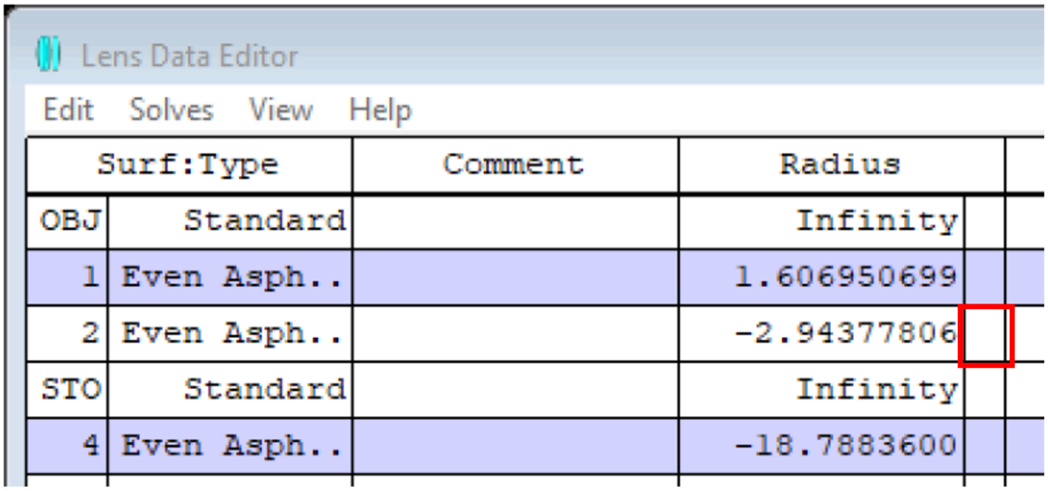
As explained above, if the goal of a POSITA aware of Ogino was to use a lens with small f-number such as 2.45, the natural and obvious thing to do would be to use one of Ogino's small f-number examples, not to take the example with the largest f-number and modify it beyond recognition. (Ex. 2001, Milster Decl., ¶ 133.) However, even if the small f-number examples in Ogino did suggest to a POSITA that they should reduce the f-number of Example 5, they would not suggest reducing it to be even lower than 2.45. (*Id.*)

According to Dr. Sasián's declaration, the second modification of Ogino has an f-number of 2.12. (Ex. 1003, Sasián Decl. at 108.) This value is consistent with his values of EFL = 5.49 and EPD = 2.59, because 5.49 / 2.59 = 2.12. (Ex. 2001, Milster Decl., ¶ 134.) This suggests that these numbers actually came from some calculation in Zemax or elsewhere and are not simply a typographical error. (*Id.*)

Right after the lunch break during his deposition, Dr. Sasián volunteered that the values on page 108 of his declaration should actually be EPD = 2.239

and f-number = 2.45, based on a file that he found on a backup drive during the break. (Ex. 2003, Sasián Depo. at 58:23–59:16.) Corephotonics made timely objections to this testimony, based on unproduced backup files, and it maintains those objections. (Ex. 2003, Sasián Depo. at 62:11–20; *see* Ex. 2001, Milster Decl., ¶ 135.)

It is similarly unclear how Dr. Sasián obtained a design with a convex image-side of the first lens. (Ex. 2001, Milster Decl., ¶ 136.) The blank box to the right of the radius of curvature for this image-side surface indicates that this value was fixed (and thus that that surface was fixed to be convex) during the run of Zemax that produced the screen capture:



Surf:Type		Comment	Radius	
OBJ	Standard		Infinity	
1	Even Asph..		1.606950699	
2	Even Asph..		-2.94377806	
STO	Standard		Infinity	
4	Even Asph..		-18.7883600	

(Ex. 1003, Sasián Decl. at 111; Ex. 2003, Sasián Depo. at 49:20–50:16; Ex. 2001, Milster Decl., ¶ 136.)

So, in this particular Zemax optimization, the output had a convex image-side of the first lens because that property had been fixed in place. (Ex. 2001, Milster Decl., ¶ 137.) Dr. Sasián testified that this value had "most likely" been produced by a Zemax optimizer in an earlier stage of his work. (Ex. 2003, Sasián Depo. at 49:20–50:1.) But he could not remember any of the details of how he had generated those values, answering a series of questions about this with "probably," "perhaps," "I don't remember exactly the sequence," "it appears," "I don't recall," etc. (Ex. 2003, Sasián Depo. at 50:18–53:9.) Nothing in his declaration explains these details, either. (Ex. 2001, Milster Decl., ¶ 137.)

At most, the declaration shows that Dr. Sasián, a highly experienced lens designer with a copy of the '897 patent claims in front of him, was able to create a lens system that completely replaced the first lens of Ogino Example 5 with a very different lens that satisfied claims 3, 8, 19, 24. (Ex. 2001, Milster Decl., ¶ 138.) In the process he ignored Ogino's own teachings about the importance of the meniscus-shaped first lens to reduce the total length. (*Id.*)

However, Dr. Sasián does not explain why ***he*** did it or how he did it in 2020, let alone why a ***POSITA*** would have been motivated to make these changes years earlier. (Ex. 2001, Milster Decl., ¶ 139.) For example, he does not cite to any example of a system with a bi-convex lens that would have motivated the POSITA to try this approach, and he doesn't explain any benefits that flow from this change. (*Id.*) Indeed, the only reason he gives for changing the radii of curvature of the first lens at all (let alone flipping one from a concave positive radius to a convex negative radius) is a vague statement that he did it "due to the location of the aperture." (Ex. 1003, Sasián Decl. at 108; Ex. 2001, Milster Decl., ¶ 139.)

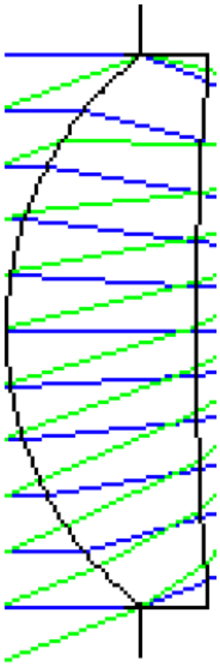
Dr. Sasián's declaration shows that a highly-skilled designer, of considerably beyond ordinary skill, could have designed a lens that met claims 3, 8, 19, and 24 if given that specific task. (Ex. 2001, Milster Decl., ¶ 140.) He provides no explanation for why a POSITA would have made the specific changes he made the first lens of Example 5, or why that POSITA would have even started with Ogino's f-number 3.94 lens if her goal were to have a lens with an f-number that matched Ogino's other examples. (*Id.*)

C. Ground 4 – Claims 16 and 30 Are Not Obvious over Chen in view of Iwasaki and Beich

A POSITA would not have been motivated to make the combination proposed by Dr. Sasián for ground 4, for many of the same reasons as explained in the above discussion of ground 2. (Ex. 2001, Milster Decl., ¶ 141.) The combination of Chen, Iwasaki, and Beich uses a first lens taken from Chen's first example. (Ex. 1003, Sasián Decl., ¶ 74, p. 115; Ex. 1020, Chen, Figure 24.) However, Chen does not specify the diameter or the edge thickness of this lens. (Ex. 2001, Milster Decl., ¶ 141.)

Dr. Sasián suggests that a POSITA would choose a semi-diameter for this first lens (or at least for its object-side surface) of 1.2375 mm, barely 0.004 mm larger than the semi-diameter of the stop, 1.2333 mm. (Ex. 1003, Sasián Decl. at 115; Ex. 2001, Milster Decl., ¶ 142.) He finds that this lens would have a center-to-edge thickness ratio of 2.92, just under the value of 3 required by claims 16 and 30. (Ex. 2001, Milster Decl., ¶ 142.)

This diameter is essentially the smallest that it could be without disrupting other characteristics of Chen that Dr. Sasián relies upon, such as its f-number. (Ex. 2001, Milster Decl., ¶ 143.) The entrance pupil diameter equals the width of the bunch of parallel blue rays entering the lens from the left, shown in Dr. Sasián's ray trace:



(Ex. 1003, Sasián Decl. at 112; Ex. 2001, Milster Decl., ¶ 143.)

As this shows, the bundle, and thus the entrance pupil, extends all the way across the left surface of the lens. (Ex. 2001, Milster Decl., ¶ 144.) Apple has not proposed making the lens smaller, but if it had, the lens cannot be made smaller without reducing the entrance pupil diameter and increasing the f-number. (*Id.*)

Likewise, Apple has not proposed making the lens larger. But, if it had, the largest that the lens semi-diameter could be without increasing the center-to-edge thickness ratio above 3 would be less than 1.249 mm, approximately

0.012 mm larger (less than 1% larger) than Dr. Sasián proposes. (Ex. 2001, Milster Decl., ¶ 145, Appx. § XI.B.)

As explained above, the manufacturing tolerances of lens fabrication do not permit a design such as this. (Ex. 2001, Milster Decl., ¶ 146.) According to Dr. Sasián, a POSITA would have made this lens using injection molded plastic and would have been motivated to choose this lens diameter based on the Beich paper. The Beich paper also says that the tolerance for the diameter of the lens is "± 0.020 mm," and that the displacement between the front surface of the lens and the back surface is "< 0.020 mm." (Ex. 2001, Milster Decl., ¶ 146.)

As noted above, the semi-diameter of the first lens is only 0.004 mm larger than the stop. (Ex. 2001, Milster Decl., ¶ 147.) If the lens is too small by 0.020 mm in diameter (0.010 mm in semi-diameter), this will make the semi-diameter of the first lens ***smaller*** than the semi-diameter of the stop by 6 μm. This is even without taking into account other sources of variation in the diameter of the stop and the alignment of the components. (*Id.*) A first lens smaller than the stop will mean that light will leak and scatter around the lens and cause a haze in the image that is highly undesirable. (*Id.*) For this reason alone, a POSITA would make the first lens from Chen larger in diameter than Dr. Sasián proposes, something that Dr. Sasián does not consider. (*Id.*)

But even if Dr. Sasián had proposed increasing the size of the lens to be as large as possible while keeping the thickness ratio under 3, the largest possible semidiameter (under 1.249 mm) would be less than 0.016 mm larger than the stop. (Ex. 2001, Milster Decl., ¶ 148.) A POSITA would recognize that this is unacceptable, given the multiple sources of manufacturing variation of the order of 0.010 mm in semi-diameter and adding under the root sum square rule. (Ex. 2004, Sasián at 116–117; Ex. 2001, Milster Decl., ¶ 148.)

The lens is unacceptable even without taking into account the need to oversize “considerably beyond the clear apertures” (Ex. 1019, Handbook of Optics, Vol. 2 at 34.16.) or by around 4–10% (Ex. 2006, Symmons at 103), or the need for room for rounded corners, discussed in connection with ground 2. (Ex. 2001, Milster Decl., ¶ 149.)

Oversizing the 1.2374 mm semi-diameter surface by even 1% (far less than is required in practice) would make it 1.2499 mm in semi-diameter and would make the center-to-edge thickness ratio greater than 3. (Ex. 2001, Milster Decl., ¶ 17, Appx. § XI.B.)

For these reasons, a POSITA would recognize that the combination of Chen, Iwasaki, and Beich proposed by Dr. Sasián would not be a practical lens, based on the very manufacturing rules of thumb in Beich, among other reasons. (Ex. 2001, Milster Decl., ¶ 151.) Even if a POSITA was motivated to make a lens with center-to-edge thickness ratio less than 3, that POSITA would not have been motivated to make the Chen Example 1 lens with that ratio, as proposed by Dr. Sasián. (*Id.*)

IX. CONCLUSION

For the reasons set forth above, Corephotonics respectfully requests that the Board affirm the validity of claims 2, 3, 5, 6, 8, 16, 18, 19, 21–24, and 30 of the ’897 patent.

Dated: February 12, 2021

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CERTIFICATE OF SERVICE

I hereby certify that "Patent Owner's Response" was served on February 12, 2021 by email sent to:

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