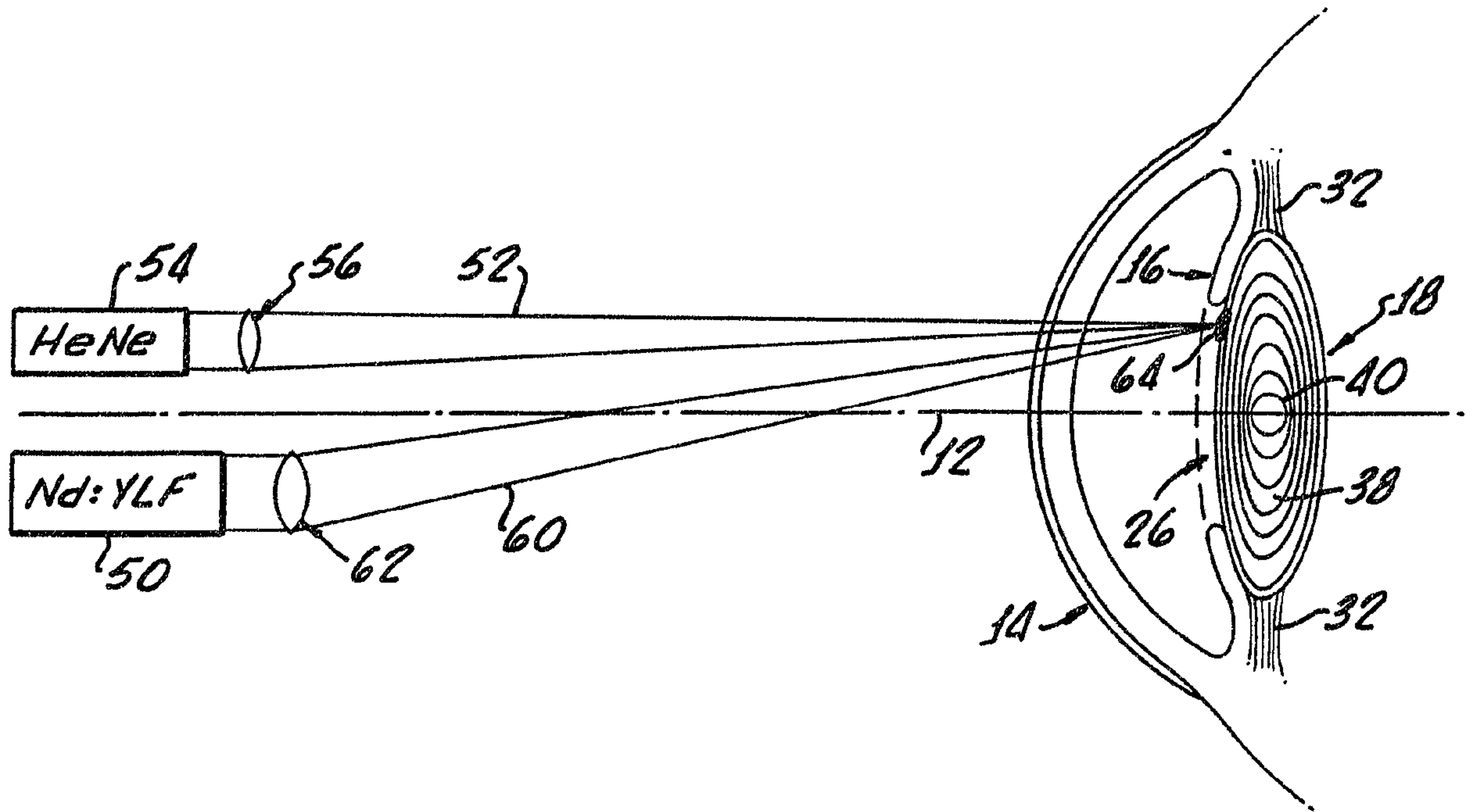




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(54) Titre : METHODE DE PHOTOABLATION DE TISSUS LENTICULAIRES POUR CORRIGER LES PROBLEMES DE VISION
 (54) Title: METHOD OF LASER PHOTOABLATION OF LENTICULAR TISSUE FOR THE CORRECTION OF VISION PROBLEMS



(57) Abrégé/Abstract:

The invention relates to photoablation of ocular lens tissue with a pulsed laser beam without causing substantial damage to surrounding tissue regions.

ABSTRACT

The invention relates to photoablation of ocular lens tissue with a pulsed laser beam without causing substantial damage to surrounding tissue regions.

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METHOD OF LASER PHOTOABLATION OF LENTICULAR TISSUE
5 FOR THE CORRECTION OF VISION PROBLEMS

BACKGROUND OF THE INVENTION:

10 Field of the Invention:

The present invention relates generally to the field of photoablation of ocular tissue to correct vision deficiencies and treat other vision-impairing ocular problems, and, more particularly, to treatment
15 of the natural ocular lens.

Background Discussion:

Historically, and until only a few decades ago, eye-glasses (i.e., spectacles) were exclusively used
20 for most correctable vision deficiencies, including, for example, hyperopia (wherein incident parallel rays of light converge to focus behind the retina), myopia (wherein incident parallel rays of light converge to a focus in front of the retina), and astigmatism (a
25 defect in vision ordinarily caused by irregularities in the cornea). However, in about the 1940s, contact lenses started being used as a viable alternative, at least for many individuals, to the use of spectacles for correcting vision deficiencies, and provided--often
30 at a cost of some discomfort--freedom from many annoyances and appearance problems associated with the wearing of spectacles.

Another method for treating some types of problems causing vision problems was introduced by Dr. Peter
35 Ridley just after the close of World War II. This new (although there is some evidence that it had been tried

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5 several hundred years ago) method involved the replacement of a diseased natural ocular lens, for example, a natural lens which had been clouded because of cataract, with a plastic artificial or prosthetic intraocular lenses (IOL). Such lens extraction and IOL implantation is now a commonly-performed surgical procedure and is credited with saving the sight of many individuals who were or would have become blind.

10 Vision correction can now be achieved on some patients, especially those with myopia, by a surgical procedure on the cornea called radial keratotomy (RK). In an RK procedure, several slits, for example about five, are made radially inwardly toward the optical axis from the peripheral edge of the cornea. These
15 radial slits enable the cornea to flatten out a bit, thereby decreasing the curvature of the cornea. Candidates for RK procedures are typically near-sighted individuals who cannot or who do not want to wear either spectacles or contact lenses.

20 Corneal onlays or implants, which may be constructed of synthetic materials or from donor corneas, are surgically attached to or implanted into patients' eyes, are also useful to enhance vision in patients whose corneas have been damaged and/or scarred
25 by corneal diseases, such as ulcers or cancer, or by injury to the cornea.

30 Due to shortcomings associated with RK surgery and a desire to provide vision correction to many individuals without the necessity for those individuals to wear spectacles or contact lenses, considerable research and development has been directed over the past several years to apparatus and techniques for reshaping the anterior (forward) surface of the cornea. Excimer lasers--lasers operating in the ultraviolet

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(UV) region of less than about 200 nanometers wavelength--have thus now been used to selectively ablate regions of the cornea to resculpt the cornea of patients in a manner correcting certain vision problems. For example, regions of the cornea around its optical axis are photoablated to a greater depth than peripheral regions of the cornea, thereby decreasing the curvature of the cornea to correct myopia. In contrast, photoablation of the cornea is concentrated near the periphery of the cornea to increase the curvature of the cornea and thereby correct for hyperopia. In a related manner, astigmatism can be corrected by selectively varying the rate of laser photoablation of an astigmatic cornea in a manner providing an appropriate vision correction. In this regard, U.S. patent No. 4,784,135 to Blum, et al., discloses a method for removing biological tissue by irradiation the tissue with UV radiation; while, for example, U.S. patent Nos. 4,665,913; 4,669,466; 4,718,418; 4,721,379; 4,729,372; 4,732,149; 4,770,172; 4,773,414; and 4,798,204 to L'Esperance disclose apparatus and methods for laser sculpting of corneal tissue to correct vision defects. In addition, U.S. patent No. 4,842,782 to Portney, et al. and No. 4,856,513 to Muller (as well as one or more of the above-cited L'Esperance patents) disclose masks useful for selectively controlling the laser beam intensity or total laser beam energy to different regions to thereby enable selective corneal ablation to effect the desired vision correction. Various of the above-cited patents to L'Esperance also disclose methods for determining the required laser ablation profile for the cornea; for example, patent No. 4,995,913 discloses computer

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mapping of the cornea and computer-controlled scanning of the cornea by the laser beam.

5 In spite of reported short-term medical successes--both in clinical testing in the United States and in use in unregulated foreign countries--with laser photoablation of corneal tissue to correct vision deficiencies, the verdict is still not in concerning the long-term effects and efficacy of corneal laser photoablation. In particular, questions have been raised whether over a long term the vision correction initially provided by photoablation of the cornea will remain effective because of the normal regrowth of the removed epithelium layer of the cornea over the ablated area. In this regard, there seems to be at least some natural tendency for the epithelium layer to regrow in a manner that, in time, the pre-ablation contour of the cornea may be reestablished or sufficiently so that vision re-correction is required. An ancillary question is, therefore, how many times and how frequently can a laser photoablation process be repeated. Also there have been reports of haze forming on the cornea after photoablation; although this appears to be a relatively transient phenomena--lasting only a few months and ordinarily not too bothersome to the patient--at the present there has been insufficient post-ablation time on any patients to determine long term effects. Moreover, it appears that there may be a maximum diopter change--around five diopters--that can presently be effectively and predictably made by corneal photoablation. Still further, at least at present, the laser ablation of corneal tissue is extremely painful to the patient on which the surgical procedure is performed.

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Further with respect to laser photoablation of the cornea, it should be appreciated that although in so doing the cornea is sculpted in a manner correcting vision, it is frequently the case that the cornea is not itself responsible for the vision problems being corrected. As an illustration, myopia may more likely be caused by an increase in lens size, usually as a natural effect of the human ageing process, of the natural lens of the eye (located posteriorly of the cornea). Other vision defects or deficiencies may also originate at the natural lens, while the associated cornea may itself be in a normal condition.

For these and other reasons, and for the reason that because the lens is closer to the retina than is the cornea, less material would have to be removed from the lens to achieve a similar vision correction, the present inventor has determined that it would often be preferable to reprofile the natural lens over reprofiling the cornea. Such natural lens reprofiling would eliminate many of the concerns presently raised about corneal photoablation and may result in reduced risks to patients, and since the lens has no nerve supply, the procedure should result in no sensation of pain to the patient. It is, therefore, a principle objective of the present invention to provide a method for laser ablation of selected regions of the natural lens in order to correct vision problems and to correct problems, such as incipient cataract, on the lens.

30 SUMMARY OF THE INVENTION:

According to the present invention, there is provided a method for the laser photoablation of ocular lens tissue, the method comprising the steps of

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determining the region of the lens tissue to be photoablated, and directing a pulsed laser beam at such region with an amount of energy effective for photoablating the region without causing substantial damage to surrounding tissue regions. Preferably, the laser is a Nd:YLF laser having an operating frequency in the infrared spectrum and more preferably having an operating frequency of about 1053 nanometers. The laser preferably has a repetition rate of between about 1 and about 1000 Hertz, and more preferably about 1000 Hertz; and operates with a pulse width of between about 1 femtosecond and about 1 millisecond and, more preferably, about 60 picoseconds. Moreover, the laser preferably operates at an energy level of between about 1 nanojoule and about 50 millijoules per pulse and, more preferably, about 30 microjoules. Still further, the laser preferably operates with a beam spot diameter of between about 1 micron and about 100 microns and, more preferably, with a beam spot diameter of about 20 microns. The laser preferably operates with a zone of effect of less than about 200 microns and, more preferably with a zone of effect of less than about 50 microns.

In accordance with one embodiment of the invention, a method is provided for the laser photoablation of ocular lens tissue for the correction of myopia, hyperopia or presbyopia. In this case, the method comprises the steps of determining the region of the lens tissue to be photoablated, calculating the amount of lens tissue to be photoablated from the determined region; and directing the pulsed infrared laser beam at the region with an amount of energy effective for photoablating the calculated amount of lens tissue in the determined region without causing

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substantial damage to lens tissue surrounding such region.

5 In another embodiment of the invention, a method is provided for the laser photoablation of ocular lens tissue for the removal of incipient cataract, the method comprising the steps of determining the region of the lens tissue to be photoablated so as to remove the incipient cataract; calculating the amount of lens tissue to be photoablated from the determined region so as to remove the incipient cataract; and directing the pulsed infrared laser beam at the region with an amount of energy effective for photoablating the calculated amount of lens tissue in the determined region so as to remove the incipient cataract without causing
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15 substantial damage to lens tissue surrounding such region.

BRIEF DESCRIPTION OF THE DRAWINGS:

20 The present invention can be more readily understood by a consideration of the following detailed description when taken in conjunction with the accompanying drawings, in which:

25 FIG. 1 is a longitudinal cross sectional drawing of a representative eye showing, in simplified form, the cornea, iris, natural lens and retina, and showing the manner in which an image is focused on the retina in a normal eye.

30 FIG. 2 is an enlarged, longitudinal cross sectional drawing of a normal lens showing, in simplified form, its composition; and

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5 FIG. 3 is a simplified, longitudinal cross sectional drawing--similar to FIG. 1--showing the manner in which the natural lens has regions thereof photoablated using, for example, a Nd:YLF laser operating at a frequency of about 1053 nanometers and operating at a repetition rate of about 1000 pulses per second, FIG. 3a showing the manner in which internal regions of the lens are photoablated for the purpose of correcting myopia, hyperopia or presbyopia, and FIG. 3b showing the manner in which generally surface regions of the lens are photoablated to remove incipient cataract.

15 In the various FIGs. identical elements and features are given the same reference number.

DETAILED DESCRIPTION OF THE INVENTION:

20 There is shown in FIG. 1, in greatly simplified diagrammatic form, a longitudinal cross sectional drawing of a typical, normal eye 10, which is generally symmetrical about an optical axis 12. Shown comprising eye 10, and in order from the front of the eye to the back, is a cornea 14, an iris 16, a natural lens 18 and a retina 20. In a normal eye, light from an object 22 is refracted by cornea 14 and lens 14 so as to form an image 24 on retina 20 (iris 16 being shown having an open central aperture 26 permitting light to pass through to the lens).

30 Shown more particularly in FIG. 2 (but still in greatly simplified form), lens 18 is a biconvex, somewhat flexible structure which is suspended behind iris 16 and is connected to a peripheral ciliary body 30 of eye 10 by zonal fibers (zonules) 32. Since lens 18

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is avascular, its pathology is more simple than most other tissues of the body; primary inflammation processes do not occur and neoplastic growths in lens 18 are unknown. However, trauma or injury to lens 18 results in passive and degenerative changes in the lens with consequent opacification.

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Focusing of lens 18, which functions to transmit and refract light to retina 20, is (assuming the lens is in its normal, youthful condition) by contraction and relaxation of zonal fibers 32. In the relaxed state of fibers 32, lens 18 assumes its maximum convex curvature and thickness; as tension in zonal fibers increases, lens 18 is stretched and its convex curvature and thickness is decreased. By this mechanism, called accommodation, the shape of lens 18 is physically varied in a manner causing images 22 to be correctly focused on retina 20 as the distance, D, between object 22 and cornea 14 changes between far and near.

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Lens 18 consists of about 65 percent water and about 35 percent protein (known as crystallins), along with traces of minerals. Lens 18 is avascular, containing no blood vessels, and has no nerve supply, and comprises a thin, transparent capsule or bag 34, a subcapsular epithelium layer 36, a cortex 38 of soft fibres and a harder, dense nucleus 40 at the center. During development of lens 18, surface ectoderm invaginates to form the lens vesicle. The posterior cells of the lens vesicle then elongate to form the primary lens fibres, which obliterate the cavity of the vesicle and abut on the anterior (forward) epithelium layer 36. This process is completed early in fetal development. Subsequently, secondary lens fibres are added throughout life by the elongation and

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differentiation of epithelial cells circumferentially at the equator of lens 18. The net result is the progressive internalization of previously-formed fibers. The older fibers are always found toward nucleus 40 and the younger fibers toward cortex 38.

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Lens 18 continues to grow throughout an individual's life in a process similar to that in which the epidermal tissue of the skin renews itself. However, unlike the skin where old cells are continually cast off from the surface, older lens cells accumulate centrally and cannot be cast off. The net result is a progressive growth of lens 18 with age, associated with a decrease in elasticity and accommodative ability. The result is that the most common degenerative condition of lens 18 is presbyopia, a condition in which loss of elasticity of the lens results in the inability of eye 10 to focus sharply for near vision, such that most individuals by about the age of forty require some visual assistance, for example, that provided by spectacles, contact lenses or RK surgery.

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Another common degenerative condition of lens 18 that is generally associated with aging is cataract, which is generally defined as any opacity in the lens. In the case of cataract, the extent of disability depends upon the location and severity of the opacity. Thus, a relatively small posterior (i.e., rearward) subcapsular cataract may be visually incapacitating because it is situated near the nodal point of the dioptric system, while peripheral opacities that do not impinge on optical axis 12 may cause little visual inconvenience. In general, patients initially complain of a visual disturbance, then a diminution of vision and finally a complete failure of vision. For small

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lens opacities and early disturbance or diminution of vision there is no proven therapeutic modality (i.e., treatment). Ophthalmologists have long considered removal of lens 18 as the only treatment for cataract. At present, the most commonly performed operation is an extracapsular cataract extraction with intraocular lens implantation, the objective of the surgical procedure being to remove as much of the lens as possible with subsequent optical device correction. The concept or selective removal of a small opacity or sections of the lens was not heretofore considered nor would it have been technically possible.

THE PRESENT INVENTION:

The present invention relates to methods to treat presbyopia, refractive errors, and cataract by means of focusing high power pulse laser photoablation of lens opacities and selected normal lens fibers. A laser 50 (FIG. 3) which can advantageously be used for such purpose is preferably, but is not limited to, a quasi-continuous Nd:YLF picosecond laser which may be purchased as ISL Model 2001 MPL or 4001 CLS from Intelligent Laser Systems, Inc. of San Diego, California. In general, laser 50 produces a shock wave in the tissue at which its beam is focused, the shock wave expanding radially from the point of focus and disintegrating the target tissue (optical breakdown), thereby causing ionization of the medium and the formation of a plasma. This plasma is a gaseous state, formed when electrons are stripped away from their atoms in either a gas, liquid or solid. Once optical breakdown occurs, the plasma that is formed absorbs or scatters subsequent light in the

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laser pulse, thereby acting as an effective shield protecting underlying structures. The quicker the laser pulses, the faster and more easily the plasma is created.

5 For the present photoablation procedure, laser 50 preferably has the following characteristics:

- 10 1. An operating frequency preferably in the visible and infrared (IR) spectrum; more preferably, about 1053 nanometers (nm).
2. A repetition rate preferably ranging from about one to about 1000 Hertz; more preferably, about 1000 pulses per second.
- 15 3. A pulse width preferably ranging from about 1 femtosecond to about 1 millisecond; more preferably, about 60 picosecond.
4. An energy level per pulse preferably ranging from about 1 nanojoule to about 50 millijoules; more preferably, about 30 microjoules.
- 20 5. A focused spot size (diameter) preferably between about 1 micron and about 100 microns; more preferably, about 20 microns.
- 25 6. A "zone of effect" preferably limited to between about 1 and about 200 microns with little collateral effect; more preferably, the zone of effect is limited to about 50 microns.

30 The procedure described hereinbelow for the laser photoablation of lens tissue ordinarily requires an initial ocular examination of the prospective patient, including refractive status, slit lamp biomicroscopy, and the measurement of axial length of lens 18 by standard applanation A-scan ultrasonography. The accommodative amplitude of lens 18 may be measured by

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various techniques. For example, Adler (Moses RA. "Accommodation" In: Moses RA, Hart, MA Jr. eds. Adler's Physiology of the Eye, St. Louis, Washington, D.C., Toronto: The C.V. Mosby Co., Chapter 11, 1987:291-310--
5 which is incorporated hereinto by specific reference) recommends that a convex lens be moved along the optical axis in front of the patient's eye, away from the eye, until a target object at a convenient distance just begins to blur--it is then assumed that
10 accommodation is relaxed. The convex lens is then reduced (to a concave lens), or, alternatively, the target object is brought closer to the patient's eye until the target again starts to blur. The range between the "far" blur and the "near" blur or maximum plus (convex lens) to blur and maximum minus (concave
15 lens) to blur is the range of accommodation in diopters.

For the treatment of presbyopia, the amount of lens thickness to be ablated can be calculated in two
20 ways:

1. Based upon Normative Charts of lens thickness and accommodative amplitude with age:
Using the ultrasound data on saggital lens length
25 with age by Rafferty (Rafferty, N. S. "Lens Morphology" In: Maisel, H., ed. The Ocular Lens. Marcel Dekker, Inc. New York and Basel. 1985:1-15, 52-60--which is incorporated hereinto by specific reference) and the accommodative amplitude at a
30 given age, as shown, by way of example, in Duane's Table (Borish, Irvin M. "Accommodation", Clinical Refraction, The Professional Press, Inc., Chicago, 1975, 3rd Ed., Vol. 1, p 170--which is incorporated hereinto by specific reference), the

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5 amount of required lens tissue ablation is
calculated by subtracting the desired
accommodation amplitude from the patient's actual
accommodation amplitude. By way of illustration,
with no limitation being thereby intended or
implied, a patient of age 60 has a lens thickness
of 4.66 mm and an accommodation amplitude of 1.25
Diopters. To increase the patient's accommodative
10 amplitude to that of a person of age 30 who has a
lens thickness of 4.15 mm and an accommodative
amplitude of 7.5 Diopters, .51 mm (4.66 mm minus
4.15 mm) of lens tissue from the patient's lens.
This would represent an increase of approximately
6.25 Diopters (7.5 Diopters minus 1.25 Diopters)
15 of accommodative amplitude. Since the maximal
thickness change in the lens during accommodation
is about 0.5 mm, this change should be sufficient
to restore the presbyopic 60 year old patient to
an accommodative state.

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2. Based on the patient's measured lens
thickness and amplitude of accommodation:
The amount of lens tissue to be ablated is
calculated based on the work of Koretz and
Handelman (Koretz, J.F., Handelman, G.H., "Model
25 of the accommodation mechanism in the human eye"
Vision Res. Vol. 22 1982:917-927--which is
incorporated hereinto be specific reference). A
two micron change in lens thickness corresponds to
a 0.02 Diopter change in accommodation. Thus, if
30 a patient's amplitude of accommodation measures
1.25 Diopters and it is desired to increase that
to 5 Diopters (a change of 3.75 Diopters) the

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amount of decrease in lens thickness required would be approximately 375 microns.

5 For the treatment of hyperopia, the amount of lens tissue to be ablated is calculated as described above for presbyopia. This will increase the amplitude of accommodation of the patient's lens to allow the hyperope to move the focus of distant objects up to his or her retina 20.

10 For the treatment of myopia, the amount of lens tissue to be ablated can be calculated based on the refractive status of the eye and the measured lens thickness as set forth above in paragraph 2.

15 PROCEDURE:

For the treatment of presbyopia and hyperopia, a beam 52 from a HeNe focusing laser 54 (FIG. 3a) is focused, by an associated lens or lens system 56, through cornea 14 (which is transparent to the focusing beam) and iris opening 26, to a region 56 to be photoablated by Nd:YLF laser 50 for correction of the specific vision problem under treatment. In this regard, it is preferred that the more centrally located, older cortical and/or nuclear fibers be ablated since the width of nucleus 40 (FIG. 2) remains relatively constant with age, whereas that of cortex 38 increases. Then, a laser beam 60 from Nd:YLF laser 50 is focused by an associated focusing lens or lens system 66 through cornea 14 (which is transparent to the laser beam) and iris opening 26, onto region 56 which is to be photoablated by the Nd:YLF laser beam. The amount of lens tissue to be ablated (i.e., decomposed) to achieve the desired vision correction

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is determined in the manner described above. The optical zone (equatorial diameter) should be approximately equal to the diameter of nucleus 40 and the axial width (for example, about 510 microns). For treatment of myopia, it is preferred that region 56 be selected so that nucleus 40 and/or centrally located older fibers in cortex 38 are ablated using a smaller optical zone so as to decrease the curvature of an anterior (forward) surface 62 of lens 18. Such laser ablation of lens 18 to correct myopia, presbyopia and hyperopia may be termed "photorefractive phacoplasty" or "phototherapeutic phacoplasty."

For the treatment of cataracts (FIG. 3b), beam 52 from HeNe focusing laser 54 (FIG. 3) may be directly focused by lens or lens system 56 (with the beam passing through cornea 14 and iris opening 26) onto an area or region 64 of small lenticular opacity. Then beam 60 from Nd:YLF laser 50 is focused, by lens or lens system 62 onto area or region 64 and the laser is pulsed until the opacity is ablated (as determined, for example, by visual observation through cornea 12 and iris opening 26).

It is preferred that if opacity area or region 64 is adjacent to lens capsule 18 (FIG. 2), aiming beam 52 from HeNe laser 52 is focused more centrally to the opacity to account for shock wave expansion. Such treatment (i.e., photoablative removal) of incipient cataract, which is intended to delay or prevent full cataract surgery, including removal of lens 18 and the replacement thereof with an IOL, may be termed "phototherapeutic phacoablation" or "photo-therapeutic phacoectomy."

In either of the above-described treatments, application of photoablation beam 60 from Nd:YLF laser

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50 produces the formation of gas bubbles at the site of optical breakdown by the focused beam within lens 18 (that is, at regions such as above-described regions 58 and 64). The formed gas bubbles are, however, usually reabsorbed within lens 18 within 24 to 48 hours and lens 18 remains optically clear.

Care is taken in the operation of Nd:YLF laser 50 not to rupture lens capsule 34 by expansion of laser shock wave. Moreover, if excessive bubbles are formed at the ablation site, as detected, for example, by viewing, with a slit lamp (not shown) the ablation region through cornea 14 and iris opening 26, the laser ablation procedure is discontinued and additional treatment is performed at a later date, for example, in one or two weeks.

By the method described above, the natural lens in an eye can be photoablated by pulsed energy from a laser--preferably a Nd:YLF laser--in a manner correcting myopia, presbyopia and hyperopia and in a manner removing incipient cataracts. Because the above-described laser-ablative procedures are relatively non-invasive (as compared, for example to laser photoablation of the cornea to correct vision problems or the surgical removal of a natural lens in the case of cataract) and because lens 18 is non-vascular and contains no nerve supply, no post-ablation inflammation or wound-healing problems are anticipated and the use of steroids--commonly used after corneal laser photoablation--is not indicated. Moreover, because of its structural nature, lens 18 is not expected to revert--with time--to its pre-ablative shape--as may be the case for laser-ablated corneas.

Although there are described above methods for laser photoablation of a natural lens for correcting

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vision problems for the purpose of illustrating the manner in which the present invention can be used to advantage, it is to be understood that the invention is not limited thereto. Therefore, any and all
5 modifications and variations which may occur to those skilled in the art are to be considered to be included within the scope and spirit of the claims appended hereto.

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What is claimed is:

1. Use of a laser to photoablate a selected volume of ocular lens tissue, said volume being of a size enabling resolve by adjacent healthy ocular lens tissue, wherein said laser comprises means of focusing a laser beam into an ocular lens with a focal point below an anterior surface of the ocular lens where ablation is intended to occur, means of pulsing said laser beam at said focal point, means of moving said focal point towards the ocular lens anterior surface, and means of pulsing said laser beam at the selected volume of ocular lens.

2. The use of claim 1, wherein said laser beam is pulsed at a repetition rate of about 1000 Hertz and a pulse width of about 60 picoseconds.

3. The use of claim 1, wherein said laser beam is pulsed with an energy per pulse of between 1 nanojoule and 50 millijoules.

4. The use of claim 1, wherein said laser beam is pulsed with an energy per pulse of about 3.0 microjoules.

5. The use of claim 1, wherein the laser further comprises means of controlling the laser beam to provide at said selected volume of ocular lens to be ablated a beam spot diameter of between 1 micron and 20 microns and a zone of effect of less than 200 microns.

6. The use of claim 1, wherein the laser further comprises means for controlling the laser beam to provide at said selected volume of ocular lens to be ablated a beam spot diameter of about 20 microns and a zone of effect of less than about 50 microns.

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7. The use of claim 1, wherein the means of moving the focal point allow movement in a pattern of a plurality of selected volumes in said ocular lens.

8. The use of claim 1, wherein the selected volume has a cross-section of up to about 0.3 square millimeters.

9. Use of a laser to photoablate a selected volume of ocular lens tissue, said volume being of a size enabling resolve by adjacent healthy ocular lens tissue, wherein said laser comprises means for directing a laser beam at a calculated volume of lens tissue to be removed, wherein the volume of lens tissue to be removed is determined based on an actual accommodation amplitude for said ocular lens.

10. The use of claim 9, wherein the laser beam is pulsed at a pulse width of between about 1 femtosecond and about 1 millisecond.

11. The use of claim 9, wherein the laser is an Nd:YLF laser having a wavelength of about 1053 nanometers.

12. The use of claim 9, wherein directing the laser beam is pulsed at a repetition rate of about 1000 pulses per second and at a pulse width of about 60 picoseconds.

13. The use of claim 9, wherein the laser further comprises means of controlling the laser beam so that a spot diameter of the laser beam at the region of the ocular lens to be photoablated is less than about 20 microns.

14. The use of claim 9, wherein the laser further comprises means of controlling the laser beam to control the beam diameter so that the diameter of a zone of effect of the laser beam at the region of the ocular lens to be removed is less than about 100 microns.

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15. The use of claim 9, wherein the laser is a targeting laser.

16. The use of claim 15, wherein the targeting laser is an HeNe laser.

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FIG. 1.
(PRIOR ART)

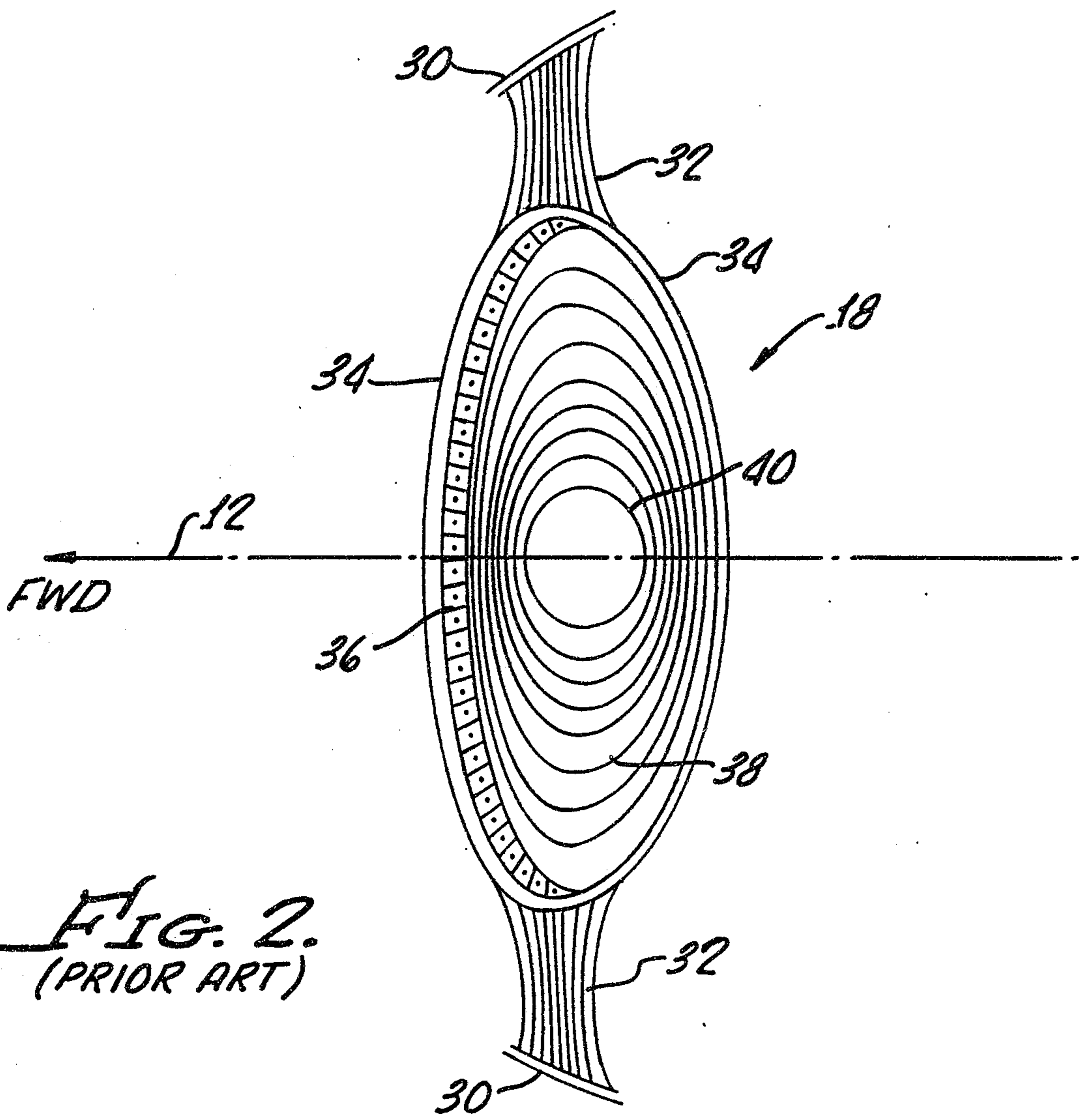
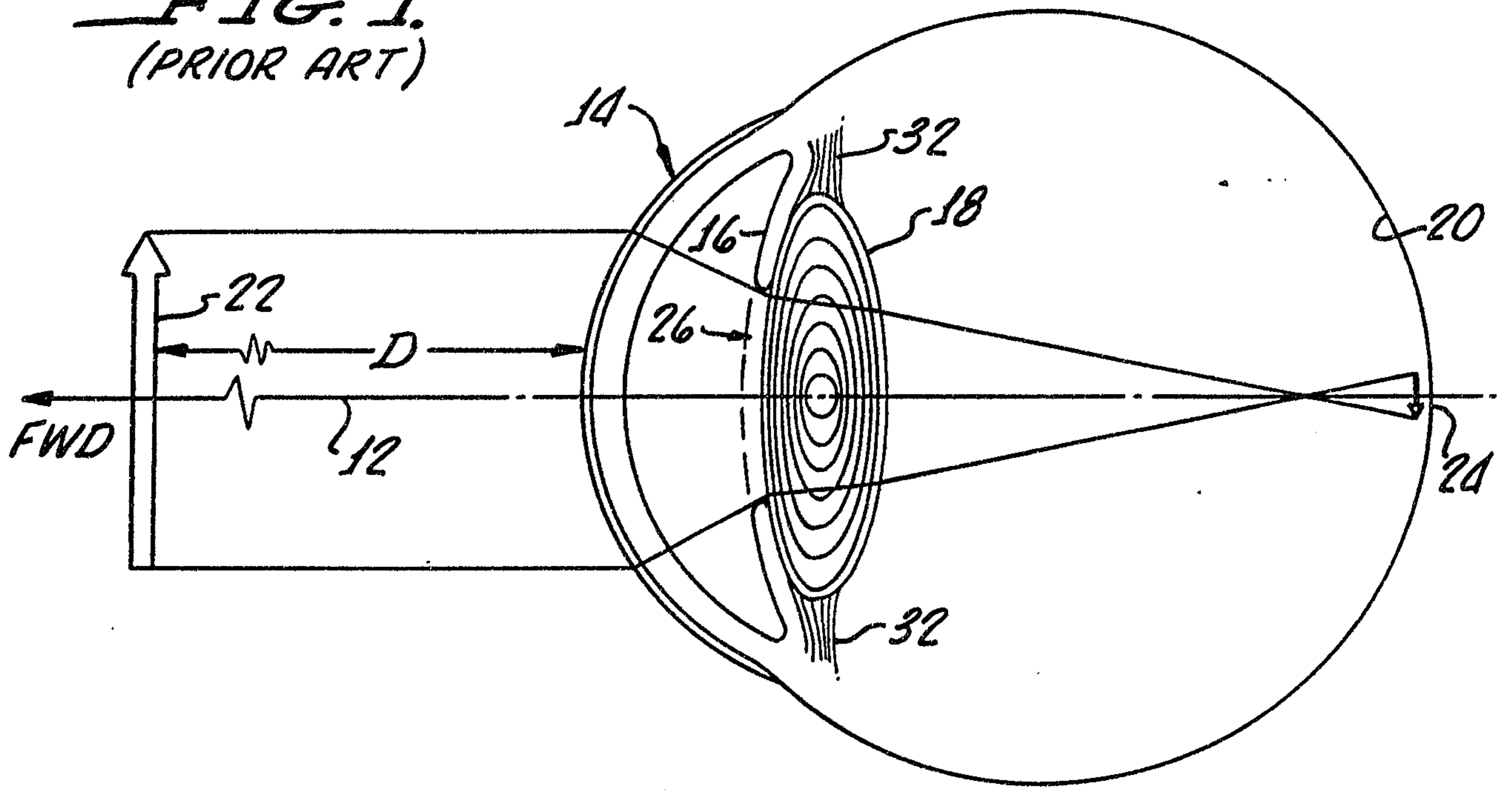


FIG. 2.
(PRIOR ART)

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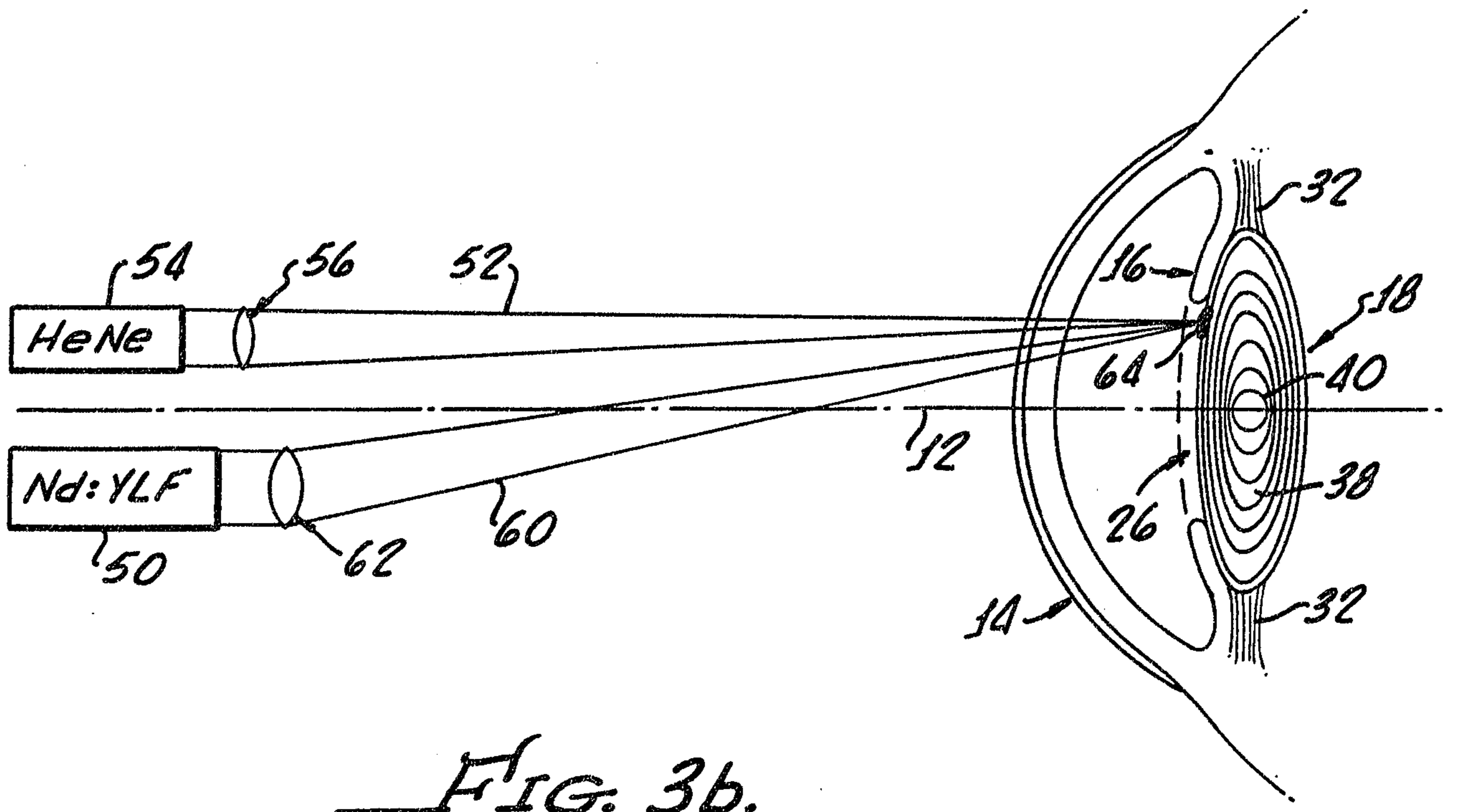


FIG. 3b.

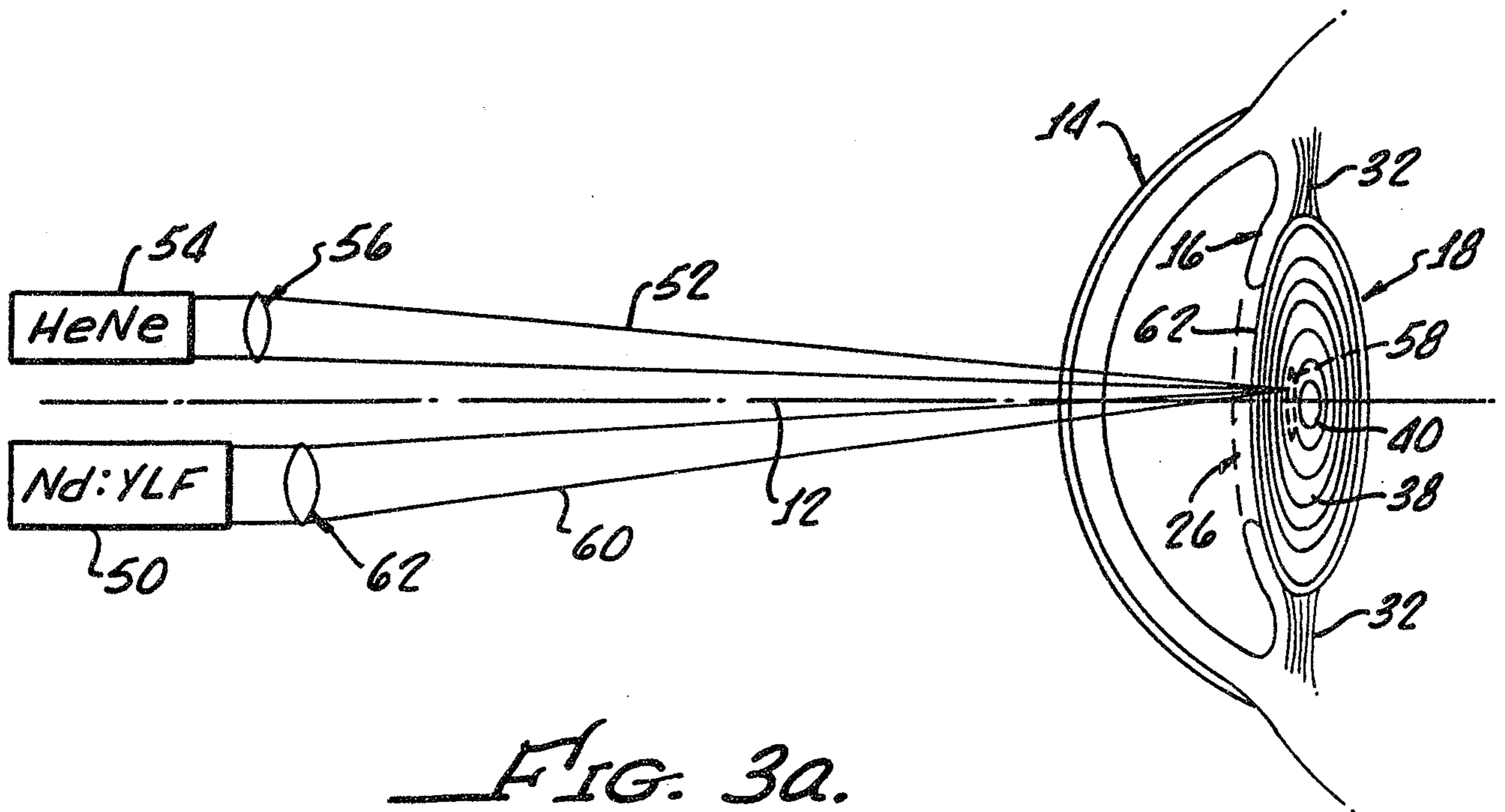


FIG. 3a.

