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CLERK U.S. DISTRICT COURT
CENTRAL DIST. OF CALIF.
SANTA ANA
BY

UNITED STATES DISTRICT COURT
CENTRAL DISTRICT OF CALIFORNIA

OAKLEY, INC., a Washington corporation, Plaintiff, vs. SWITCH VISION SYSTEMS, LLC, a New Jersey limited liability company, Defendant	Case No.: SACV10-708 JVS (ANx) COMPLAINT FOR PATENT INFRINGEMENT DEMAND FOR JURY TRIAL

Plaintiff, Oakley, Inc. (hereinafter referred to as "Oakley") complains of Defendant Switch Vision Systems, LLC (hereinafter referred to as "Switch") and alleges as follows:

JURISDICTION AND VENUE

1. Jurisdiction over this action is founded upon 28 U.S.C. §§ 1331 and 1338. Venue is proper under 28 U.S.C. §§ 1391(a-c) and 28 U.S.C. § 1400(b). Defendant resides in this judicial district, the claim arose in this judicial district, and Defendant is doing business in this judicial district.

… … …

… … …

THE PARTIES

2. Plaintiff Oakley, Inc. is a corporation organized and existing under the laws of the state of Washington having its principal place of business located at One Icon, Foothill Ranch, CA 92610.

1. Oakley is informed and believes, and thereupon alleges, that Defendant Switch was and is a limited liability corporation duly organized and existing under the laws of the state of New Jersey with its principal place of business located at 103 Fairfield Road, Fairfield, NJ 07004. Oakley is informed and believes, and thereupon alleges, that Defendant sells its products in this district, directs sales and marketing to this district, and otherwise puts its products, including the accused products, in the stream of commerce for resale in this district.

FACTUAL BACKGROUND

3. Oakley is a manufacturer and seller of high performance eyewear and accessories.

4. In 1995, employees of Oakley developed certain lens technology that features optically corrected lenses in nonprescription dual lens eyeglasses ("decentered noncorrective lenses"). Decentered noncorrective lenses provide for better optical quality and minimal prismatic distortion. This lens technology, known in the industry as Oakley's "XYZ Optics®," is incorporated in numerous lines of Oakley sunglass products. All of these lines of sunglasses have enjoyed enormous commercial success, which is expected to continue. Since developing the XYZ Optics technology, Oakley sought and obtained several patents disclosing, claiming, and protecting this technology.

5. Oakley is the owner by assignment of U.S. Patent No. 5,648,832 duly and lawfully issued on July 15, 1997, describing and claiming the invention of Malcolm Neal Houston, James H. Jannard and Carlos D. Reyes entitled "DECENTERED NONCORRECTIVE LENS FOR EYEWEAR" protecting

Oakley's XYZ Optics technology embodied in its various lines of sunglasses. A true and correct copy of U.S. Patent No. 5,648,832 is attached hereto as Exhibit 1 and incorporated herein by reference.

6. Oakley is the owner by assignment of U.S. Patent No. 5,689,323 duly and lawfully issued on November 18, 1997, describing and claiming the invention of Malcolm Neal Houston, James H. Jannard and Carlos D. Reyes entitled "DECENTERED NONCORRECTIVE LENS FOR EYEWEAR" protecting Oakley's XYZ Optics technology embodied in its various lines of sunglasses. A true and correct copy of U.S. Patent No. 5,689,323 is attached hereto as Exhibit 2 and incorporated herein by reference.

7. Oakley is the owner by assignment of U.S. Patent No. 5,969,789 duly and lawfully issued on October 19, 1999, describing and claiming the invention of Malcolm Neal Houston, James H. Jannard and Carlos D. Reyes entitled "DECENTERED NONCORRECTIVE LENS FOR EYEWEAR" protecting Oakley's XYZ Optics technology embodied in its various lines of sunglasses. A true and correct copy of U.S. Patent No. 5,969,789 is attached hereto as Exhibit 3 and incorporated herein by reference.

8. Oakley is the owner by assignment of U.S. Patent No. 6,010,218 duly and lawfully issued on January 4, 2000, describing and claiming the invention of Malcolm Neal Houston, James H. Jannard and Carlos D. Reyes entitled "DECENTERED NONCORRECTIVE LENS FOR EYEWEAR" protecting Oakley's XYZ Optics technology embodied in its various lines of sunglasses. A true and correct copy of U.S. Patent No. 6,010,218 is attached hereto as Exhibit 4 and incorporated herein by reference.

9. Oakley is the owner by assignment of U.S. Patent No. 6,168,271 duly and lawfully issued on January 2, 2001, describing and claiming the invention of Malcolm Neal Houston, James H. Jannard and Carlos D. Reyes entitled "DECENTERED NONCORRECTIVE LENS FOR EYEWEAR" protecting

Oakley's XYZ Optics technology embodied in its various lines of sunglasses. A true and correct copy of U.S. Patent No. 6,168,271 is attached hereto as Exhibit 5 and incorporated herein by reference.

10. Defendant Switch is presently marketing and selling sunglass models, specifically including but not limited to its the *Tenaya, Avalanche,* and *Headwall* sunglass models, with decentered corrective lenses which embody the subject matter claimed one or more of the claims in Oakley's U.S. Patent Nos. 5,648,832, 5,689,323, 5,969,789, 6,010,218 and 6,168,271.

11. Defendant received actual notice of Oakley's proprietary rights in its Patents-In-Suit by way of actual notice. Additionally, Oakley sunglasses come in packaging that contain patent notification constituting constructive notice to the Defendant of Oakley's rights in at least its 5,648,832, 5,689,323, 5,969,789, 6,010,218 and 6,168,271patents. Despite such notice, of Oakley's patent rights, Defendant is continuing to sell its infringing models. On information and belief, Defendant's infringement was willful and wanton.

12. Oakley is informed and believes and thereupon alleges that the sale of Defendant's infringing sunglasses has resulted in lost sales, has reduced the business and profit of Oakley, and has greatly injured the goodwill and reputation associated with Oakley, all to Oakley's damage in an amount not yet fully determined. Oakley seeks a judgment and award of damages to compensate it in an amount equal to no less than a reasonable royalty.

13. Moreover, the Defendant wrongfully profited from Oakley's invention by selling sunglasses that infringed Oakley's 5,648,832, 5,689,323, 5,969,789, 6,010,218 and 6,168,271 patents. The exact amount of profits realized by Defendant as a result of its infringing activities are presently unknown to Oakley, as are the exact amount of damages suffered by Oakley as a result of these activities. These profits and damages cannot be accurately ascertained without an accounting.

FIRST CLAIM FOR RELIEF

14. The allegations of paragraph 1 through 13 are repled and realleged as though fully set forth herein.

15. This is a claim for patent infringement and arises under 35 U.S.C. §§ 271 and 281.

16. Jurisdiction is founded upon 28 U.S.C. §§ 1331 and 1338.

17. Oakley is the owner of U.S. Patent No. 5,648,832, which protects, among others, products embodying Oakley's XYZ Optics technology embodied in its various lines of sunglasses, as set forth above. By statute, the patent is presumed to be valid and enforceable under 35 U.S.C. § 282.

18. Defendant Switch, through its agents, suppliers, employees and/or servants, manufactured, imported, offered for sale and sold sunglasses that fall within the scope and claims contained in U.S. Patent No. 5,648,832, without any rights or license under that patent.

19. Oakley is informed and believes, and thereupon alleges, that Defendant Switch willfully infringed upon Oakley's exclusive rights under the patent, with full notice and knowledge thereof. Defendant is presently selling infringing sunglasses, has not ceased the sale thereof, and will continue to sell unless restrained by this court, all to the great loss and injury of Oakley.

20. Oakley is informed and believes and thereupon alleges that Defendant Switch has derived, received, and will continue to derive and receive from these acts of infringement, gains, profits and advantages in an amount not presently known to Oakley. By reason of these acts of infringement, Oakley has been and will continue to be greatly damaged. Oakley is seeking a judgment and award of damages in an amount of not less than a reasonable royalty.

21. Defendant Switch will continue to infringe U.S. Patent No. 5,648,832 to the great and irreparable injury of Oakley, for which Oakley has no adequate remedy at law unless said Defendants are enjoined by this court.

SECOND CLAIM FOR RELIEF

22. The allegations of paragraph 1 through 13 are repled and realleged as though fully set forth herein.

23. This is a claim for patent infringement and arises under 35 U.S.C. §§ 271 and 281.

24. Jurisdiction is founded upon 28 U.S.C. §§ 1331 and 1338.

25. Oakley is the owner of U.S. Patent No. 5,689,323, which protects, among others, products embodying Oakley's XYZ Optics technology embodied in its various lines of sunglasses, as set forth above. By statute, the patent is presumed to be valid and enforceable under 35 U.S.C. § 282.

26. Defendant Switch, through its agents, suppliers, employees and/or servants, manufactured, imported, offered for sale and sold sunglasses that fall within the scope and claims contained in U.S. Patent No. 5,689,323, without any rights or license under that patent.

27. Oakley is informed and believes, and thereupon alleges, that Defendant Switch willfully infringed upon Oakley's exclusive rights under the patent, with full notice and knowledge thereof. Defendant is presently selling infringing sunglasses, has not ceased the sale thereof, and will continue to sell unless restrained by this court, all to the great loss and injury of Oakley.

28. Oakley is informed and believes and thereupon alleges that Defendant Switch has derived, received, and will continue to derive and receive from these acts of infringement, gains, profits and advantages in an amount not presently known to Oakley. By reason of these acts of infringement, Oakley has been and will continue to be greatly damaged. Oakley is seeking a judgment and award of damages in an amount of not less than a reasonable royalty.

29. Defendant Switch will continue to infringe U.S. Patent No5,689,323 to the great and irreparable injury of Oakley, for which Oakley has no adequate remedy at law unless said Defendants are enjoined by this court.

THIRD CLAIM FOR RELIEF

30. The allegations of paragraph 1 through 13 are repled and realleged as though fully set forth herein.

31. This is a claim for patent infringement and arises under 35 U.S.C. §§ 271 and 281.

32. Jurisdiction is founded upon 28 U.S.C. §§ 1331 and 1338.

33. Oakley is the owner of U.S. Patent No. 5,969,789, which protects, among others, products embodying Oakley's XYZ Optics technology embodied in its various lines of sunglasses, as set forth above. By statute, the patent is presumed to be valid and enforceable under 35 U.S.C. § 282.

34. Defendant Switch, through its agents, suppliers, employees and/or servants, manufactured, imported, offered for sale and sold sunglasses that fall within the scope and claims contained in U.S. Patent No5,969,789, without any rights or license under that patent.

35. Oakley is informed and believes, and thereupon alleges, that Defendant Switch willfully infringed upon Oakley's exclusive rights under the patent, with full notice and knowledge thereof. Defendant is presently selling infringing sunglasses, has not ceased the sale thereof, and will continue to sell unless restrained by this court, all to the great loss and injury of Oakley.

36. Oakley is informed and believes and thereupon alleges that Defendant Switch has derived, received, and will continue to derive and receive from these acts of infringement, gains, profits and advantages in an amount not presently known to Oakley. By reason of these acts of infringement, Oakley has been and will continue to be greatly damaged. Oakley is seeking a judgment and award of damages in an amount of not less than a reasonable royalty.

37. Defendant Switch will continue to infringe U.S. Patent No. 5,969,789 to the great and irreparable injury of Oakley, for which Oakley has no adequate remedy at law unless said Defendants are enjoined by this court.

FOURTH CLAIM FOR RELIEF

38. The allegations of paragraph 1 through 13 are repled and realleged as though fully set forth herein.

39. This is a claim for patent infringement and arises under 35 U.S.C. §§ 271 and 281.

40. Jurisdiction is founded upon 28 U.S.C. §§ 1331 and 1338.

41. Oakley is the owner of U.S. Patent No. 6,010,218, which protects, among others, products embodying Oakley's XYZ Optics technology embodied in its various lines of sunglasses, as set forth above. By statute, the patent is presumed to be valid and enforceable under 35 U.S.C. § 282.

42. Defendant Switch, through its agents, suppliers, employees and/or servants, manufactured, imported, offered for sale and sold sunglasses that fall within the scope and claims contained in U.S. Patent No. 6,010,218, without any rights or license under that patent.

43. Oakley is informed and believes, and thereupon alleges, that Defendant Switch willfully infringed upon Oakley's exclusive rights under the patent, with full notice and knowledge thereof. Defendant is presently selling infringing sunglasses, has not ceased the sale thereof, and will continue to sell unless restrained by this court, all to the great loss and injury of Oakley.

44. Oakley is informed and believes and thereupon alleges that Defendant Switch has derived, received, and will continue to derive and receive from these acts of infringement, gains, profits and advantages in an amount not presently known to Oakley. By reason of these acts of infringement, Oakley has been and will continue to be greatly damaged. Oakley is seeking a judgment and award of damages in an amount of not less than a reasonable royalty.

45. Defendant Switch will continue to infringe U.S. Patent No. 6,010,218 to the great and irreparable injury of Oakley, for which Oakley has no adequate remedy at law unless said Defendants are enjoined by this court.

FIFTH CLAIM FOR RELIEF

46. The allegations of paragraph 1 through 13 are repled and realleged as though fully set forth herein.

47. This is a claim for patent infringement and arises under 35 U.S.C. §§ 271 and 281.

48. Jurisdiction is founded upon 28 U.S.C. §§ 1331 and 1338.

49. Oakley is the owner of U.S. Patent No. 6,168,271, which protects, among others, products embodying Oakley's XYZ Optics technology embodied in its various lines of sunglasses, as set forth above. By statute, the patent is presumed to be valid and enforceable under 35 U.S.C. § 282.

50. Defendant Switch, through its agents, suppliers, employees and/or servants, manufactured, imported, offered for sale and sold sunglasses that fall within the scope and claims contained in U.S. Patent No. 6,168,271, without any rights or license under that patent.

51. Oakley is informed and believes, and thereupon alleges, that Defendant Switch willfully infringed upon Oakley's exclusive rights under the patent, with full notice and knowledge thereof. Defendant is presently selling infringing sunglasses, has not ceased the sale thereof, and will continue to sell unless restrained by this court, all to the great loss and injury of Oakley.

52. Oakley is informed and believes and thereupon alleges that Defendant Switch has derived, received, and will continue to derive and receive from these acts of infringement, gains, profits and advantages in an amount not presently known to Oakley. By reason of these acts of infringement, Oakley has been and will continue to be greatly damaged. Oakley is seeking a judgment and award of damages in an amount of not less than a reasonable royalty.

53. Defendant Switch will continue to infringe U.S. Patent No. 6,168,271 to the great and irreparable injury of Oakley, for which Oakley has no adequate remedy at law unless said Defendants are enjoined by this court.

WHEREFORE, Plaintiff Oakley, Inc. prays as follows:

1. That Defendant Switch be adjudicated to have infringed U .S. Patent No. 5,648,832 and that said patent is valid, enforceable and is owned by Oakley;

2. That Defendant Switch be adjudicated to have infringed U .S. Patent No. 5,689,323 and that said patent is valid, enforceable and is owned by Oakley;

3. That Defendant Switch be adjudicated to have infringed U .S. Patent No. 5,969,789 and that said patent is valid, enforceable and is owned by Oakley;

4. That Defendant Switch be adjudicated to have infringed U .S. Patent No. 6,010,218 and that said patent is valid, enforceable and is owned by Oakley;

5. That Defendant Switch be adjudicated to have infringed U.S. Patent No. 6,168,271 and that said patent is valid, enforceable and is owned by Oakley;

6. That Defendant Switch, its agents, suppliers, servants, employees, managers, and officers, and all those persons in active concert or participation with them, be forthwith preliminarily and thereafter permanently enjoined from making, using, offering for sale or selling any sunglass which infringes U.S. Patent Nos. 5,648,832, 5,689,323, 5,969,789, 6,010,218, and 6,168,271;

7. That Defendant Switch be directed to file with this court and serve upon Oakley within 30 days after the service of the injunction, a report in writing under oath, setting forth in detail the manner and form in which Defendant has compiled with the injunction;

8. That Defendant Switch be required to account to Oakley for any and all lost profits suffered by Oakley and in no event less than a reasonable royalty by reason of Defendant's infringement of U.S. Patent Nos. 5,648,832, 5,689,323, 5,969,789, 6,010,218, and 6,168,271;

9. That the Court award Oakley damages in an amount equal to its lost profits or a reasonable royalty, at Oakley's election, pursuant to 35 U.S.C. § 284;

10. That patent infringement damages be awarded in an amount up to three times the amount of damages found or assessed to compensate Oakley for the willful, deliberate and intentional acts of infringement by Defendant, pursuant to 35 U.S.C. § 284;

11. For an order requiring Defendant to deliver up and destroy all infringing sunglasses;

12. That an award of reasonable costs, expenses and attorneys' fees be awarded against Defendants pursuant to 35 U.S.C. § 285; and

13. That Oakley have such other and further relief as circumstances of this case may require and that this court may deem just and proper.

DATED: 5/27/2010

WEEKS, KAUFMAN, NELSON & JOHNSON

GREGORY K. NELSON
Attorney for Plaintiff, Oakley, Inc.

JURY DEMAND

Plaintiff Oakley, Inc. hereby requests a trial by jury in this matter.

DATED: 5/27/2010

WEEKS, KAUFMAN, NELSON & JOHNSON

GREGORY K. NELSON
Attorney for Plaintiff, Oakley, Inc.

US005648832A

United States Patent [19]

Houston et al.

[11] **Patent Number: 5,648,832**

[45] **Date of Patent: Jul. 15, 1997**

[54] **DECENTERED NONCORRECTIVE LENS FOR EYEWEAR**

[75] Inventors: **Malcolm Neal Houston**, Foothill Ranch, Calif.; **James H. Jannard**, Eastsound, Wash.; **Carlos D. Reyes**, Mission Viejo, Calif.

[73] Assignee: **Oakley, Inc.**, Irvine, Calif.

[21] Appl. No.: **567,434**

[22] Filed: **Dec. 5, 1995**

[51] **Int. Cl.**[6] **G02C 7/02**

[52] **U.S. Cl.** **351/159**; 351/41

[58] **Field of Search** 351/159, 41, 44, 351/43, 47

[56] **References Cited**

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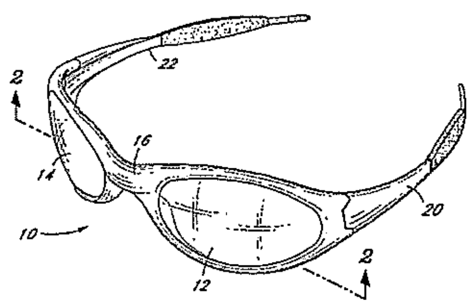
Primary Examiner—Georgia Y. Epps
Assistant Examiner—Jordan M. Schwartz
Attorney, Agent, or Firm—Knobbe, Martens, Olson & Bear, L.L.P.

[57] **ABSTRACT**

Disclosed is an optically corrected lens for nonprescription, dual lens eyeglasses. In a preferred embodiment, the anterior surface of the lens lies on a portion of a first sphere having a first center. The posterior surface of the lens lies on the surface of a second sphere having a second center. The first and second centers are offset from one another to provide a tapered lens. The lens is oriented on the head of the wearer by a frame that maintains the lens in a position such that a line drawn through the first and second centers is maintained substantially in parallel to the normal sight line of the wearer. Methods of making the lenses, and eyewear incorporating the lenses, are also disclosed.

12 Claims, 7 Drawing Sheets



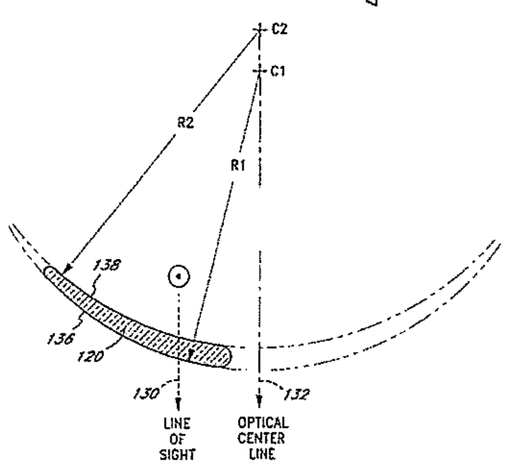


Fig. 1

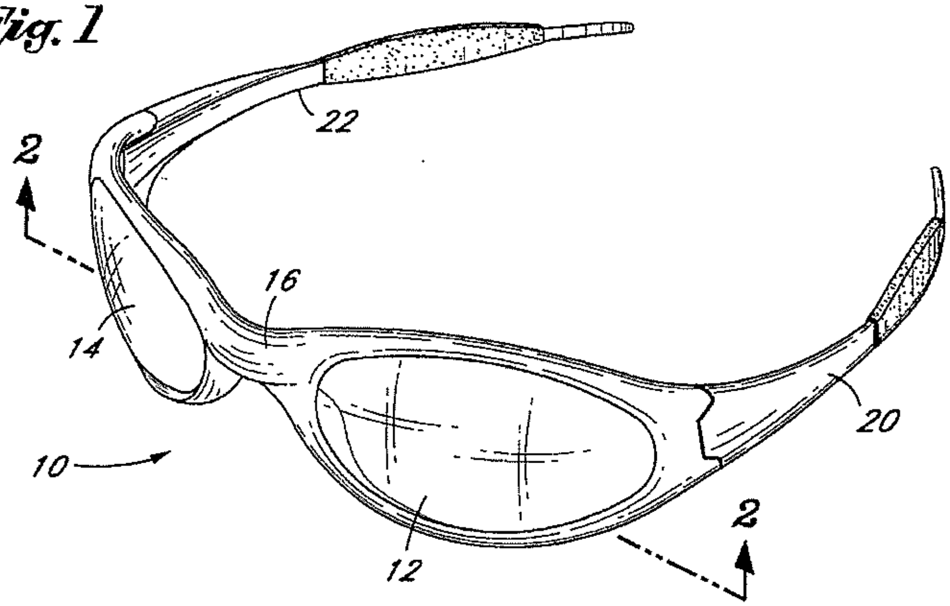


Fig. 2

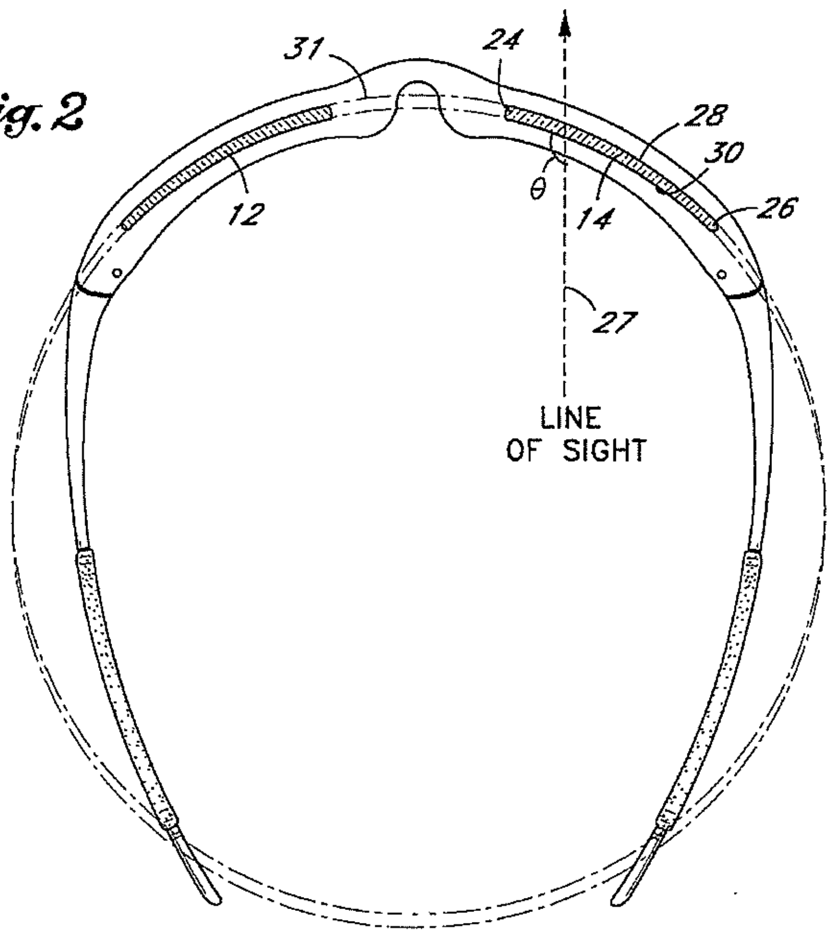
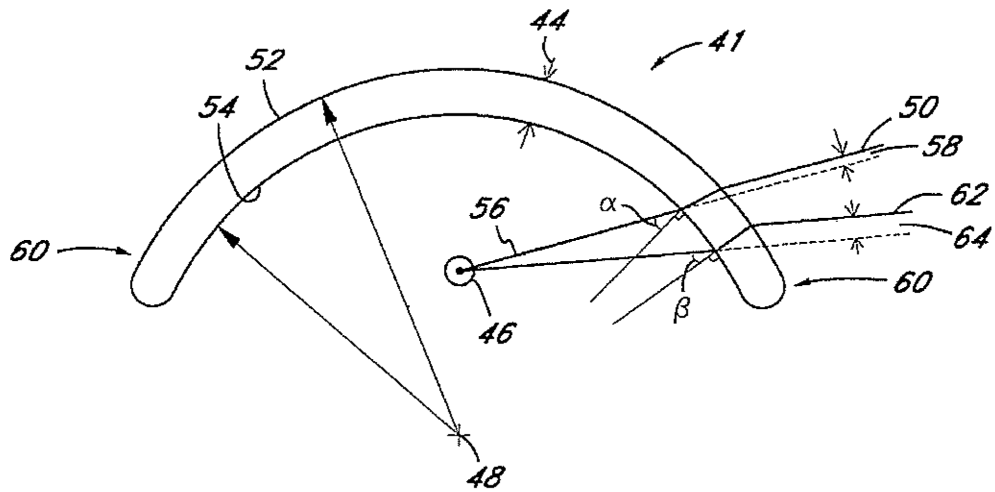


Fig. 3
(PRIOR ART)



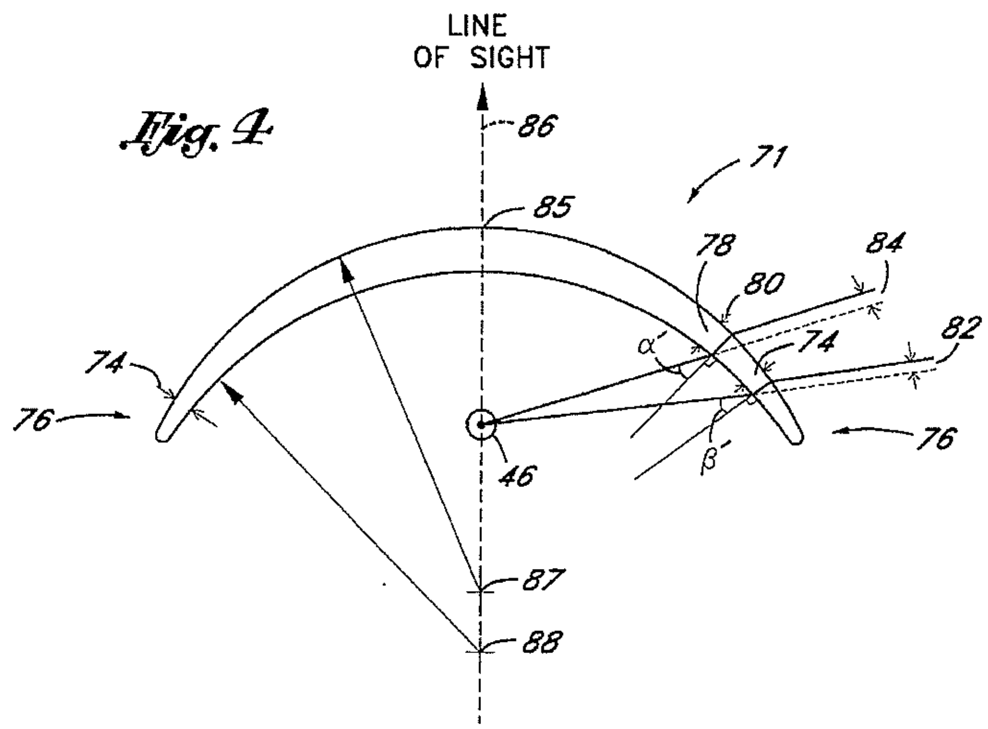
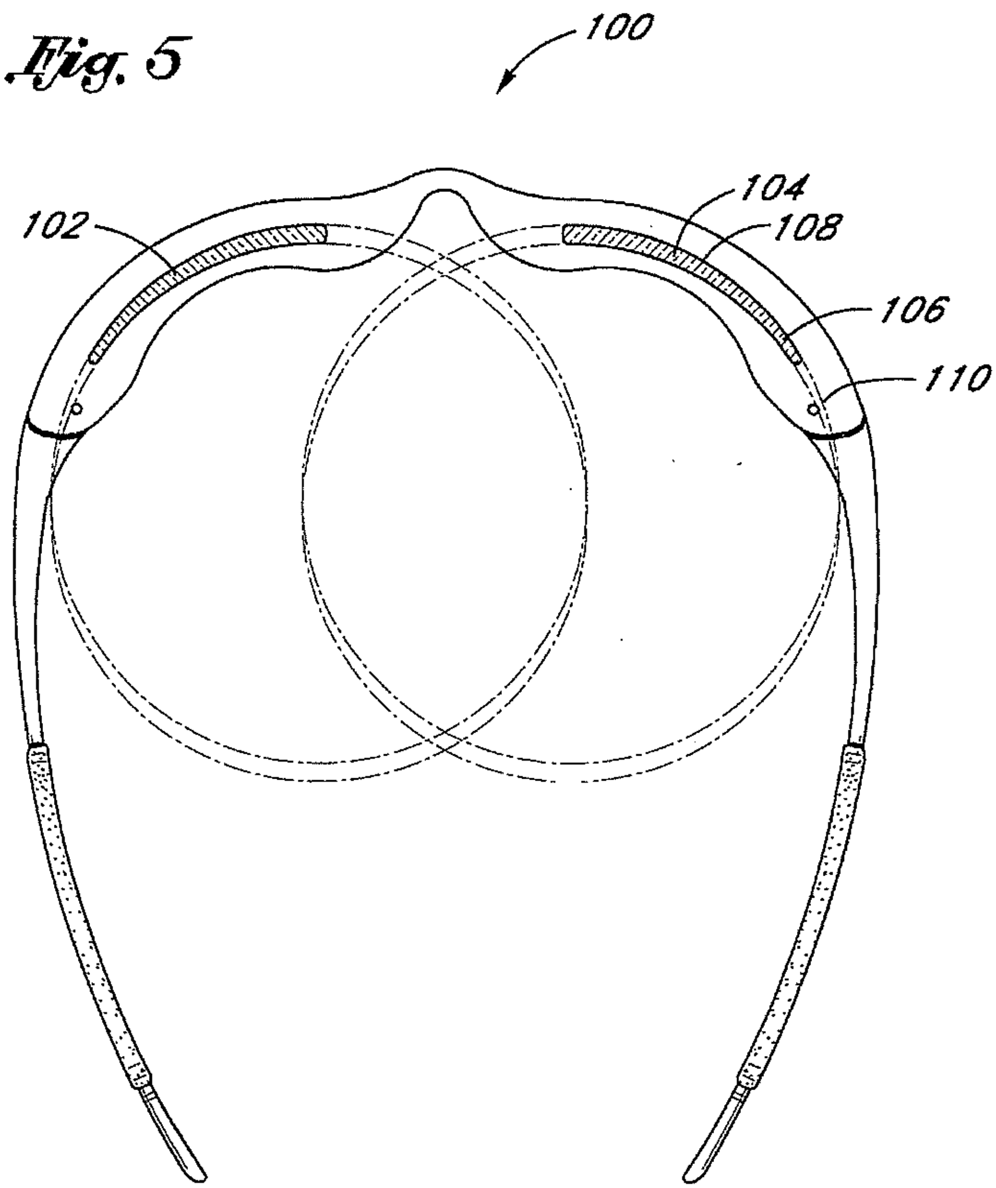
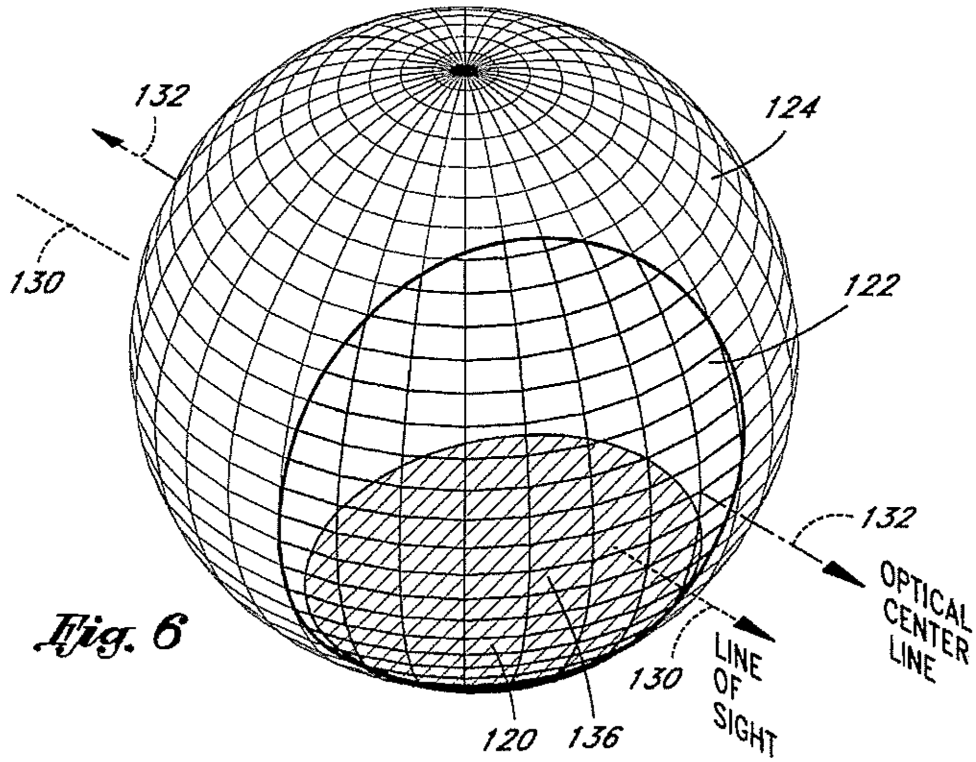


Fig. 4

Fig. 5

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124
130
122
132
OPTICAL CENTER LINE
130
LINE OF SIGHT
120
136

Fig. 6

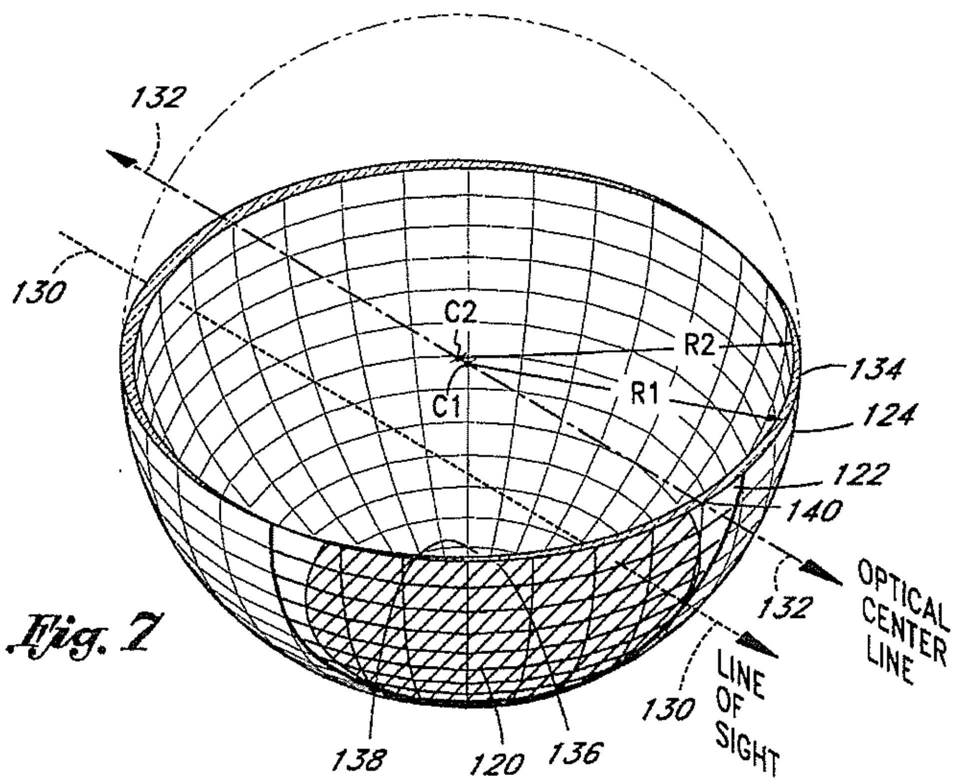

132
130
C2
C1
R2
R1
134
124
122
140
132
OPTICAL CENTER LINE
130
LINE OF SIGHT
138
120
136

Fig. 7

Fig. 8

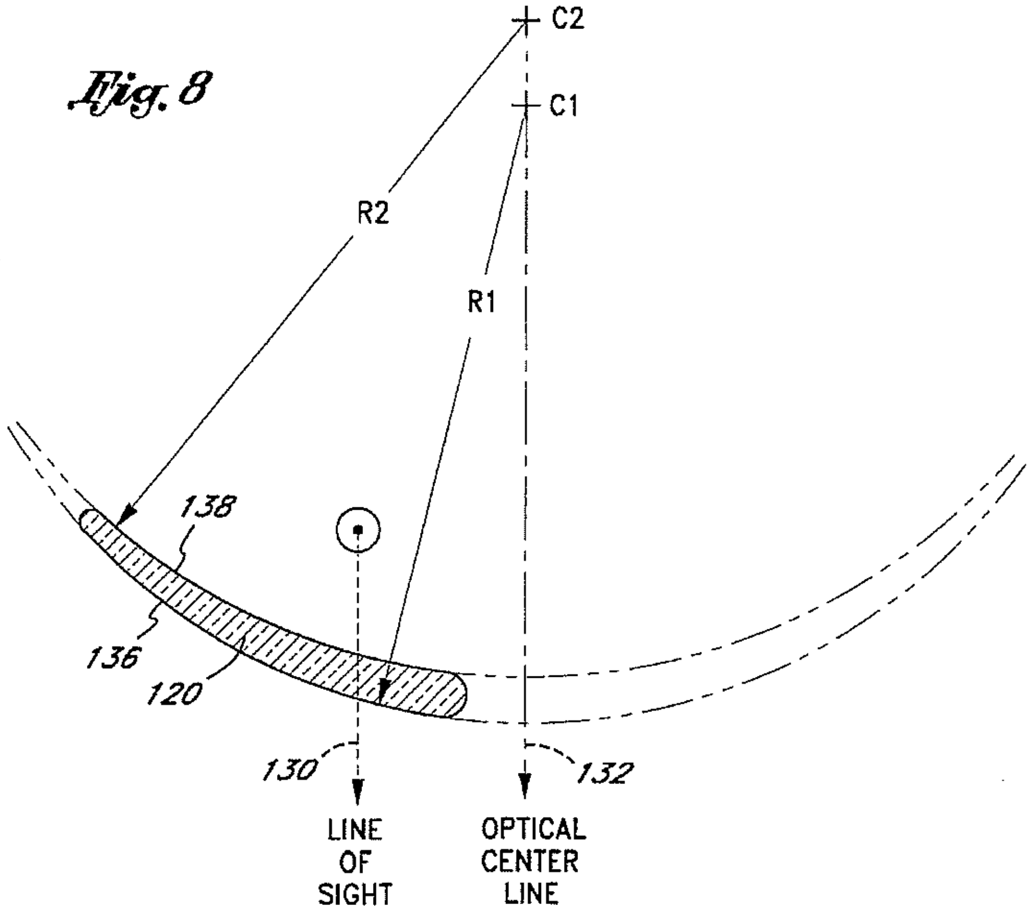


Fig. 9

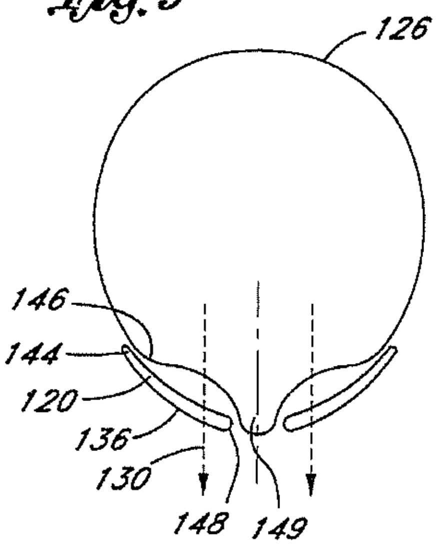


Fig. 10

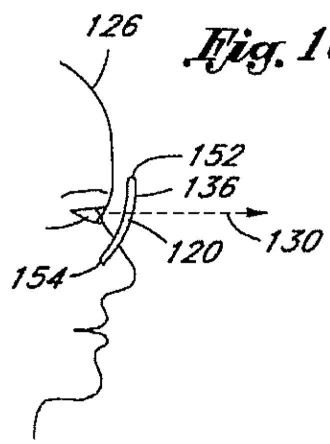


Fig. 11

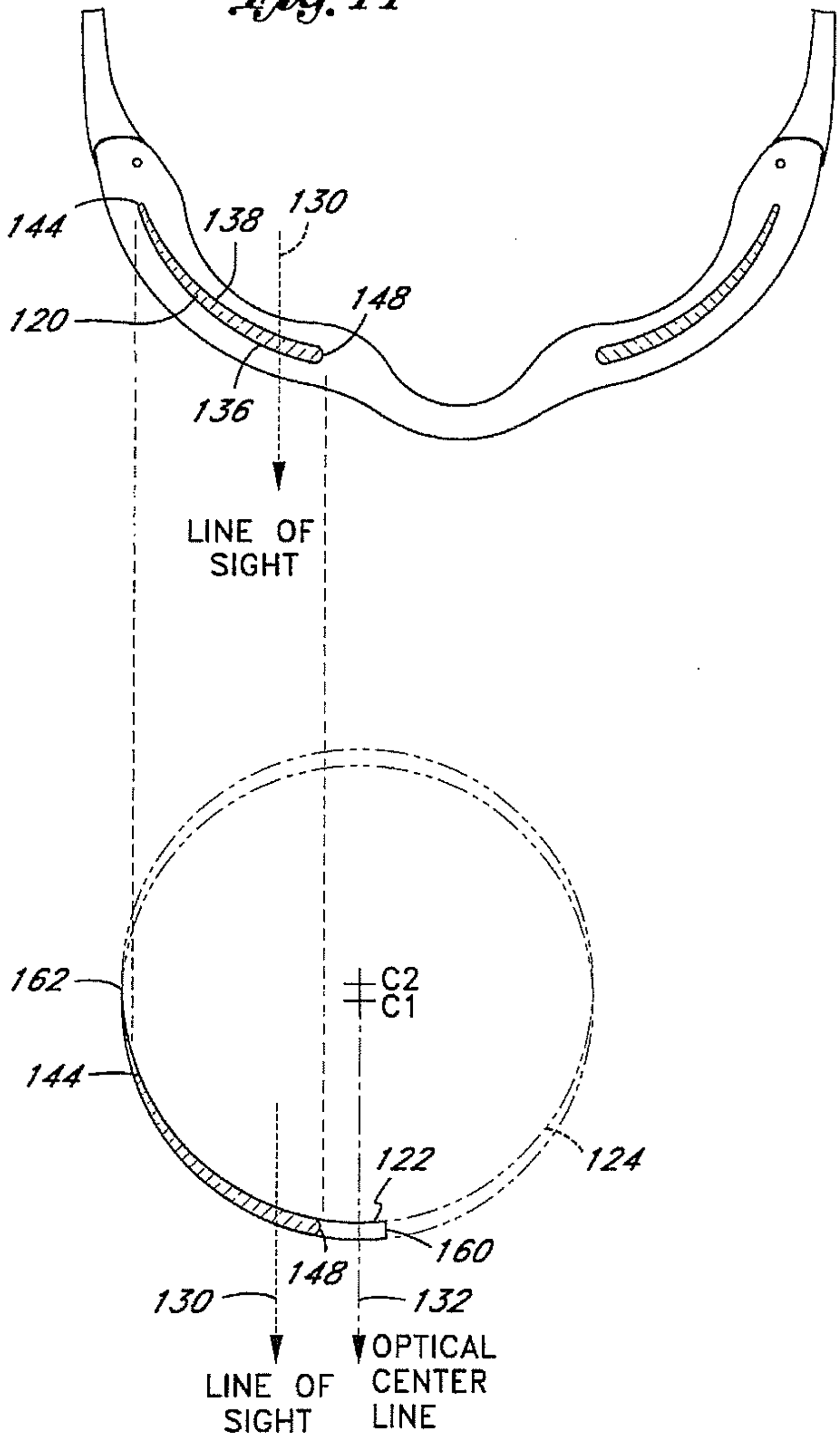
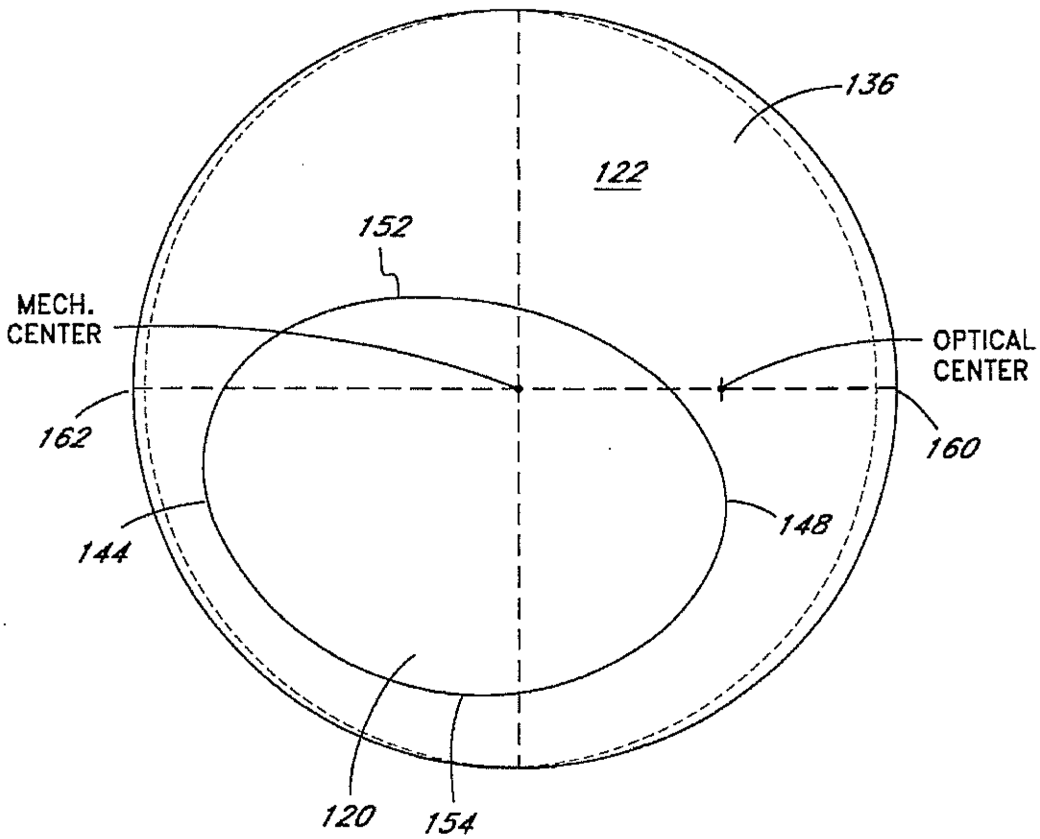

144
138
130
120
148
136
LINE OF
SIGHT
C2
C1
162
144
122
124
160
148
130
132
LINE OF
SIGHT
OPTICAL
CENTER
LINE

Fig. 12


136
122
152
MECH.
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DECENTERED NONCORRECTIVE LENS FOR EYEWEAR

The present invention relates generally to lenses used in eyewear, and more particularly to a decentered, noncorrective lens to reduce optical distortion.

BACKGROUND OF THE INVENTION

A wide variety of improvements have been made in recent years in the eyewear field, particularly with respect to eyewear intended for use in active sports or as fashion sunglasses. These improvements have been incorporated into eyewear having a unitary lens, such as the "Blades®" design (Oakley, Inc.) the "M Frame®" line (Oakley, Inc.), and the "Zero®" line also produced by Oakley, Inc. These eyewear designs accomplish a variety of functional advantages, such as maximizing interception of peripheral light, reducing optical distortion and increasing the wearer's comfort level, compared to previous active sport eyewear.

The unitary lens of the "Blades®" eyewear incorporates the cylindrical geometry disclosed, for example, in U.S. Pat. No. 4,859,048, issued to Jannard. This geometry allows the lens to closely conform to the wearer's face and intercept light, wind, dust, etc. from directly in front of the wearer (anterior direction) and peripherally (lateral direction). See also U.S. Pat. No. 4,867,550 to Jannard (toroidal lens geometry).

Although the early unitary lens systems provided a full side-to-side range of vision and good lateral eye protection, the potential for optical distortion still exists. In a unitary lens system, for example, the angle of incidence from the wearer's eye to the posterior lens surface changes as the wearer's sight line turns in the lateral direction. This results in disparate refraction between light entering closer to the front of the lens and peripheral light entering at the lateral ends. To address this source of prismatic distortion, U.S. Pat. No. 4,859,048 discloses tapering the thickness of the lens from the medial portion toward the lateral edge.

Prior art eyewear has also employed dual lens systems in which two separate lenses are mounted along a front frame. In the early dual lens eyeglass systems, each of the right and left lenses were roughly co-planar in the as-worn configuration. Thus, the sight line of the wearer, when looking straight ahead, generally crossed the posterior surface of the lens at a normal to the lens surface in the optical zone. One of the disadvantages of this lens configuration was that the eyeglasses provided essentially no lateral eye protection without the use of special modifications, such as vertically elongated earstems or side attachments.

Dual lens systems were thereafter developed in which the lateral edge of each lens curved rearwardly from the frontal plane, and around the side of the wearer's head to provide a lateral wrap similar to that achieved by the high wrap unitary lens systems. Although the dual lens eyeglasses with significant wrap provided lateral eye protection, the lens curvature generally introduced measurable prismatic distortion through the wearer's angular range of vision. This was particularly pronounced in lenses comprising low index of refraction materials. In addition, although high base curvatures (e.g. base 6 or higher) are sometimes desirable to optimize wrap while maintaining a low profile, such lenses have not been practical in the past due to the relatively high level of prismatic distortion.

Thus, there remains a need for a high base nonprescription lens for use in dual lens eyewear which can intercept light over essentially the full angular range of vision while at the same time minimize optical distortion throughout that range.

SUMMARY OF THE INVENTION

There is provided in accordance with one aspect of the present invention, an eyeglass lens for use in noncorrective dual lens eyewear. The eyeglass lens is utilized in combination with a frame to support the lens in the path of the wearer's normal line of sight.

The lens comprises a lens body, having a front surface, a rear surface, and a thickness therebetween.

The front surface of the lens conforms to a portion of the surface of a solid geometric shape. Preferably, the front surface of the lens conforms substantially to a portion of the surface of a first sphere having a first center. The rear surface of the lens conforms substantially to a portion of the surface of a solid geometric shape, which may be the same or different than that conforming to the front surface. Preferably, the rear surface conforms substantially to a portion of the surface of a second sphere having a second center.

The first and second centers are offset from one another to taper the lens thickness. The lens is mounted in the frame such that a line drawn through the first and second centers is maintained substantially parallel with the wearer's normal line of sight.

The lens may be cut from a lens blank, or formed directly into its final configuration such as by injection molding or other techniques known in the art. Preferably, the lens is oriented on the head of a wearer by the eyeglass frame such that the normal sight line of the wearer crosses the anterior surface of the lens at an angle of greater than about 95°, and preferably within the range of from about 100° to about 120°, while maintaining the optical centerline of the lens in a substantially parallel relationship with the normal sight line of the wearer. The optical centerline of the lens may or may not pass through the lens.

Methods of making the lens of the present invention are also disclosed.

Further features and advantages of the present invention will become apparent from the detailed description of preferred embodiments which follows, when considered together with the attached claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of eyewear incorporating taper corrected lenses made in accordance with an embodiment of the present invention.

FIG. 2 is a cross-sectional view taken along the lines 2—2 of FIG. 1.

FIG. 3 is a schematic horizontal cross-sectional view of a prior art untapered lens for a dual lens eyewear system.

FIG. 4 is a schematic horizontal cross-sectional view of a tapered lens for a dual lens eyewear system.

FIG. 5 is a cross-sectional view like that in FIG. 2, showing taper corrected lenses having a greater base curvature, in accordance with another embodiment of the present invention.

FIG. 6 is a perspective view of a lens blank conforming to a portion of the surface of a sphere, showing a lens profile to be cut from the blank in accordance with a preferred embodiment of the present invention.

FIG. 7 is a perspective cutaway view of the hollow, tapered wall spherical shape, lens blank, and lens of FIG. 6.

FIG. 8 is a horizontal cross-sectional view of a lens constructed in accordance with a preferred embodiment of the present invention.

FIG. 9 is a top plan view of the lens of FIG. 8 showing a high wrap in relation to a wearer.

FIG. 10 is a right side elevational cross-section of the lens and wearer of FIG. 9, showing lens rake.

FIG. 11 schematically illustrates the projection of the lens profile from a desired orientation within an eyewear frame to the lens blank in accordance with a preferred embodiment of the present invention.

FIG. 12 is a front elevational view of the lens and lens blank of FIG. 6, rotated to project the mechanical centerline of the blank normal to the page.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Although the preferred embodiments will be discussed below in terms of lenses having "spherical" front and rear surfaces (surfaces which conform substantially to a portion of the surface of a sphere), it will be understood by those having ordinary skill in the art that the invention may also be applicable to lenses having different surface geometries. Additionally, it will be understood that the present invention has application to lenses of many front elevational shapes and orientations in the as worn position beyond those illustrated herein.

Referring to FIGS. 1 and 2, there is illustrated an eyeglass 10, such as a sunglass having first and second lenses 12, 14 constructed in accordance with an embodiment of the present invention. Although the invention is illustrated in the context of an eyeglass design marketed by Oakley under the Eye Jackets™ name, the present invention relates solely to the lens curvature, taper, and orientation on the head of the wearer. Therefore the particular lens shape revealed in FIG. 1 is not critical to the invention. Rather, lenses of many other shapes and configurations may be constructed which incorporate the present invention as will become apparent based upon the disclosure herein.

Similarly, the particular mounting frame 16 shown is not essential to the present invention. The frame 16 may bound only the bottom edge(s) of the lenses 12, 14, only the top edges, or the entire lenses as illustrated. Alternatively, the frame 16 can bound any other portions of the lenses as will be evident to those of skill in the art. Frameless eyeglasses can also be constructed in accordance with the present invention, as long as the lens orientation on the head of the wearer is substantially maintained in a predetermined relationship to the normal sight line as will be discussed below. Preferably, though, the lenses 12, 14 are each mounted in an annular orbital as shown.

A pair of earstems 20, 22 pivotally attach to the frame 16. Alternatively, the earstems 20, 22 may attach directly to the lenses 12, 14. The frame may comprise of any of a variety of metals, composites or relatively rigid, molded thermoplastic materials which are well known in the art, and may be transparent or any of a variety of colors. Injection molding, machining and other construction techniques are well known in the art.

Lenses in accordance with the present invention can be manufactured by any of a variety of processes well known in the art.

Typically, high optical quality lenses are cut from a preformed injection molded lens blank. Since the right and left lenses are preferably mirror images of each other, only the right lens will generally be discussed below. Alternatively, the lens can be molded directly into its final shape and size, to eliminate the need for post molding cutting steps.

Preferably, the lens, or the lens blank from which it is cut, is injection molded and comprises a relatively rigid and optically acceptable material, such as polycarbonate. Other polymeric lens materials can also be used, such as CR-39 and a variety of high index plastics which are known in the art. The decentered taper correction of the present invention may also be applicable to glass lenses, although the need for correction in the present context is generally more pronounced in nonglass materials.

If the lens is to be cut from a lens blank, the taper and curvature of a carefully preselected portion of the molded lens blank is transferred to the lens in accordance with a preferred manufacturing process described below. Preferably, the frame is provided with a slot or other attachment structure that cooperates with the molded curvature of the lens to minimize deviation from, and even improve retention of the as-molded curvature.

Alternatively, the lens or lens blank can be stamped or cut from generally planar tapered sheet stock and then bent into the curved configuration in accordance with the present invention. This curved configuration can then be maintained by the use of a relatively rigid, curved frame, or by heating the curved sheet to retain its curved configuration, as is well known in the thermoforming art.

Most preferably, the curvature of both surfaces of the lens are created in the lens blank molding and polishing processes, and the lens shape is cut from the blank in accordance with the invention as described below.

Referring to FIG. 2, the lens 14 of the present invention is characterized in a horizontal plane by a generally arcuate shape, extending from a medial edge 24 throughout at least a portion and preferably substantially all of the wearer's range of vision to a lateral edge 26. The arc length of the lens from the medial edge 24 to the lateral edge 26 in a dual lens system will generally be within the range of from about 1½ inches to about 3½ inches, and preferably within the range of from about 2 inches to about 3 inches. In one preferred embodiment, the arc length of the lens is about 2⅜ inches.

Although the outer surfaces of the lenses 12, 14 appear to be illustrated as lying on a common circle 31, the right and left lenses will generally be canted such that the medial edge of each lens will fall outside of the circle 31 and the lateral edges will fall inside of the circle 31. Such canting of the lens increases the angle θ (FIG. 2) and increases the desirability of the optical correction achieved by the present invention.

When worn, the lens 14 should at least extend across the wearer's normal line of sight 27, and preferably substantially across the wearer's peripheral zones of vision. As used herein, the wearer's normal line of sight shall refer to a line projecting straight ahead of the wearer's eye, with substantially no angular deviation in either the vertical or horizontal planes as illustrated by line 130 in FIGS. 9 and 10.

The lens 14 is provided with an anterior surface 28, a posterior surface 30, and a varying thickness therebetween. The thickness of the lens 14 in the region of the medial edge 24 for a polycarbonate lens is generally within the range of from about 1 mm to about 2.5 mm, and preferably in the range of from about 1.5 mm to about 1.8 mm. In a preferred embodiment, the thickest portion of the lens 14 is at or about the optical centerline, and is about 1.65 mm.

Preferably, the thickness of the lens 14 tapers smoothly, though not necessarily linearly, from the maximum thickness proximate the medial edge 24 to a relatively lesser thickness at the lateral edge 26. The thickness of the lens near the lateral edge 26 is generally within the range of from about 0.635 mm to about 1.52 mm, and, preferably, within the range of from about 0.762 mm to about 1.27 mm. In one preferred polycarbonate embodiment, the lens has a minimum thickness in the lateral zone of about 1.15 mm. The minimum thickness at lateral edge **26** is generally governed by the desired impact resistance of the lens.

FIG. 3 schematically illustrates refraction in a prior art lens **41** with circular inside and outside surface horizontal cross-sections, having a uniform thickness **44**. With such a lens **41**, the angle of incidence of rays from the lens **41** to the eye **46** changes throughout the angular range of vision. For example, a ray which shall be referred to for descriptive purposes as a medial light ray **50** strikes the lens **41** at an angle α to the normal at the point of incidence. As is well known in this art, bending of light at transmitting surfaces depends in part upon the angle of incidence of light rays. The ray **50** is refracted or bent in opposite directions at each of an outer surface **52** and an inner surface **54** of the lens **41**, resulting in a transmitted ray **56** parallel to the incident ray **50**. The transmitted ray **50** is laterally displaced, relative to the path of the incident ray **50**, by a distance **58**. This displacement represents a first order source of optical distortion.

Furthermore, refractory displacement is even more pronounced at a lateral end **60** due to a greater angle of incidence β. A peripheral incident ray **62** experiences greater displacement **64** than the medial incident ray **50**, in accordance with Snell's Law, as will be understood by those of ordinary skill in the optical arts. The discrepancy between the peripheral ray displacement **64** and the medial ray displacement **58** results in a second order of optical distortion. This second order of distortion may cause substantial warping of an image seen through relatively lateral portions of the lens **41**.

FIG. 4 schematically illustrates a lens **71** of tapered thickness, to compensate for the greater angle of incidence at the lateral ends **60** of the lens **41** (FIG. 3), as disclosed in the context of unitary lens systems in U.S. Pat. No. 4,859,048, issued to Jannard. Tapering produces a smaller lens thickness **74** at a lateral end **76**, relative to a lens thickness **78** at a more medial point **80**. This smaller thickness **74** reduces an amount of peripheral ray displacement **82**, relative to the peripheral ray displacement **64** through the untapered lens **41** of FIG. 4. In other words, lesser lens thickness **74** near the lateral end **76** of the tapered lens **71** compensates to some extent for a greater angle of incidence β', relative to the thickness **78** and angle of incidence α' at the more medial point **80**.

The resulting difference between peripheral ray displacement **82** and medial ray displacement **84** on the same lens **71** is not as great as the corresponding difference in FIG. 3, reducing the second order optical distortion. Note that the degree of correction of the second order distortion depends upon a relationship between the manner and degree of tapering from the apex **85** to each lateral end **76** and the manner in which the angle of incidence changes over the same range.

The lens **71** of FIG. 4 is illustrated as though it were mounted within a frame (not shown) such that the wearer's normal line of sight **86** passes perpendicularly through the lens **71** at the lens apex or mechanical center **85**. In other words, the angle of incidence to the lens normal is zero for the wearer's normal line of sight. The outer and inner surfaces of lens **71** in the cross-sectional illustration conform to offset, equal-radius circles represented by centerpoints **87** and **88**, respectively. A line drawn through centerpoints **87** and **88**, referred to herein as the optical centerline of the lens, is collinear with the normal line of sight in the as-worn orientation. This conventional configuration shall be defined as a centrally oriented lens, for ease of description. Circumferentially clockwise or counterclockwise of the normal line of sight **86**, the angle of incidence to the lens normal increases in a regular fashion from zero at the lens apex **85**.

A high degree of wrap may be desirable for aesthetic styling reasons, for lateral protection of the eyes from flying debris, or for interception of peripheral light. Wrap may be attained by utilizing lenses of tight horizontal curvature (high base), such as small-radius spherical lenses, or by mounting each lens in a position which is canted laterally and rearwardly relative to centrally oriented dual lenses. Such canting shifts the normal line of sight **86** out of a collinear relationship with the optical centerline, and changes the optics of the lens. As a result, prior art dual lens eyewear with substantial "wrap" around the sides of a wearer's face has generally been accompanied by some degree of prismatic distortion.

In accordance with the present invention, there is provided an improved optical configuration and method for minimizing prismatic distortion. Though the present invention may be applied to a wide variety of lens shapes and orientations, the invention has particular utility for dual lens eyewear using high base curvature and demonstrating a high degree of wrap in the as-worn orientation.

Referring to FIGS. 2 and 5, the illustrated eyewear incorporates canted lenses **12** and **14** or **102** and **104**, mounted in a position rotated laterally relative to conventional centrally oriented dual lens mountings. A canted lens may be conceived as having an orientation, relative to the wearer's head, which would be achieved by starting with conventional dual lens eyewear having centrally oriented lenses and bending the frame inwardly at the temples to wrap around the side of the head.

As a consequence of the increased wrap, the wearer's normal line of sight **27** no longer strikes the lens **14** perpendicularly, as illustrated in FIG. 4. Instead, the angle of incidence θ (FIG. 2) for the wearer's line of sight **27** is generally greater than 90°, and to achieve good wrap it may be greater than about 95°, preferably is within the range of from about 100° to about 135°, and in one 9.5 base embodiment is about 101.75°. Lower base lenses generally will exhibit a larger angle θ in the as worn orientation, and the angle θ in an embodiment having a base of 6.5 was about 113.4°. In a base 4 embodiment having a pupillary distance of 2.8 inches, the angle θ was about 119.864°.

FIG. 5 illustrates the horizontal cross-section of an eyeglass **100** in accordance with an embodiment of the present invention, similar in style to that illustrated in FIG. 2, except having lenses **102** and **104** of tighter curvature (higher base) as well as possibly greater wrap. When the eyeglass **100** is worn, a lateral edge **106** of the lens **104** wraps significantly around and comes in close proximity to the wearer's temple to provide significant lateral eye protection as has been discussed.

An anterior (front) surface **108** of the lens of the present invention will generally conform to a portion of the surface of a regular geometric solid, such as a sphere **110**, shown here in horizontal cross-section. The front surfaces of spherical lenses **102** and **104** of the illustrated embodiment can, therefore, be characterized by a radius. By convention in the industry, the curvature may also be expressed in terms of a base value, such that the radius (R) in millimeters of the anterior surface of the lens is equal to 530 divided by the base curve, or

$$R=\frac{530}{B} \quad (1)$$

The present invention provides the ability to construct dual lens eyeglass systems having relatively high wrap using lens blanks having a base curve of 6 or greater, preferably between about 7½ and 10½, more preferably between about 8 and 9½, and, in one embodiment between about 8¾ and 9. The radius of the circle conforming to the anterior surface of a base 8¾ lens, for example, is about 60.57 millimeters. For comparison, the radius of the circle which characterizes the anterior surface of a base 3 lens is about 176.66 millimeters.

The embodiment of the present invention illustrated in FIG. 5 may be cut from a base 8¾ lens blank having a thickness of about 0.0649 inches at the optical centerline and about 0.053 inches at reference a point two inches along the outer circumference of the lens from the optical centerline. Alternatively, the lens can be molded directly into its final shape and configuration.

FIG. 6 is a perspective view of a lens blank **122**, a convex outside surface **136** of which generally conforms to a portion of the surface of a three-dimensional geometric shape **124**. It will be understood by those of skill in this art that lenses in accordance with the present invention may conform to any of a variety of geometric shapes.

Preferably, the outside surface of the lens will conform to a shape having a smooth, continuous surface having a constant horizontal radius (sphere or cylinder) or progressive curve (ellipse, toroid or ovoid) in either the horizontal or vertical planes. The geometric shape **124** of the preferred embodiments herein described, however, generally approximates a sphere.

The sphere **124** illustrated in FIGS. **6** and **7** is an imaginary three-dimensional solid, a portion of the wall of which is suitable from which to cut a lens **120**. As is known in the art, precision lens cutting is often accomplished by producing a lens blank **122** from which a lens **120** is ultimately cut. However, it should be clear to those of skill in the art from the illustrations of FIGS. **6** and **7**, that the use of a separate lens blank is optional, and the lens **120** may be molded directly into its final shape and configuration if desired.

It can also be seen from FIGS. **6** and **7** that the lens **120** and/or the lens blank **122** can be positioned at any of a variety of locations along the sphere **124**. For the purpose of the present invention, the optical centerline **132** operates as a reference line for orientation of the lens **120** with respect to the sphere **124**. In the illustrated embodiment, wherein both the outside surface and the inside surface conform to a portion of a sphere, the optical centerline is defined as the line **132** which joins the two centers C1 and C2. The analogous reference line for the purpose of nonspherical lens geometry may be formed in a manner different than connection of the two geometric centers of the spheres, as will be apparent to one of skill in the art.

The lens **120** is ultimately formed in such a manner that it retains the geometry of a portion of the wall of the sphere as illustrated in FIG. **7**. The location of the lens **120** on the sphere **124** is selected such that when the lens **120** is oriented in the eyeglass frame, the normal line of sight **130** of the wearer through the lens will be maintained substantially parallel to the optical centerline **132** of the geometric configuration from which the lens **120** was obtained. In the illustration of FIGS. **6** and **7**, the lens **120** is a right lens which has a significant degree of wrap, as well as some degree of rake. A lens having a different shape, or a lesser degree of wrap may overlap the optical centerline **132** of the imaginary sphere **124** from which the lens was formed. However, whether the optical centerline of the imaginary sphere **124** crosses through the lens **120** or not is unimportant, so long as the line of sight **130** in the lens **120** is maintained substantially parallel in the as-worn orientation with the optical centerline **132**.

For purposes of the present invention, "substantially parallel" shall mean that the line of sight **130** when the lens **120** is oriented in the as worn position generally does not deviate within the horizontal plane by more than about ±15° from parallel to the optical centerline **132**. Preferably, the normal line of sight **130** should not deviate by more than about ±10° from the optical centerline **132**, more preferably the normal line of sight **130** deviates by no more than about ±5° and most preferably no more than about ±2° from parallel to the optical centerline **132**. Optimally, the line of sight **130** is parallel to the optical centerline in the as worn orientation. Typically, an eyewear frame has a vertical plane of symmetry which is substantially parallel to the line of sight **130**. Accordingly, the optical centerline **132** will be substantially parallel to the frame's vertical plane of symmetry.

Variations from parallel in the horizontal plane generally have a greater negative impact on the lens than variations from parallel in the vertical plane. Accordingly, the solid angle between the line of sight **130** and optical centerline **132** in the vertical plane may exceed the ranges set forth above, for some eyewear, as long as the horizontal component of the angle of deviation is within the above-mentioned ranges of deviation from the parallel orientation. Preferably, the line of sight **130** deviates in the vertical plane no more than about ±10° and, more preferably, no more than gut ±3° from the optical centerline in the as worn orientation.

FIG. **7** is a cutaway view of the lens **120**, lens blank **122**, and geometric shape **124** of FIG. **6**. This view shows that the preferred geometric shape **124** is hollow with walls of varying thickness, as revealed by a horizontal cross-section **134** at the optical centerline of the geometric shape **124**.

The tapered walls of the preferred geometric shape **124** result from two horizontally offset spheres, represented by their center points C1 and C2 and radii R1 and R2. An outer surface **136** of the preferred lens blank **122** conforms to one sphere (of radius R1) while an inner surface **138** of the lens blank **122** conforms to the other sphere (of radius R2). By adjusting the parameters which describe the two spheres, the nature of the taper of the lens blank **122** may also be adjusted.

In particular, the parameters for the two spheres to which the lens blank outer surface **136** and inner surface **138** conform is preferably chosen to produce zero refractive power, or non-prescription lenses. Where CT represents a chosen center thickness (maximum thickness of the wall of the hollow geometric shape **124**), n is an index of refraction of the lens blank material, R1 is set by design choice for the curvature of the outer surface **136**, R2 may be determined according to the following equation:

$$R_2=R_1-CT+\frac{CT}{n} \quad (2)$$

CT/n represents the separation of the spherical centers C1 and C2. For example, where a base **6** lens is desired as a matter of design choice, the center thickness is chosen to be 3 mm, and the index of refraction of the preferred material (polycarbonate) is 1.586, R2 may be determined as follows:

$$R_2 = \frac{530}{6} - 3 + \frac{3}{1.586} = 87.225 \text{ mm} \quad (3)$$

For this example, the radius R1 of the outer surface **136** is equal to 88.333 mm, the radius R2 of the inner surface **138** is equal to 87.225 mm, and the spherical centers C1 and C2 are separated by 1.892 mm. These parameters describe the curvature of the lens blank **122** of the preferred embodiment.

In the case of the preferred embodiment, the optical centerline **132** is that line which passes through both center points C1 and C2 of the offset spheres. This happens to pass through the thickest portion of the preferred geometrical shape **124** walls at an optical center **140**, though this may not be true for alternative nonspherical embodiments. The optical center **140** happens to pass through surface **136** of the illustrated lens blank **122**, although this is not necessary. The optical center **140** does not happen to lie on the lens **120**, although it may for larger lenses or lenses intended to exhibit less wrap in the as-worn orientation.

FIG. **8** illustrates a horizontal cross-section of the preferred lens **120**, showing in phantom the geometric shape **124** to which the outer surface **136** and inner surface **138** conform. The lens blank **122** is omitted from this drawing. In accordance with the present invention, the optical centerline **132** associated with the chosen taper is aligned to be parallel with the normal line of sight **130** of the wearer as the lens **120** is to be mounted in an eyeglass frame.

Furthermore, although the preferred embodiments are circular in both horizontal and vertical cross-section, a variety of lens configurations in both planes are possible in conjunction with the present invention. Thus, for example, the outer surface of the lens of the present invention may generally conform to a spherical shape as shown in FIGS. **6** and **7**. Alternatively the lens may conform to a right circular cylinder, a frusto-conical, an elliptic cylinder, an ellipsoid, an ellipsoid of revolution, or any of a number of other three dimensional shapes. Regardless of the particular vertical or horizontal curvature of the outer surface, however, the inner surface should be chosen such as to smoothly taper the lens thickness at least in the horizontal plane.

FIGS. **9–12** will aid in describing a method of choosing a location on the lens blank **122** from which to cut the right lens **120**, in accordance with a preferred embodiment of the present invention. It will be understood that a similar method would be used to construct the left lens for the dual lens eyewear of the preferred embodiment.

As a first step, a desired general curvature of the lens outer surface **136** may be chosen. For the preferred lens **120**, this choice determines the base value of the lens blank **122**. As noted elsewhere herein, a number of other curvatures may be utilized in conjunction with the present invention. A choice of lens thickness may also be preselected. In particular, the minimum thickness may be selected such that the lens will withstand a preselected impact force.

A desired lens shape may also be chosen. For example, FIG. **12** illustrates an example of a front elevational shape for the lens **120**. The particular shape chosen is generally not relevant to the decentered lens optics disclosed herein.

A desired as-worn orientation for the lens should also be chosen, relative to the normal line of sight **130** of the wearer **126**. As mentioned above, preferred orientations may provide significant lateral wrap for lateral protection and interception of peripheral light, and for aesthetic reasons. For example, the embodiment illustrated in FIGS. **6–12** uses a canted lens **120** to achieve wrap. Alternatively, wrap may be achieved through use of a higher base lens and a more conventional (non-canted) orientation. FIGS. **9** and **10** illustrate more plainly how the orientations may be related to the line of sight **130** of the wearer.

The eyewear designer may also choose a degree of rake, or vertical tilt, as will be understood from FIG. **10**, schematically illustrating the vertical orientation of the lens **120** relative to the head of the wearer **126**, and relative in particular to the normal line of sight **130**. A downward rake, as illustrated, is desirable for a variety of reasons, including improved conformity to common head anatomy. As will be apparent to those of skill in the art, a lens **120** having a mechanical center point which falls below the horizontal plane intersecting the optical centerline **132** (see FIG. **7**) will tend to have a downward rake as illustrated in FIG. **10**. This is because the lens **120** will have been formed below the equator of the sphere relative to the optical centerline. Since the orientation of the lens **120** to the optical centerline **132** in the imaginary sphere should be the same as the orientation between the lens **120** and a parallel to the normal line of sight **130** in the as-worn condition, any lens cut from this sphere below the optical centerline **132** should exhibit a corresponding degree of downward rake.

Referring now to FIG. **11**, a mapping of the horizontal orientation of the lens **120** onto the lens blank **122** is illustrated. The normal line of sight **130**, with respect to which the chosen orientation is measured, is maintained substantially parallel to the optical centerline **132**.

Once the aesthetic design such as that illustrated in FIG. **11** has been determined, and the lens blank **122** formed having a suitable base curvature for fitting within the aesthetic design, the aesthetic design may be "projected" onto the surface of the sphere to reveal that portion of the sphere which is suitable for use as the lens **120**. The projection of the lens shape onto the sphere should be moved about the surface of the sphere until it is positioned such that the lens cut from the sphere at that location will exhibit the appropriate wrap and rake for the aesthetic design without any rotation of the lens **120** out of its orientation in which the optical centerline of the sphere is substantially parallel to the normal line of sight in the as-worn orientation.

Although not illustrated, it will be understood that a similar projection may be performed for the vertical orientation chosen, as depicted in FIG. **10**, for instance. FIG. **10** provides reference points in the form of the lens top edge **152** and bottom edge **154** in relation to the line of sight **130**. The projection may then be shifted up or down until the top edge **152** and the bottom edge are both simultaneously aligned with corresponding points on the outer surface **136** of the lens blank, while maintaining the line of sight **130** substantially parallel with the optical centerline **132**.

Projection of both the horizontal profile and the vertical profile may be performed simultaneously, locating a unique position on the lens blank **122** corresponding to the desired three-dimensional shape of the lens (including the front elevational shape shown in FIG. **12**) at which the line of sight **130** is parallel to the optical centerline **132** or other reference line of the lens blank **122**. Of course, it will be understood that the lines **130** and **132** may be substantially parallel, that is, within the acceptable range of angular deviation set forth above.

This shape may then be cut from the blank **122** or molded directly in the final lens configuration. The resultant lens **120** not only conforms to the desired shape, but also minimizes prismatic distortion.

FIG. **12** illustrates a lens blank **122**, such as that shown conforming to a portion of the surface of the sphere in FIGS. **6** and **7**. In FIG. **12**, the lens blank **122** has been rotated such that the mechanical center of the blank is illustrated in the center of the drawing. The illustrated lens **120** has a medial edge **148**, a lateral edge **144**, an upper edge **152** and a lower edge **154**. At least a portion of the right lens **120** lies in the lower left-hand (third) quadrant of the lens blank **122**. Preferably, in an embodiment of the invention exhibiting both wrap and downward rake, at least about half of the lens area will fall within the third quadrant of the lens blank **122**. Preferably all or substantially all of the area of the lens **120** will lie below and to the left of the optical center as illustrated. Lenses exhibiting a similar degree of rake but lesser wrap may be positioned on the lens blank **122** such that as much as 50% or more of the lens area is within the lower right (second) quadrant of the lens blank **122**.

The present invention thus provides a precise method of furnishing the correct correspondence between taper and the varying angle of incidence from the wearer's eye to the surface of a lens. By recognizing a novel relationship among the wearer's line of sight and the form of taper, the present invention allows use of any of a variety of lens designs while minimizing prismatic distortion. For example, a designer may choose a desirable orientation and curvature for the lens, relative to a wearer's line of sight. The orientation and curvature may be chosen from a wide range of rake (i.e., vertical "tilt" of the lens), horizontal cant, base value and proximity to a wearer's face, including those parameters resulting in a high degree of wrap. The form of taper may then be chosen, by the method of the present invention, such that the prismatic distortion is minimized.

Although the foregoing invention has been described in terms of certain preferred embodiments, other embodiments will become apparent to those of ordinary skill in the art in view of the disclosure herein. Accordingly, the present invention is not intended to be limited by the recitation of preferred embodiments, but is intended to be defined solely by reference to the appended claims.

What is claimed:

1. An eyeglass lens, for use in noncorrective dual lens eyewear, in combination with a frame to support the lens in the path of a wearer's normal line of sight, comprising:

a lens body;

a front surface and a rear surface on the lens body, defining a lens thickness therebetween;

the front surface conforming substantially to a portion of the surface of a first sphere having a first center;

the rear surface conforming substantially to a portion of the surface of a second sphere having a second center;

said first center and said second center offset from one another to taper said lens thickness;

wherein said lens is mounted in the frame such that an optical centerline drawn through said first and second centers is spaced from and maintained substantially parallel with the wearer's normal line of sight in each of a horizontal plane and a vertical plane.

2. An eyeglass lens as in claim **1**, wherein said first sphere has a base curve of greater than about base 6.

3. An eyeglass lens as in claim **2**, wherein said first sphere has a base curve of greater than about base 8.

4. An eyeglass lens as in claim **3** wherein said first sphere has a base curve of about base 8.75, and said lens is no thicker at any point than about 1.65 mm and is no thinner at any point than about 1.15 mm.

5. An eyeglass lens as in claim **1**, wherein a horizontal component of the wearer's normal line of sight in a horizontal plane deviates in an as worn orientation by no more than about ±10° from parallel with a horizontal component of said optical centerline in said horizontal plane.

6. An eyeglass lens as in claim **5**, wherein said horizontal component of the wearer's normal line of sight deviates in an as worn orientation by no more than about ±5° from parallel with said horizontal component of said optical centerline.

7. An eyeglass lens as in claim **6**, wherein said horizontal component of the wearer's normal line of sight deviates in an as worn orientation by no more than about ±2° from parallel with said horizontal component of said optical centerline.

8. An eyeglass lens as in claim **7**, wherein said horizontal component of the wearer's normal line of sight is parallel in an as worn orientation with said horizontal component of said optical centerline.

9. An eyeglass lens as in claim **1**, wherein a vertical component of the wearer's normal line of sight in a vertical plane deviates in an as worn orientation by no more than about ±10° from parallel with a vertical component of said optical centerline in said vertical plane.

10. An eyeglass lens as in claim **9**, wherein said vertical component of the wearer's normal line of sight deviates in an as worn orientation by no more than about ±3° from parallel with said vertical component of said optical centerline.

11. An eyeglass lens as in claim **10**, wherein said vertical component of the wearer's normal line of sight is parallel in an as worn orientation with said vertical component of said optical centerline.

12. An eyeglass lens as in claim **10**, wherein a horizontal component of the wearer's normal line of sight in a horizontal plane deviates in an as worn orientation by no more than about ±2° from parallel with a horizontal component of said optical centerline in said horizontal plane.

* * * * *

US005689323A

United States Patent [19]

Houston et al.

[11] **Patent Number: 5,689,323**

[45] **Date of Patent: Nov. 18, 1997**

[54] **DECENTERED NONCORRECTIVE LENS FOR EYEWEAR**

[75] Inventors: **Malcolm Neal Houston**, Foothill Ranch, Calif.; **James H. Jannard**, Double Island, Wash.; **Carlos D. Reyes**, Mission Viejo, Calif.

[73] Assignee: **Oakley, Inc.**, Foothill Ranch, Calif.

[21] Appl. No.: **706,564**

[22] Filed: **Sep. 5, 1996**

Related U.S. Application Data

[62] Division of Ser. No. 567,434, Dec. 5, 1995, Pat. No. 5,648,832.

[51] **Int. Cl.**^{6} **G02C 13/00**

[52] **U.S. Cl.** **351/41**; 351/178

[58] **Field of Search** 351/41, 44, 159, 351/177, 178

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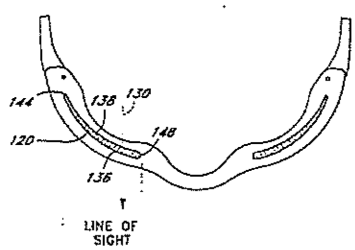
Primary Examiner—Huy Mai

Attorney, Agent, or Firm—Knobbe, Martens, Olson & Bear, LLP

[57] **ABSTRACT**

Disclosed is an optically corrected lens for nonprescription, dual lens eyeglasses. In a preferred embodiment, the anterior surface of the lens lies on a portion of a first sphere having a first center. The posterior surface of the lens lies on the surface of a second sphere having a second center. The first and second centers are offset from one another to provide a tapered lens. The lens is oriented on the head of the wearer by a frame that maintains the lens in a position such that a line drawn through the first and second centers is maintained substantially in parallel to the normal sight line of the wearer. Methods of making the lenses, and eyewear incorporating the lenses, are also disclosed.

15 Claims, 7 Drawing Sheets



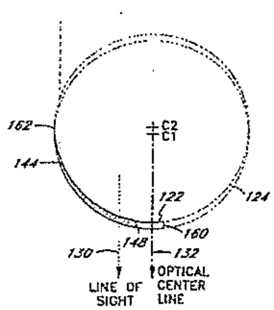


Fig. 1

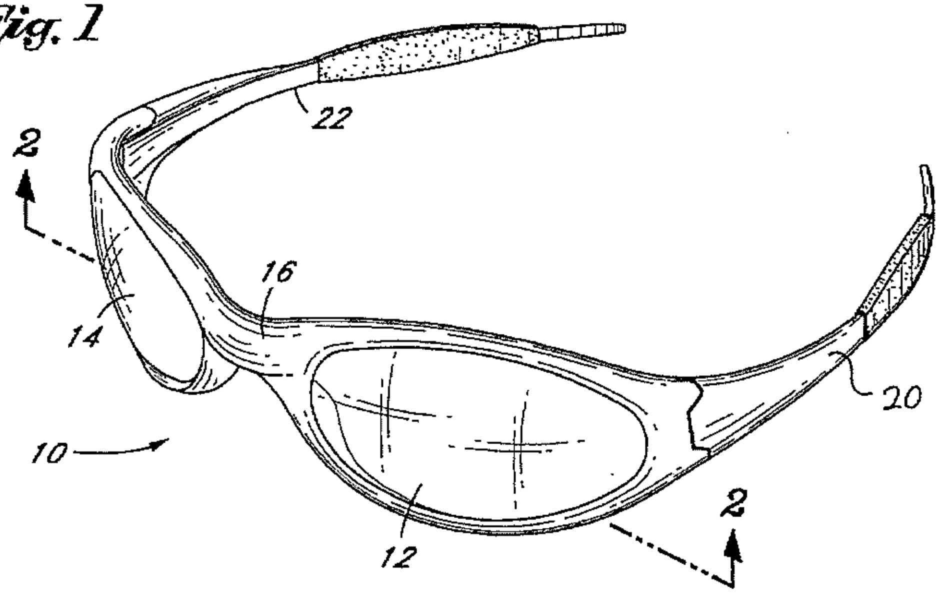


Fig. 2

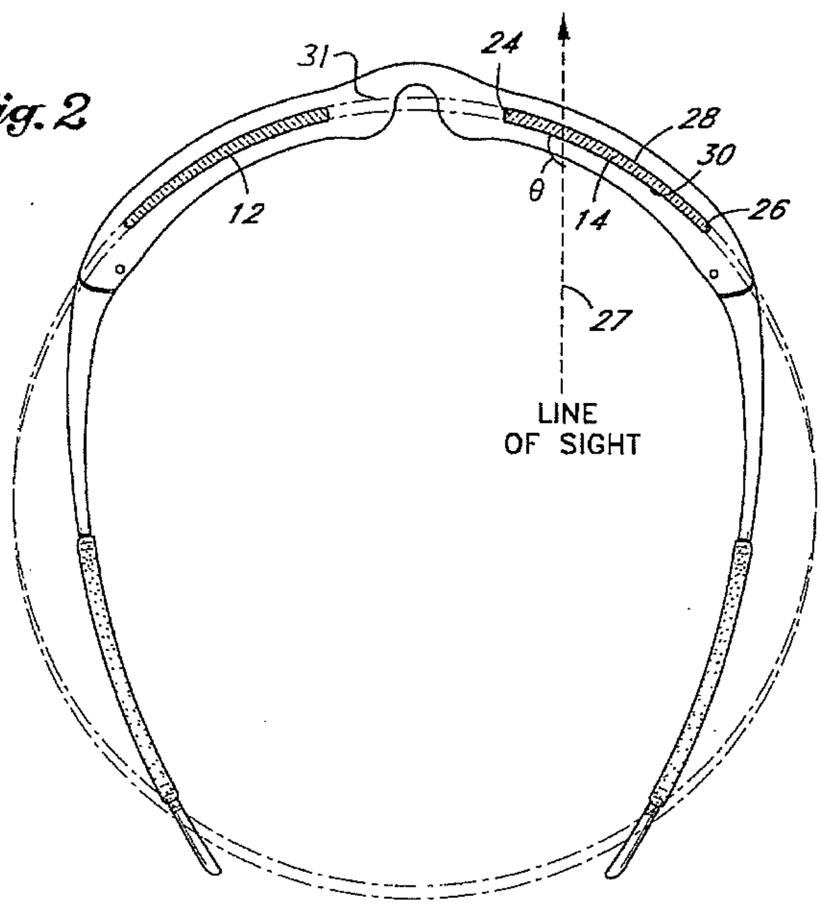


Fig. 3

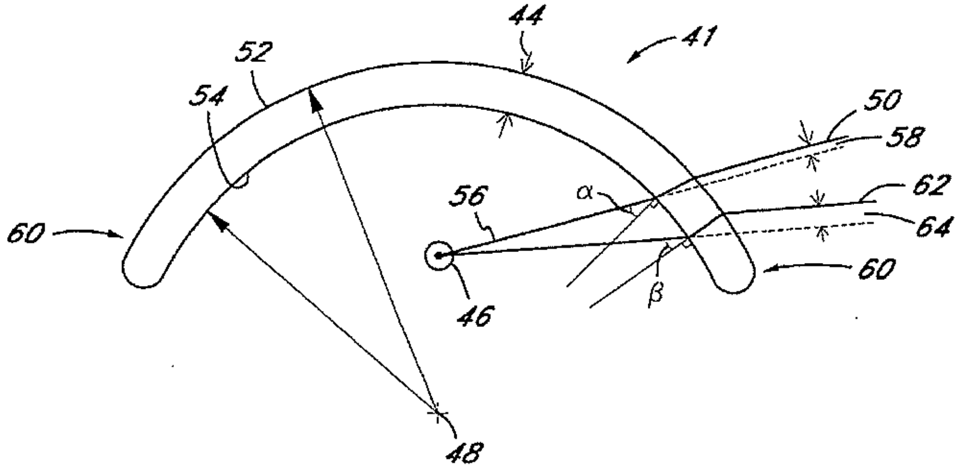

44
41
52
54
50
58
62
64
56
α
60
60
β
46
48

Fig. 4

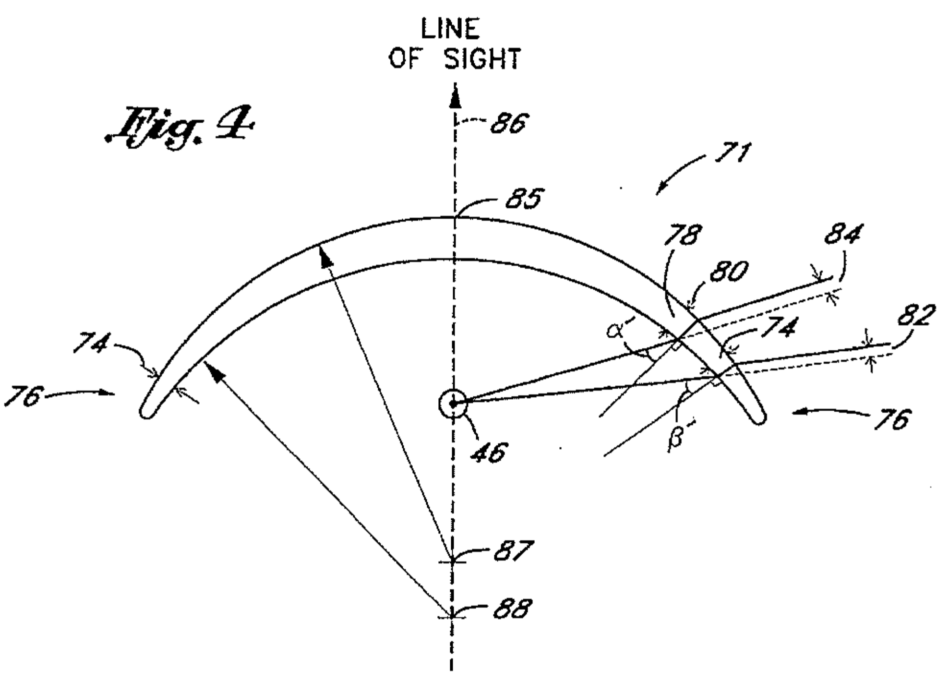
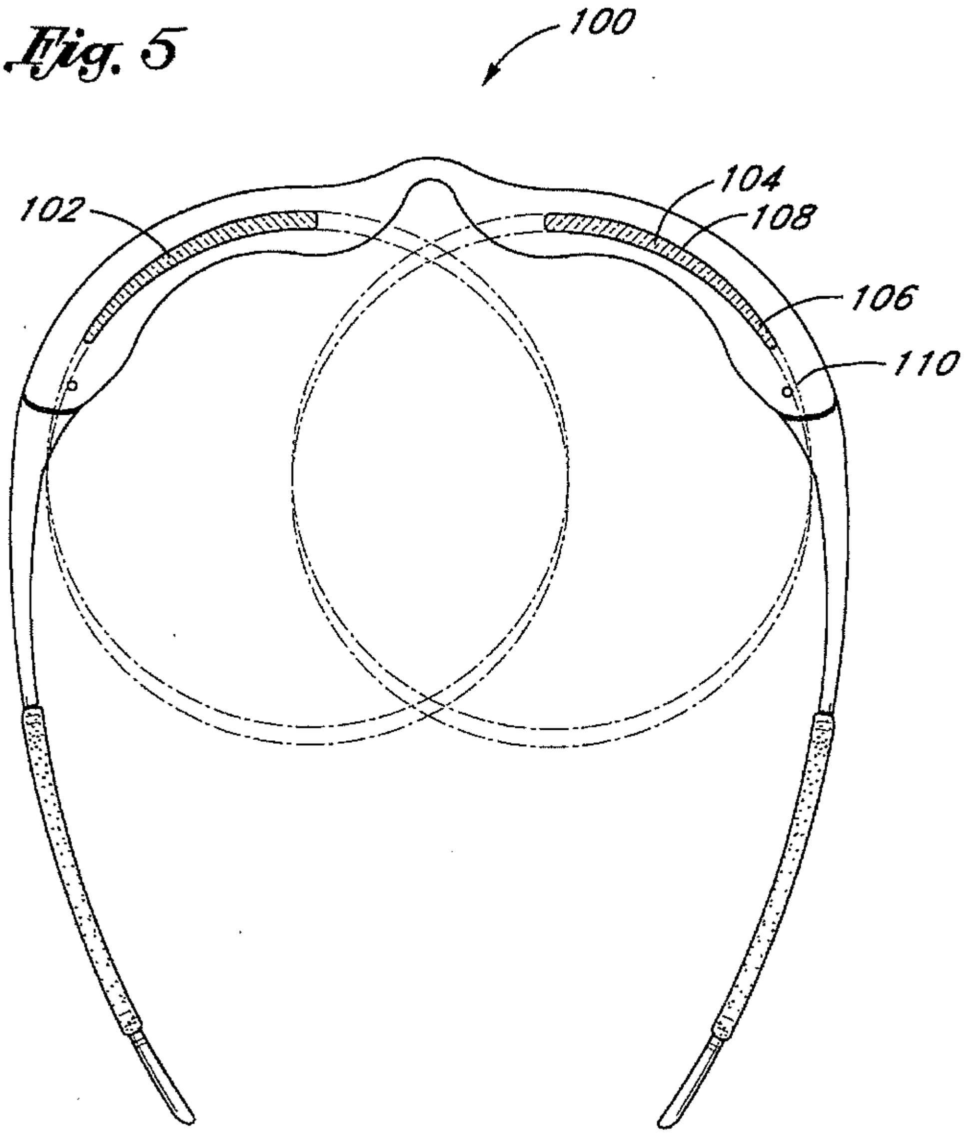

LINE
OF SIGHT
86
71
85
78
84
80
α'
74
82
74
76
76
β'
46
87
88

Fig. 5



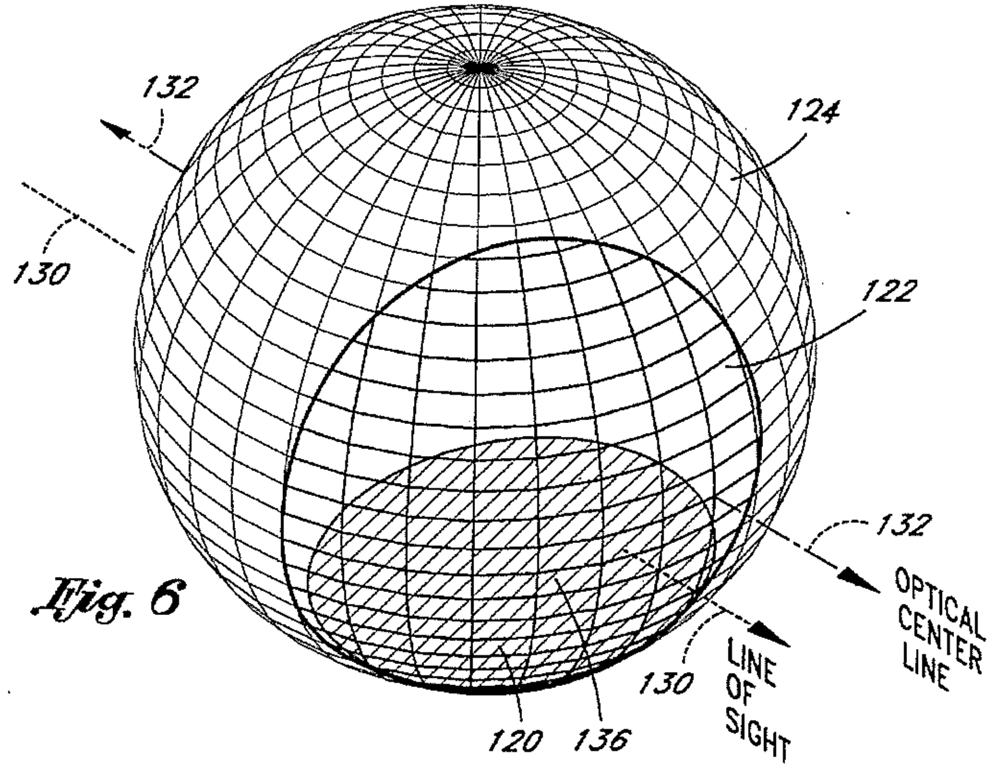

132
124
130
122
132
OPTICAL CENTER LINE
130
LINE OF SIGHT
120
136

Fig. 6

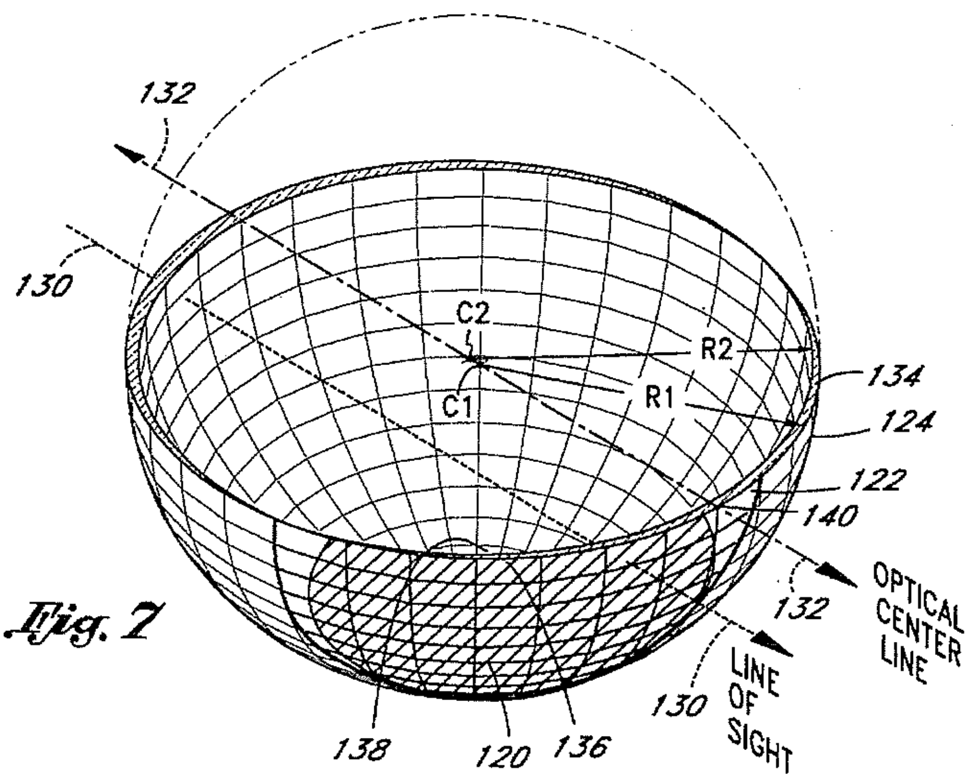

132
130
C2
R2
C1
R1
134
124
122
140
OPTICAL CENTER LINE
132
130
LINE OF SIGHT
138
120
136

Fig. 7

Fig. 8

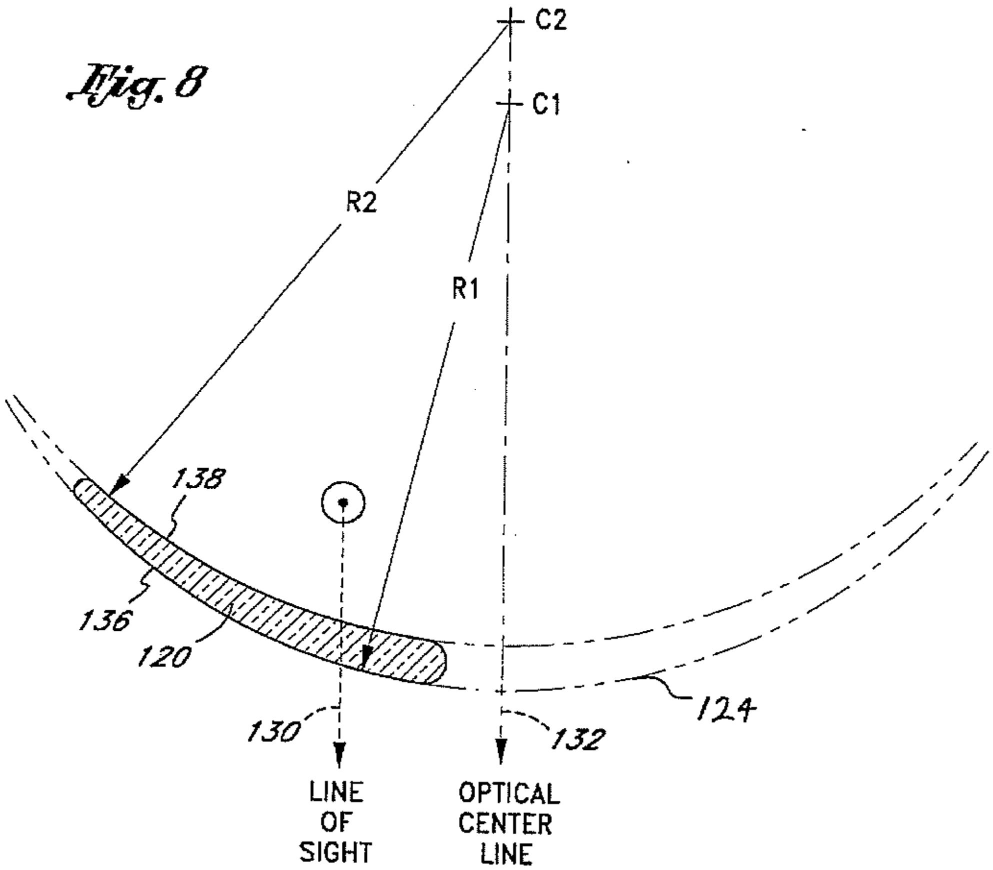


Fig. 9

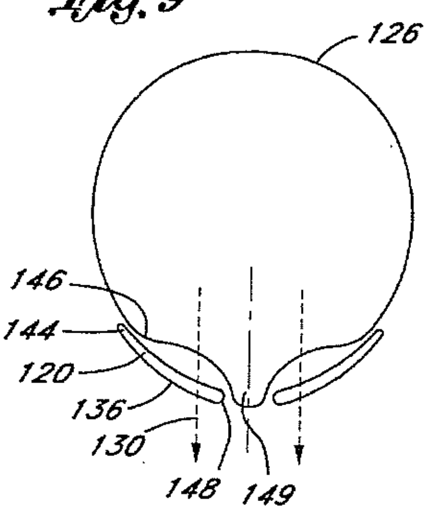


Fig. 10

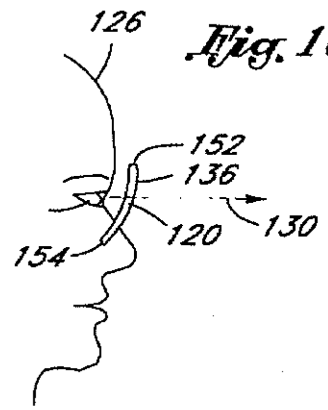


Fig. 11

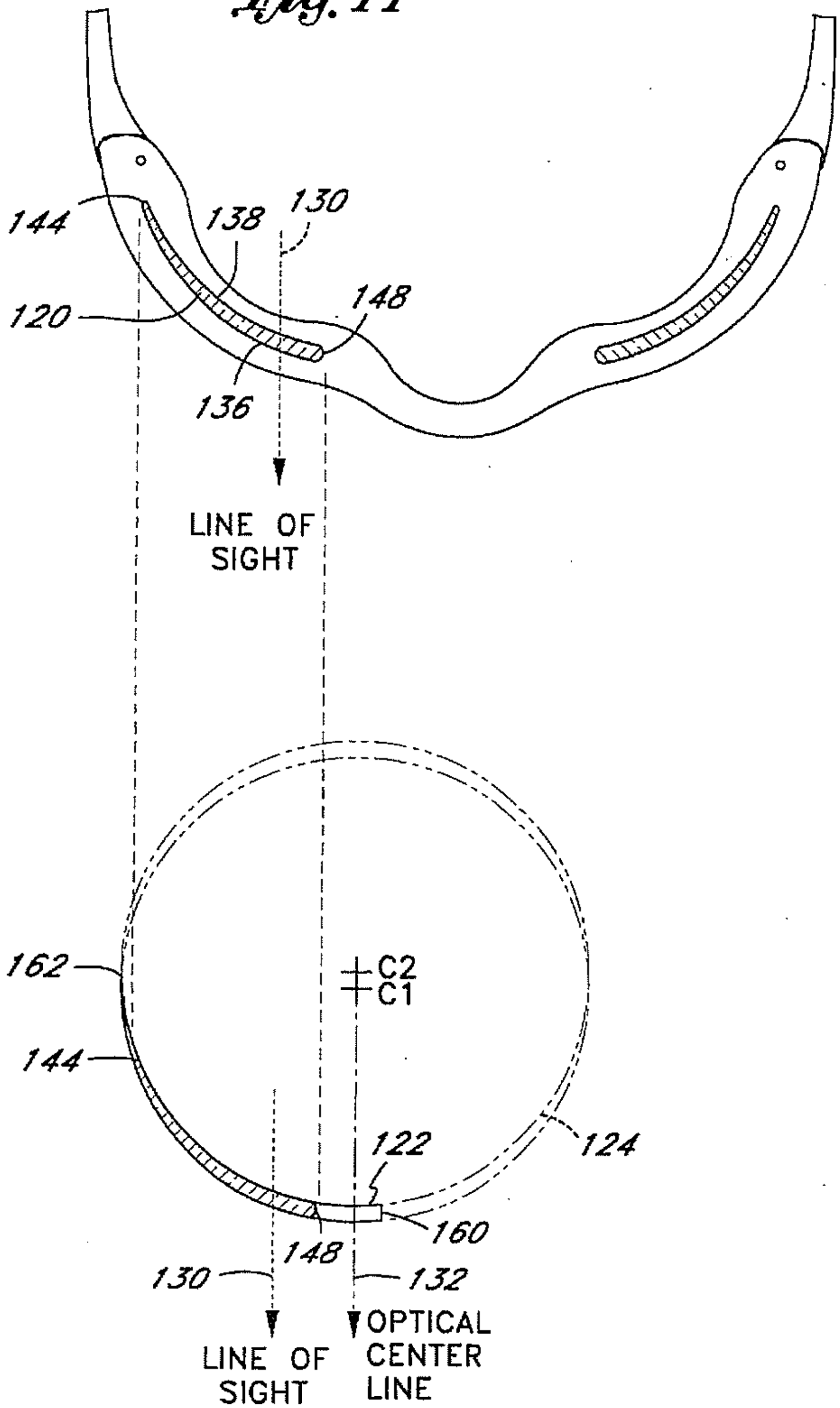
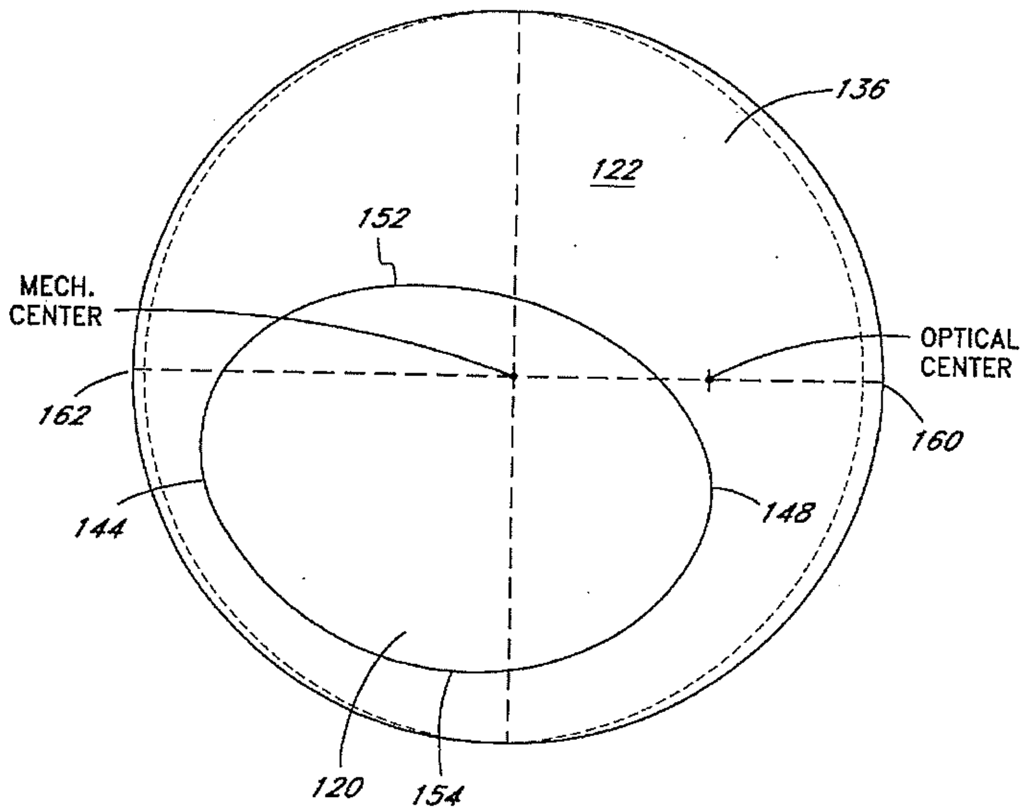

144
138
130
120
148
136
LINE OF
SIGHT
162
C2
C1
144
122
124
160
148
130
132
LINE OF
SIGHT
OPTICAL
CENTER
LINE

Fig. 12


136
122
152
MECH.
CENTER
OPTICAL
CENTER
162
160
144
148
120
154

DECENTERED NONCORRECTIVE LENS FOR EYEWEAR

This application is a divisional U.S. patent application Ser. No. 08/567,434, filed Dec. 5, 1995, now U.S. Pat. No. 5,648,832.

The present invention relates generally to lenses used eyewear, and more particularly to a decentered, noncorrective lens to reduce optical distortion.

BACKGROUND OF THE INVENTION

A wide variety of improvements have been made in recent years in the eyewear field, particularly with respect to eyewear intended for use in active sports or as fashion sunglasses. These improvements have been incorporated into eyewear having a unitary lens, such as the "Blades®" design (Oakley, Inc.) the "M Frame®" line (Oakley, Inc.), and the "Zero®" line also produced by Oakley, Inc. These eyewear designs accomplish a variety of functional advantages, such as maximizing interception of peripheral light, reducing optical distortion and increasing the wearer's comfort level, compared to previous active sport eyewear.

The unitary lens of the "Blades®" eyewear incorporates the cylindrical geometry disclosed, for example, in U.S. Pat. No. 4,859,048, issued to Jannard. This geometry allows the lens to closely conform to the wearer's face and intercept light, wind, dust, etc. from directly in front of the wearer (anterior direction) and peripherally (lateral direction). See also U.S. Pat. No. 4,867,550 to Jannard (toroidal lens geometry).

Although the early unitary lens systems provided a full side-to-side range of vision and good lateral eye protection, the potential for optical distortion still exists. In a unitary lens system, for example, the angle of incidence from the wearer's eye to the posterior lens surface changes as the wearer's sight line turns in the lateral direction. This results in disparate refraction between light entering closer to the front of the lens and peripheral light entering at the lateral ends. To address this source of prismatic distortion, U.S. Pat. No. 4,859,048 discloses tapering the thickness of the lens from the medial portion toward the lateral edge.

Prior art eyewear has also employed dual lens systems in which two separate lenses are mounted along a front frame. In the early dual lens eyeglass systems, each of the right and left lenses were roughly co-planar in the as-worn configuration. Thus, the sight line of the wearer, when looking straight ahead, generally crossed the posterior surface of the lens at a normal to the lens surface in the optical zone. One of the disadvantages of this lens configuration was that the eyeglasses provided essentially no lateral eye protection without the use of special modifications, such as vertically elongated earstems or side attachments.

Dual lens systems were thereafter developed in which the lateral edge of each lens curved rearwardly from the frontal plane, and around the side of the wearer's head to provide a lateral wrap similar to that achieved by the high wrap unitary lens systems. Although the dual lens eyeglasses with significant wrap provided lateral eye protection, the lens curvature generally introduced measurable prismatic distortion through the wearer's angular range of vision. This was particularly pronounced in lenses comprising low index of refraction materials. In addition, although high base curvatures (e.g. base 6 or higher) are sometimes desirable to optimize wrap while maintaining a low profile, such lenses have not been practical in the past due to the relatively high level of prismatic distortion.

Thus, there remains a need for a high base nonprescription lens for use in dual lens eyewear which can intercept light over essentially the full angular range of vision while at the same time minimize optical distortion throughout that range.

SUMMARY OF THE INVENTION

There is provided in accordance with one aspect of the present invention, an eyeglass lens for use in noncorrective dual lens eyewear. The eyeglass lens is utilized in combination with a frame to support the lens in the path of the wearer's normal line of sight.

The lens comprises a lens body, having a front surface, a rear surface, and a thickness therebetween.

The front surface of the lens conforms to a portion of the surface of a solid geometric shape. Preferably, the front surface of the lens conforms substantially to a portion of the surface of a first sphere having a first center. The rear surface of the lens conforms substantially to a portion of the surface of a solid geometric shape, which may be the same or different than that conforming to the front surface. Preferably, the rear surface conforms substantially to a portion of the surface of a second sphere having a second center.

The first and second centers are offset from one another to taper the lens thickness. The lens is mounted in the frame such that a line drawn through the first and second centers is maintained generally in parallel with the wearer's normal line of sight.

The lens may be cut from a lens blank, or formed directly into its final configuration such as by injection molding or other techniques known in the art. Preferably, the lens is oriented on the head of a wearer by the eyeglass frame such that the normal sight line of the wearer crosses the anterior surface of the lens at an angle of greater than about 95°, and preferably within the range of from about 100° to about 120°, while maintaining the optical centerline of the lens in a generally parallel relationship with the normal sight line of the wearer. The optical centerline of the lens may or may not pass through the lens.

Methods of making the lens of the present invention are also disclosed.

Further features and advantages of the present invention will become apparent from the detailed description of preferred embodiments which follows, when considered together with the attached claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of eyewear incorporating taper corrected lenses made in accordance with an embodiment of the present invention.

FIG. 2 is a cross-sectional view taken along the lines 2—2 of FIG. 1.

FIG. 3 is a schematic horizontal cross-sectional view of a prior art untapered lens for a dual lens eyewear system.

FIG. 4 is a schematic horizontal cross-sectional view of a tapered lens for a dual lens eyewear system.

FIG. 5 is a cross-sectional view like that in FIG. 2, showing taper corrected lenses having a greater base curvature, in accordance with another embodiment of the present invention.

FIG. 6 is a perspective view of a lens blank conforming to a portion of the surface of a sphere, showing a lens profile to be cut from the blank in accordance with a preferred embodiment of the present invention.

FIG. 7 is a perspective cutaway view of the hollow, tapered wall spherical shape, lens blank, and lens of FIG. 6.

FIG. 8 is a horizontal cross-sectional view of a lens constructed in accordance with a preferred embodiment of the present invention.

FIG. 9 is a top plan view of the lens of FIG. 8 showing a high wrap in relation to a wearer.

FIG. 10 is a right side elevational cross-section of the lens and wearer of FIG. 9, showing lens rake.

FIG. 11 schematically illustrates the projection of the lens profile from a desired orientation within an eyewear frame to the lens blank in accordance with a preferred embodiment of the present invention.

FIG. 12 is a front elevational view of the lens and lens blank of FIG. 6, rotated to project the mechanical centerline of the blank normal to the page.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Although the preferred embodiments will be discussed below in terms of lenses having "spherical" front and rear surfaces (surfaces which conform substantially to a portion of the surface of a sphere), it will be understood by those having ordinary skill in the art that the invention may also be applicable to lenses having different surface geometries. Additionally, it will be understood that the present invention has application to lenses of many front elevational shapes and orientations in the as worn position beyond those illustrated herein.

Referring to FIGS. 1 and 2, there is illustrated an eyeglass 10, such as a sunglass having first and second lenses 12, 14 constructed in accordance with an embodiment of the present invention. Although the invention is illustrated in the context of an eyeglass design marketed by Oakley under the Eye Jackets™ name, the present invention relates solely to the lens curvature, taper, and orientation on the head of the wearer. Therefore the particular lens shape revealed in FIG. 1 is not critical to the invention. Rather, lenses of many other shapes and configurations may be constructed which incorporate the present invention as will become apparent based upon the disclosure herein.

Similarly, the particular mounting frame 16 shown is not essential to the present invention. The frame 16 may bound only the bottom edge(s) of the lenses 12, 14, only the top edges, or the entire lenses as illustrated. Alternatively, the frame 16 can bound any other portions of the lenses as will be evident to those of skill in the art. Frameless eyeglasses can also be constructed in accordance with the present invention, as long as the lens orientation on the head of the wearer is substantially maintained in a predetermined relationship to the normal sight line as will be discuss, below. Preferably, though, lenses 12, 14 are each mounted in an annular orbital as shown.

A pair of earstems 20, 22 pivotally attach to the frame 16. Alternatively, the earstems 20, 22 may attach directly to the lenses 12, 14. The frame may comprise of any of a variety of metals, composites or relatively rigid, molded thermoplastic materials which are well known in the art, and may be transparent or any of a variety of colors. Injection molding, machining and other construction techniques are well known in the art.

Lenses in accordance with the present invention can be manufactured by any of a variety of processes well known in the art.

Typically, high optical quality lenses are cut from a preformed injection molded lens blank. Since the right and left lenses are preferably mirror images of each other, only the right lens will generally be discussed below. Alternatively, the lens can be molded directly into its final shape and size, to eliminate the need for post molding cutting steps.

Preferably, the lens, or the lens blank from which it is cut, is injection molded and comprises a relatively rigid and optically acceptable material, such as polycarbonate. Other polymeric lens materials can also be used, such as CR-39 and a variety of high index plastics which are known in the art. The decentered taper correction of the present invention may also be applicable to glass lenses, although the need for correction in the present context is generally more pronounced in nonglass materials.

If the lens is to be cut from a lens blank, the taper and curvature of a carefully preselected portion of the molded lens blank is transferred to the lens in accordance with a preferred manufacturing process described below. Preferably, the frame is provided with a slot or other attachment structure that cooperates with the molded curvature of the lens to minimize deviation from, and even improve retention of the as-molded curvature.

Alternatively, the lens or lens blank can be stamped or cut from generally planar tapered sheet stock and then bent into the curved configuration in accordance with the present invention. This curved configuration can then be maintained by the use of a relatively rigid, curved frame, or by heating the curved sheet to retain its curved configuration, as is well known in the thermoforming art.

Most preferably, the curvature of both surfaces of the lens are created in the lens blank molding and polishing processes, and the lens shape is cut from the blank in accordance with the invention as described below.

Referring to FIG. 2, the lens 14 of the present invention is characterized in a horizontal plane by a generally arcuate shape, extending from a medial edge 24 throughout at least a portion and preferably substantially all of the wearer's range of vision to a lateral edge 26. The arc length of the lens from the medial edge 24 to the lateral edge 26 in a dual lens system will generally be within the range of from about 1½ inches to about 3 inches, and preferably within the range of from about 2 inches to about 3 inches. In one preferred embodiment, the arc length of the lens is about 2⅜ inches.

Although the outer surfaces of the lenses 12, 14 appear to be illustrated as lying on a common circle 31, the right and left lenses will generally be canted such that the medial edge of each lens will fall outside of the circle 31 and the lateral edges will fall inside of the circle 31. such canting of the lens increases the angle θ (FIG. 2) and increases the desirability of the optical correction achieved by the present invention.

When worn, the lens 14 should at least extend across the wearer's normal line of sight 27, and preferably substantially across the wearer's peripheral zones of vision. As used herein, the wearer's normal line of sight shall refer to a line projecting straight ahead of the wearer's eye, with substantially no angular deviation in either the vertical or horizontal planes as illustrated by line 130 in FIGS. 9 and 10.

The lens 14 is provided with an anterior surface 28, a posterior surface 30, and a varying thickness therebetween. The thickness of the lens 14 in the region of the medial edge 24 for a polycarbonate lens is generally within the range of from about 1 mm to about 2.5 mm, and preferably in the range of from about 1.5 mm to about 1.8 mm. In a preferred embodiment, the thickest portion of the lens 14 is at or about the optical centerline, and is about 1.65 mm.

Preferably, the thickness of the lens 14 tapers smoothly, though not necessarily linearly, from the maximum thickness proximate the medial edge **24** to a relatively lesser thickness at the lateral edge **26**. The thickness of the lens near the lateral edge **26** is generally within the range of from about 0.635 mm to about 1.52 mm, and, preferably, within the range of from about 0.762 mm to about 1.27 mm. In one preferred polycarbonate embodiment, the lens has a minimum thickness in the lateral zone of about 1.15 mm. The minimum thickness at lateral edge **26** is generally governed by the desired impact resistance of the lens.

FIG. 3 schematically illustrates refraction in a prior art lens **41** with circular inside and outside surface horizontal cross-sections, having a uniform thickness **44**. With such a lens **41**, the angle of incidence of rays from the lens **41** to the eye **46** changes throughout the angular range of vision. For example, a ray which shall be referred to for descriptive purposes as a medial light ray **50** strikes the lens **41** at an angle α to the normal at the point of incidence. As is well known in this art, bending of light at transmitting surfaces depends in part upon the angle of incidence of light rays. The ray **50** is refracted or bent in opposite directions at each of an outer sinner surface **54** inner surface **54** of the lens **41**, resulting in a transmitted ray **56** parallel to the incident ray **50**. The transmitted ray **50** is laterally displaced, relative to the path of the incident ray **50**, by a distance **58**. This displacement represents a first order source of optical distortion.

Furthermore, refractory displacement is even more pronounced at a lateral end **60** due to a greater angle of incidence β. A peripheral incident ray **62** experiences greater displacement **64** than the medial incident ray **50**, in accordance with Snell's Law, as will be understood by those of ordinary skill in the optical arts. The discrepancy between the peripheral ray displacement **64** and the medial ray displacement **58** results in a second order of optical distortion. This second order of distortion may cause substantial warping of an image seen through relatively lateral portions of the lens **41**.

FIG. 4 schematically illustrates a lens **71** of tapered thickness, to compensate for the greater angle of incidence at the lateral ends **60** of the lens **41** (FIG. 3), as disclosed in the context of unitary lens systems in U.S. Pat. No. 4,859,048, issued to Jannard. Tapering produces a smaller lens thickness **74** at a lateral end **76**, relative to a lens thickness **78** at a more medial point **80**. This smaller thickness **74** reduces an amount of peripheral ray displacement **82**, relative to the peripheral ray displacement **64** through the untapered lens **41** of FIG. 4. In other words, lesser lens thickness **74** near the lateral end **76** of the tapered lens **71** compensates to some extent for a greater angle of incidence β', relative to the thickness **78** and angle of incidence α' at the more medial point **80**.

The resulting difference between peripheral ray displacement **82** and medial ray displacement **84** on the same lens **71** is not as great as the corresponding difference in FIG. 3, reducing the second order optical distortion. Note that the degree of correction of the second order distortion depends upon a relationship between the manner and degree of tapering from the apex **85** to each lateral end **76** and the manner in which the angle of incidence changes over the same range.

The lens **71** of FIG. 4 is illustrated as though it were mounted within a frame (not shown) such that the wearer's normal line of sight **86** passes perpendicularly through the lens **71** at the lens apex or mechanical center **85**. In other words, the angle of incidence to the lens normal is zero for the wearer's normal line of sight. The outer and inner surfaces of lens **71** in the cross-sectional illustration conform to offset, equal-radius circles represented by centerpoints **87** and **88**, respectively. A line drawn through centerpoints **87** and **88**, referred to herein as the optical centerline of the lens, is collinear with the normal line of sight in the as-worn orientation. This conventional configuration shall be defined as a centrally oriented lens, for ease of description. Circumferentially clockwise or counterclockwise of the normal line of sight **86**, the angle of incidence to the lens normal increases in a regular fashion from zero at the lens apex **85**.

A high degree of wrap may be desirable for aesthetic styling reasons, for lateral protection of the eyes from flying debris, or for interception of peripheral light. Wrap may be attained by utilizing lenses of tight horizontal curvature (high base), such as small-radius spherical lenses, or by mounting each lens in a position which is canted laterally and rearwardly relative to centrally oriented dual lenses. Such canting shifts the normal line of sight **86** out of a collinear relationship with the optical centerline, and changes the optics of the lens. As a result, prior art dual lens eyewear with substantial "wrap" around the sides of a wearer's face has generally been accompanied by some degree of prismatic distortion.

In accordance with the present invention, there is provided an improved optical configuration and method for minimizing prismatic distortion. Though the present invention may be applied to a wide variety of lens shapes and orientations, the invention has particular utility for dual lens eyewear using high base curvature and demonstrating a high degree of wrap in the as-worn orientation.

Referring to FIGS. **2** and **5**, the illustrated eyewear incorporates canted lenses **12** and **14** or **102** and **104**, mounted in a position rotated laterally relative to conventional centrally oriented dual lens mountings. A canted lens may be conceived as having an orientation, relative to the wearer's head, which would be achieved by starting with conventional dual lens eyewear having centrally oriented lenses and bending the frame inwardly at the temples to wrap around the side of the head.

As a consequence of the increased wrap, the wearer's normal line of sight **27** no longer strikes the lens **14** perpendicularly, as illustrated in FIG. **4**. Instead, the angle of incidence θ (FIG. **2**) for the wearer's line of sight **27** is generally greater than 90°, and to achieve good wrap it may be greater than about 95°, preferably is within the range of from about 100° to about 135°, and in one 9.5 base embodiment is about 101.75°. Lower base lenses generally will exhibit a larger angle θ in the as worn orientation, and the angle θ in an embodiment having a base of 6.5 was about 113.4°. In a base **4** embodiment having a pupillary distance of 2.8 inches, the angle θ was about 119.864°.

FIG. **5** illustrates the horizontal cross-section of an eyeglass **100** in accordance with an embodiment of the present invention, similar in style to that illustrated in FIG. **2**, except having lenses **102** and **104** of tighter curvature (higher base) as well as possibly greater wrap. When the eyeglass **100** is worn, a lateral edge **106** of the lens **104** wraps significantly around and comes in close proximity to the wearer's temple to provide significant lateral eye protection as has been discussed.

An anterior (front) surface **108** of the lens of the present invention will generally conform to a portion of the surface of a regular geometric solid, such as a sphere **110**, shown here horizontal cross-section. The front surfaces of spherical lenses **102** and **104** of the illustrated embodiment can, therefore, be characterized by a radius. By convention in the industry, the curvature may also be expressed in terms of a base value, such that the radius (R) in millimeters of the anterior surface of the lens is equal to 530 divided by the base curve, or

$$R=530/B \quad (1)$$

The present invention provides the ability to construct dual lens eyeglass systems having relatively high wrap using lens blanks having a base curve of 6 or greater, preferably between about 7½ and 10½, more preferably between about 8 and 9½, and, in one embodiment between about 8¾ and 9. The radius of the circle conforming to the anterior surface of a base 8¾ lens, for example, is about 60.57 millimeters. For comparison, the radius of the circle which characterizes the anterior surface of a base 3 lens is about 176.66 millimeters.

The embodiment of the present invention illustrated in FIG. 5 may be cut from a base 8¾ lens blank having a thickness of about 0.0649 inches at the optical centerline and about 0.053 inches at reference a point two inches along the outer circumference of the lens from the optical centerline. Alternatively, the lens can be molded directly into its final shape and configuration.

FIG. 6 is a perspective view of a lens blank 122, a convex outside surface 136 of which generally conforms to a portion of the surface of a three-dimensional geometric shape 124. It will be understood by those of skill in this art that lenses in accordance with the present invention may conform to any of a variety of geometric shapes.

Preferably, the outside surface of the lens will conform to a shape having a smooth, continuous surface having a constant horizontal radius (sphere or cylinder) or progressive curve (ellipse, toroid or ovoid) in either the horizontal or vertical planes. The geometric shape 124 of the preferred embodiments herein described, however, generally approximates a sphere.

The sphere 124 illustrated in FIGS. 6 and 7 is an imaginary three-dimensional solid, a portion of the wall of which is suitable from which to cut a lens 120. As is known in the art, precision lens cutting is often accomplished by producing a lens blank 122 from which a lens 120 is ultimately cut. However, it should be clear to those of skill in the art from the illustrations of FIGS. 6 and 7, that the use of a separate lens blank is optional, and the lens 120 may be molded directly into its final shape and configuration if desired.

It can also be seen from FIGS. 6 and 7 that the lens 120 and/or the lens blank 122 can be positioned at any of a variety of locations along the sphere 124. For the purpose of the present invention, the optical centerline 132 operates as a reference line for orientation of the lens 120 with respect to the sphere 124. In the illustrated embodiment, wherein both the outside surface and the inside surface conform to a portion of a sphere, the optical centerline is defined as the line 132 which joins the two centers C1 and C2. The analogous reference line for the purpose of nonspherical lens geometry may be formed in a manner different than connection of the two geometric centers of the spheres, as will be apparent to one of skill in the art.

The lens 120 is ultimately formed in such a manner that it retains the geometry of a portion of the wall of the sphere as illustrated in FIG. 7. The location of the lens 120 on the sphere 124 is selected such that when the lens 120 is oriented in the eyeglass frame, the normal line of sight 130 of the wearer through the lens will be maintained generally in parallel to the optical centerline 132 of the geometric configuration from which the lens 120 was obtained. In the illustration of FIGS. 6 and 7, the lens 120 is a right lens which has a significant degree of wrap, as well as some degree of rake. A lens having a different shape, or a lesser degree of wrap may overlap the optical centerline 132 of the imaginary sphere 124 from which the lens was formed. However, whether the optical centerline of the imaginary sphere 124 crosses through the lens 120 or not is unimportant, so long as the line of sight 130 in the lens 120 is maintained generally in parallel in the as-worn orientation with the optical centerline 132.

For purposes of the present invention, "substantially parallel" shall mean that the line of sight 130 when the lens 120 is oriented in the as worn position generally does not deviate within the horizontal plane by more than about ±15° from parallel to the optical centerline 132. Preferably, the normal line of sight 130 should not deviate by more than about ±10° from the optical centerline 132, more preferably the normal line of sight 130 deviates by no more than about ±5° and most preferably no more than about ±2° from parallel to the optical centerline 132. Optimally, the line of sight 130 is parallel to the optical centerline in the as worn orientation. Typically, an eyewear frame has a vertical plane of symmetry which is substantially parallel to the line of sight 130. Accordingly, the optical centerline 132 will be substantially parallel to the frame's vertical plane of symmetry.

Variations from parallel an the horizontal plane generally have a greater negative impact on the lens than variations from parallel in the vertical plane. Accordingly, the solid angle between the line of sight 130 and optical centerline 132 in the vertical plane may exceed the ranges set forth above, for some eyewear, as long as the horizontal component of the angle of deviation is within the above-mentioned ranges of deviation from the parallel orientation. Preferably, the line of sight 130 deviates in the vertical plane no more than about ±10° and, more preferably, no more than about ±3° from the optical centerline in the as worn orientation.

FIG. 7 is a cutaway view of the lens 120, lens blank 122, and geometric shape 124 of FIG. 6. This view shows that the preferred geometric shape 124 is hollow with walls of varying thickness, as revealed by a horizontal cross-section 134 at the optical centerline of the geometric shape 124.

The tapered walls of the preferred geometric shape 124 result from two horizontally offset spheres, represented by their center points C1 and C2 and radii R1 and R2. An outer surface 136 of the preferred lens blank 122 conforms to one sphere (of radius R1) while an inner surface 138 of the lens blank 122 conforms to the other sphere (of radius R2). By adjusting the parameters which describe the two spheres, the nature of the taper of the lens blank 122 may also be adjusted.

In particular, the parameters for the two spheres to which the lens blank outer surface 136 and inner surface 138 conform is preferably chosen to produce zero refractive power, or non-prescription lenses. Where CT represents a chosen center thickness (maximum thickness of the wall of the hollow geometric shape 124), n is an index of refraction of the lens blank material, R1 is set by design choice for the curvature of the outer surface 136, R2 may be determined according to the following equation:

$$R_2 = R_1 - CT + \frac{CT}{n} \quad (2)$$

CT/n represents the separation of the spherical centers C1 and C2. For example, where a base 6 lens is desired as a matter of design choice, the center thickness is chosen to be 3 mm, and the index of refraction of the preferred material (polycarbonate) is 1.586, R2 may be determined as follows:

$$R_2=\frac{530}{6}-3+\frac{3}{1.586}=87.225\text{ mm} \quad (3)$$

For this example, the radius R1 of the outer surface 136 is equal to 88.333 mm, the radius R2 of the inner surface 138 is equal to 87.225 mm, and the spherical centers C1 and C2 are separated by 1.892 mm. These parameters describe the curvature of the lens blank 122 of the preferred embodiment.

In the case of the preferred embodiment, the optical centerline 132 is that line which passes through both center points C1 and C2 of the offset spheres. This happens to pass through the thickest portion of the preferred geometrical shape 124 walls at an optical center 140, though this may not be true for alternative nonspherical embodiments. The optical center 140 happens to pass through surface 136 of the illustrated lens blank 122, although this is not necessary. The optical center 140 does not happen to lie on the lens 120, although it may for larger lenses or lenses intended to exhibit less wrap in the as-worn orientation.

FIG. 8 illustrates a horizontal cross-section of the preferred lens 120, showing in phantom the geometric shape 124 to which the outer surface 136 and inner surface 138 conform. The lens blank 122 is omitted from this drawing. In accordance with the present invention, the optical centerline 132 associated with the chosen taper is aligned to be parallel with the normal line of sight 130 of the wearer as the lens 120 is to be mounted in an eyeglass frame.

Furthermore, although the preferred embodiments are circular in both horizontal and vertical cross-section, a variety of lens configurations in both planes are possible in conjunction with the present invention. Thus, for example, the outer surface of the lens of the present invention may generally conform to a spherical shape as shown in FIGS. 6 and 7. Alternatively the lens may conform to a right circular cylinder, a frusto-conical, an elliptic cylinder, an ellipsoid, an ellipsoid of revolution, or any of a number of other three dimensional shapes. Regardless of the particular vertical or horizontal curvature of the outer surface, however, the inner surface should be chosen such as to smoothly taper the lens thickness at least in the horizontal plane.

FIGS. 9–12 will aid in describing a method of choosing a location on the lens blank 122 from which to cut the right lens 120, in accordance with a preferred embodiment of the present invention. It will be understood that a similar method would be used to construct the left lens for the dual lens eyewear of the preferred embodiment.

As a first step, a desired general curvature of the lens outer surface 136 may be chosen. For the preferred lens 120, this choice determines the base value of the lens blank 122. As noted elsewhere herein, a number of other curvatures may be utilized in conjunction with the present invention. A choice of lens thickness may also be preselected. In particular, the minimum thickness may be selected such that the lens will withstand a preselected impact force.

A desired lens shape may also be chosen. For example, FIG. 12 illustrates an example of a front elevational shape for the lens 120. The particular shape chosen is generally not relevant to the decentered lens optics disclosed herein.

A desired as-worn orientation for the lens should also be chosen, relative to the normal line of sight 130 of the wearer 126. As mentioned above, preferred orientations may provide significant lateral wrap for lateral protection and interception of peripheral light, and for aesthetic reasons. For example, the embodiment illustrated in FIGS. 6–12 uses a canted lens 120 to achieve wrap. Alternatively, wrap may be achieved through use of a higher base lens and a more conventional (non-canted) orientation. FIGS. 9 and 10 illustrate more plainly how the orientations may be related to the line of sight 130 of the wearer.

The eyewear designer may also choose a degree of rake, or vertical tilt, as will be understood from FIG. 10, schematically illustrating the vertical orientation of the lens 120 relative to the head of the wearer 126, and relative in particular to the normal line of sight 130. A downward rake, as illustrated, is desirable for a variety of reasons, including improved conformity to common head anatomy. As will be apparent to those of skill in the art, a lens 120 having a mechanical center point which falls below the horizontal plane intersecting the optical centerline 132 (see FIG. 7) will tend to have a downward rake as illustrated in FIG. 10. This is because the lens 120 will have been formed below the equator of the sphere relative to the optical centerline. Since the orientation of the lens 120 to the optical centerline 122 in the imaginary sphere should be the same as the orientation between the lens 120 and a parallel to the normal line of sight 130 in the as-worn condition, any lens cut from this sphere below the optical centerline 132 should exhibit a corresponding degree of downward rake.

Referring now to FIG. 11, a mapping of the horizontal orientation of the lens 120 onto the lens blank 122 is illustrated. The normal line of sight 130, with respect to which the chosen orientation is measured, is maintained substantially parallel to the optical centerline 132.

Once the aesthetic design such as that illustrated in FIG. 11 has been determined, and the lens blank 122 formed having a suitable base curvature for fitting within the aesthetic design, the aesthetic design may be "projected" onto the surface of the sphere to reveal that portion of the sphere which is suitable for use as the lens 120. The projection of the lens shape onto the sphere should be moved about the surface of the sphere until it is positioned such that the lens cut from the sphere at that location will exhibit the appropriate wrap and rake for the aesthetic design without any rotation of the lens 120 out of its orientation in which the optical centerline of the sphere is generally parallel to the normal line of sight in the as-worn orientation.

Although not illustrated, it will be understood that a similar projection may be performed for the vertical orientation chosen, as depicted in FIG. 10, for instance. FIG. 10 provides reference points in the form of the lens top edge 152 and bottom edge 154 in relation to the line of sight 130. The projection may then be shifted up or down until the top edge 152 and the bottom edge are both simultaneously aligned with corresponding points on the outer surface 136 of the lens blank, while maintaining the line of sight 130 substantially parallel with the optical centerline 132.

Projection of both the horizontal profile and the vertical profile may be performed simultaneously, locating a unique position on the lens blank 122 corresponding to the desired three-dimensional shape of the lens (including the front elevational shape shown in FIG. 12) at which the line of sight 130 is parallel to the optical centerline 132 or other reference line of the lens blank 122. Of course, it will be understood that the lines 130 and 132 may be substantially parallel, that is, within the acceptable range of angular deviation set forth above.

This shape may then be cut from the blank 122 or molded directly in the final lens configuration. The resultant lens 120 not only conforms to the desired shape, but also minimizes prismatic distortion.

FIG. 12 illustrates a lens blank 122, such as that shown conforming to a portion of the surface of the sphere in FIGS. 6 and 7. In FIG. 12, the lens blank 122 has been rotated such that the mechanical center of the blank is illustrated in the center of the drawing. The illustrated lens 120 has a medial edge 148, a lateral edge 144, an upper edge 152 and a lower edge 154. At least a portion of the right lens 120 lies in the lower left-hand (third) quadrant of the lens blank 122. Preferably, in an embodiment of the invention exhibiting both wrap and downward rake, at least about half of the lens area will fall within the third quadrant of the lens blank 122. Preferably all or substantially all of the area of the lens 120 will lie below and to the left of the optical center as illustrated. Lenses exhibiting a similar degree of rake but lesser wrap may be positioned on the lens blank 122 such that as much as 50% or more of the lens area is within the lower right (second) quadrant of the lens blank 122.

The present invention thus provides a precise method of furnishing the correct correspondence between taper and the varying angle of incidence from the wearer's eye to the surface of a lens. By recognizing a novel relationship among the wearer's line of sight and the form of taper, the present invention allows use of any of a variety of lens designs while minimizing prismatic distortion. For example, a designer may choose a desirable orientation and curvature for the lens, relative to a wearer's line of sight. The orientation and curvature may be chosen from a wide range of rake (i.e., vertical "tilt" of the lens), horizontal cant, base value and proximity to a wearer's face, including those parameters resulting in a high degree of wrap. The form of taper may then be chosen, by the method of the present invention, such that the prismatic distortion is minimized.

Although the foregoing invention has been described in terms of certain preferred embodiments, other embodiments will become apparent to those of ordinary skill in the art in view of the disclosure herein. Accordingly, the present invention is not intended to be limited by the recitation of preferred embodiments, but is intended to be defined solely by reference to the appended claims.

What is claimed:

1. A method of manufacturing a right lens for dual lens optically corrected eyewear exhibiting wrap and downward rake, the method comprising:

providing a lens blank, the lens blank having a thickness which is vertically tapered symmetrically on either side of a central equatorial line and horizontally tapered from a relatively greater thickness at an optical center located between the geometric center of the blank and a medial edge of the blank to a relatively lesser thickness at a lateral edge of the blank, the equatorial line dividing the lens blank into an upper half and a lower half; and

cutting the right lens from the lens blank such that greater than 50% of the right lens is cut from the lower half.

2. The method of claim 1, greater than about 50% of the lens is cut from the lower lateral quadrant.

3. The method of claim 1, wherein the optical center lies outside the right lens.

4. A method of manufacturing noncorrective, dual lens eyewear exhibiting wrap and downward rake, the method comprising:

obtaining a lens blank comprising an inner surface conforming to a first sphere having a first center, and an outer surface conforming to a second sphere having a second center offset from the first center, a vertically and horizontally tapered lens thickness defined between the inner and outer surfaces, and an optical centerline passing through the first and second centers;

selecting a desired lens shape;

selecting a desired lens orientation relative to a wearer's normal line of sight;

projecting the desired lens shape onto the lens blank;

cutting a lens having the desired lens shape from a preselected location on the lens blank which location relates to the desired lens orientation;

mounting the lens in a frame such that the optical centerline is vertically spaced from and substantially parallel with the wearer's theoretical normal straight ahead line of sight.

5. The method of claim 4, wherein the optical centerline is horizontally spaced from the wearer's normal line of sight.

6. The method of claim 4, wherein the optical centerline deviates by no more than about ±10° from parallel with the normal line of sight.

7. The method of claim 6, wherein the optical centerline deviates within a vertical plane by no more than about ±3° from parallel with the normal line of sight and deviates within a horizontal plane by no more than about ±2°.

8. A method of manufacturing optically corrected, non-power eyewear, comprising the steps of:

providing a lens blank having a thickness which tapers in both a vertical and horizontal plane, and having an optical centerline;

providing an eyeglass frame configured to maintain at least one lens in a predetermined relationship with respect to a wearer's reference line of sight when the eyewear is worn on the head of the wearer;

cutting a lens from a location on the lens blank such that the optical centerline is maintained generally parallel with the reference line of sight when the lens is supported by the eyeglass frame and worn on the head of the wearer; and

attaching the lens to the eyeglass frame to produce optically corrected eyewear.

9. A method of manufacturing optically corrected non-power eyewear as in claim 8, wherein the attaching step comprises attaching a unitary lens to the eyeglass frame.

10. A method of manufacturing optically corrected non-power eyewear as in claim 8, wherein the attaching step comprises attaching two lenses to the eyeglass frame.

11. A method of manufacturing optically corrected non-power eyewear as in claim 8, wherein the wearer's reference line of sight is the wearer's straight ahead normal line of sight.

12. A method of manufacturing optically corrected non-power eyewear as in claim 8, wherein the cutting step comprises cutting a lens from a position on the lens blank such that the geometric center of the lens is displaced from the geometric center of the lens blank in both a vertical and a horizontal plane.

13. A method as in claim 8, wherein said providing step comprises providing an eyeglass frame configured to maintain at least one lens in the predetermined relationship with respect to the wearer's reference line of sight, in which relationship the lens has both rake and wrap.

14. A method in claim 8, wherein the wearer's normal line of sight deviates, within the horizontal plane by no more than about plus or minus 2° from parallel with the optical centerline.

15. The method of claim 8, wherein the wearer's normal line of sight deviates in the vertical plane by no more than about plus or minus 3° from parallel with the optical centerline.

* * * * *

US005969789A

United States Patent [19]

Houston et al.

[11] **Patent Number: 5,969,789**

[45] **Date of Patent: *Oct. 19, 1999**

[54] **DECENTERED NONCORRECTIVE LENS FOR EYEWEAR**

[75] Inventors: **Malcolm Neal Houston**, Foothill Ranch, Calif.; **James H. Jannard**, Eastsound, Wash.; **Carlos D. Reyes**, Mission Viejo, Calif.

[73] Assignee: **Oakley, Inc.**, Foothill Ranch, Calif.

[*] Notice: This patent is subject to a terminal disclaimer.

[21] Appl. No.: **08/822,185**

[22] Filed: **Mar. 20, 1997**

Related U.S. Application Data

[63] Continuation of application No. 08/567,434, Dec. 5, 1995, Pat. No. 5,648,832.

[51] **Int. Cl.**[6] **G02C 7/02**; G02C 1/13

[52] **U.S. Cl.** **351/159**; 351/41

[58] **Field of Search** 351/159, 41, 43, 351/44

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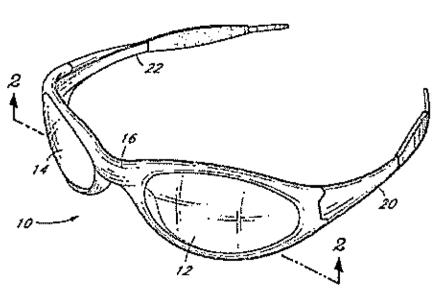
Primary Examiner—Georgia Epps
Assistant Examiner—Jordon M. Schwartz
Attorney, Agent, or Firm—Knobbe, Martens, Olson & Bear, LLP

[57] **ABSTRACT**

Disclosed is an optically corrected lens for nonprescription, dual lens eyeglasses. In a preferred embodiment, the anterior surface of the lens lies on a portion of a first sphere having a first center. The posterior surface of the lens lies on the surface of a second sphere having a second center. The first and second centers are offset from one another to provide a tapered lens. The lens is oriented on the head of the wearer by a frame that maintains the lens in a position such that a line drawn through the first and second centers is maintained substantially in parallel to the normal sight line of the wearer. Methods of making the lenses, and eyewear incorporating the lenses, are also disclosed.

27 Claims, 7 Drawing Sheets



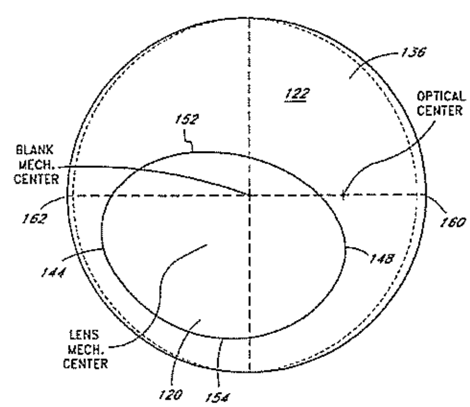


Fig. 1

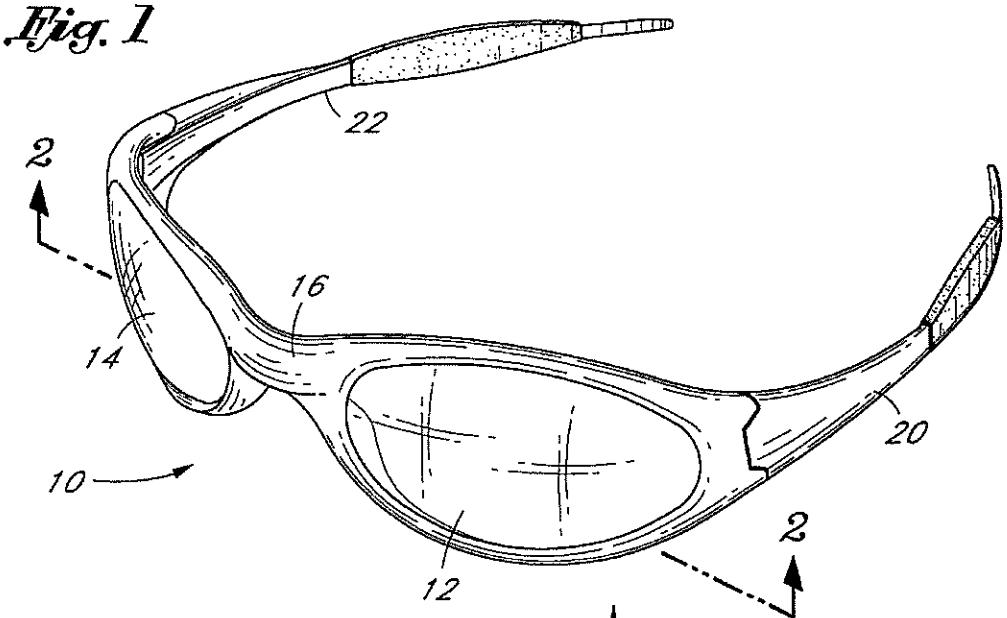


Fig. 2

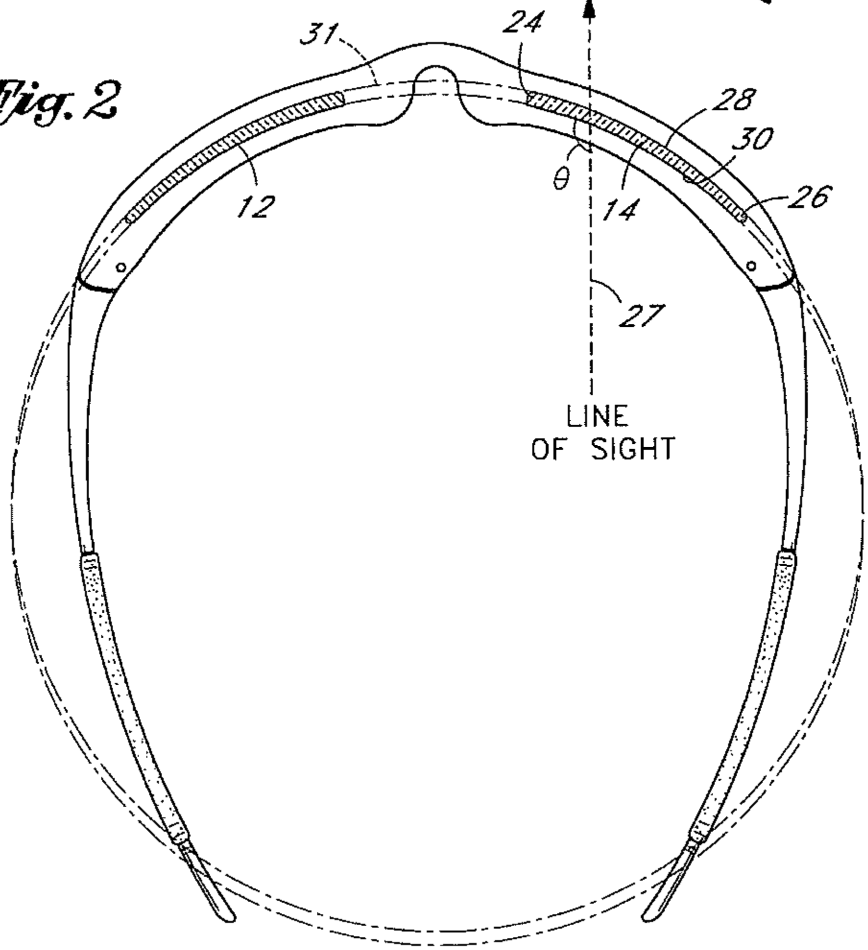


Fig. 3
(PRIOR ART)

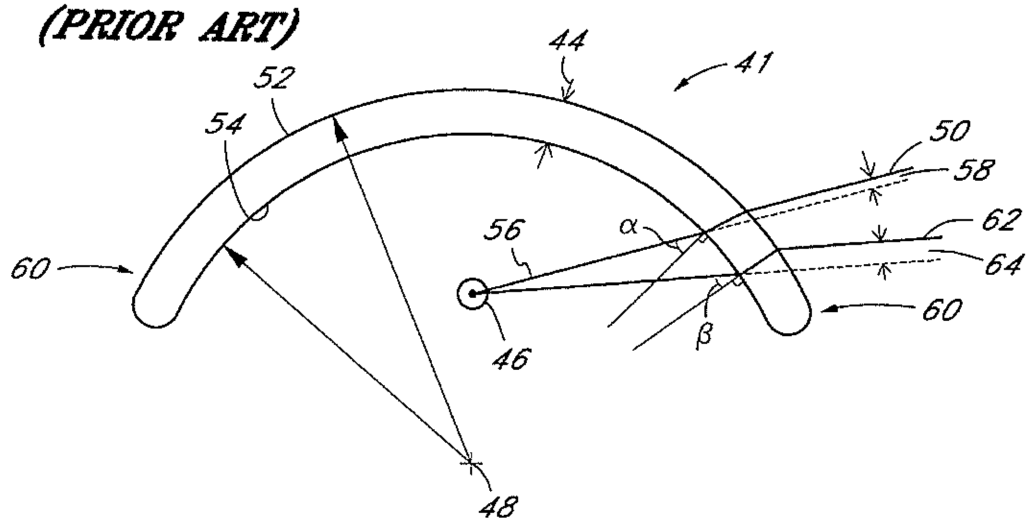


Fig. 4
(PRIOR ART)

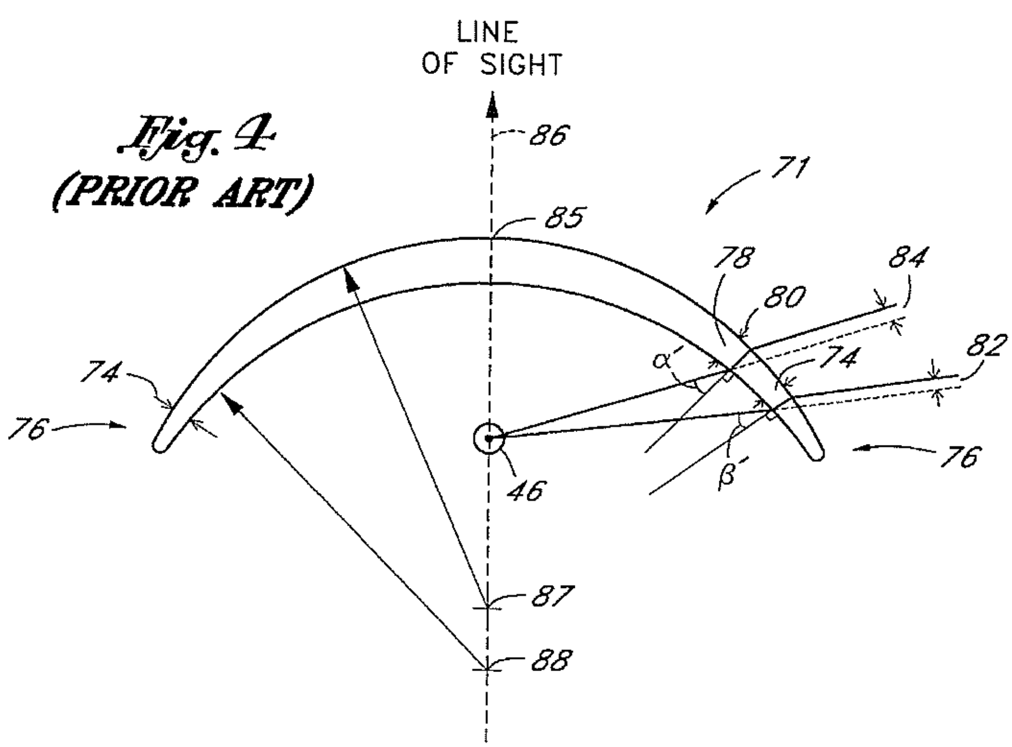
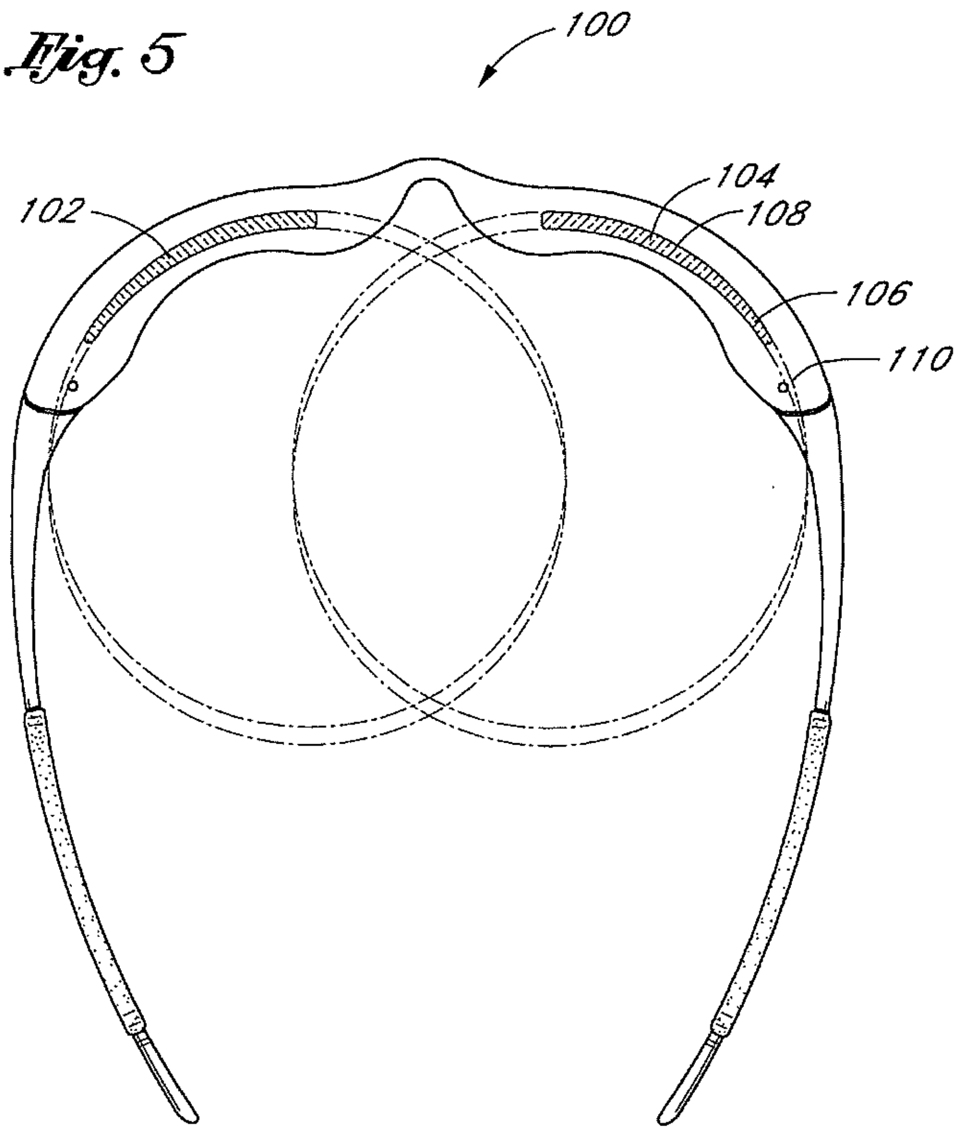


Fig. 5



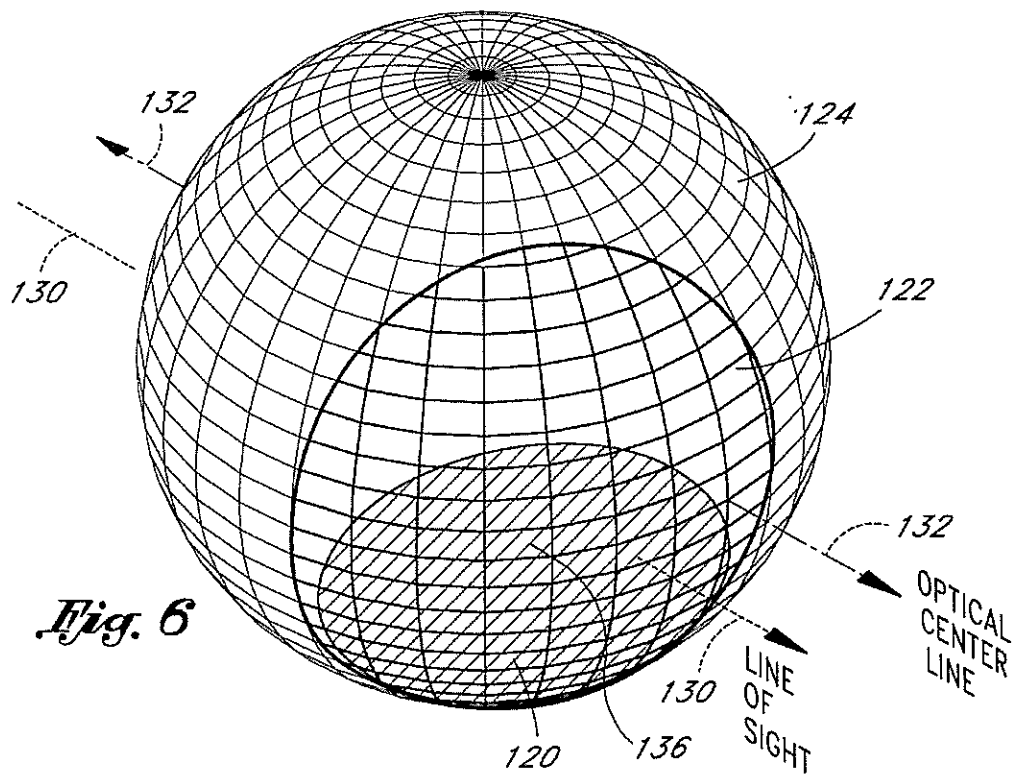

132
124
130
122
132
OPTICAL CENTER LINE
LINE OF SIGHT
130
120
136

Fig. 6

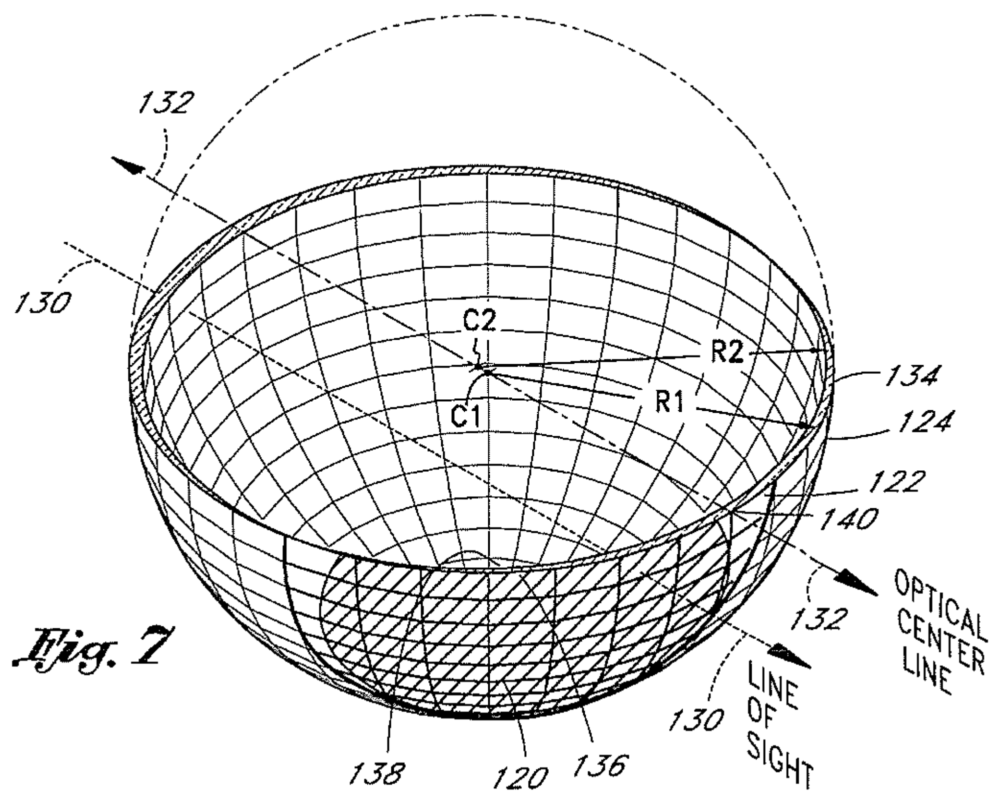

132
130
C2
C1
R2
R1
134
124
122
140
OPTICAL CENTER LINE
132
LINE OF SIGHT
130
138
120
136

Fig. 7

Fig. 8

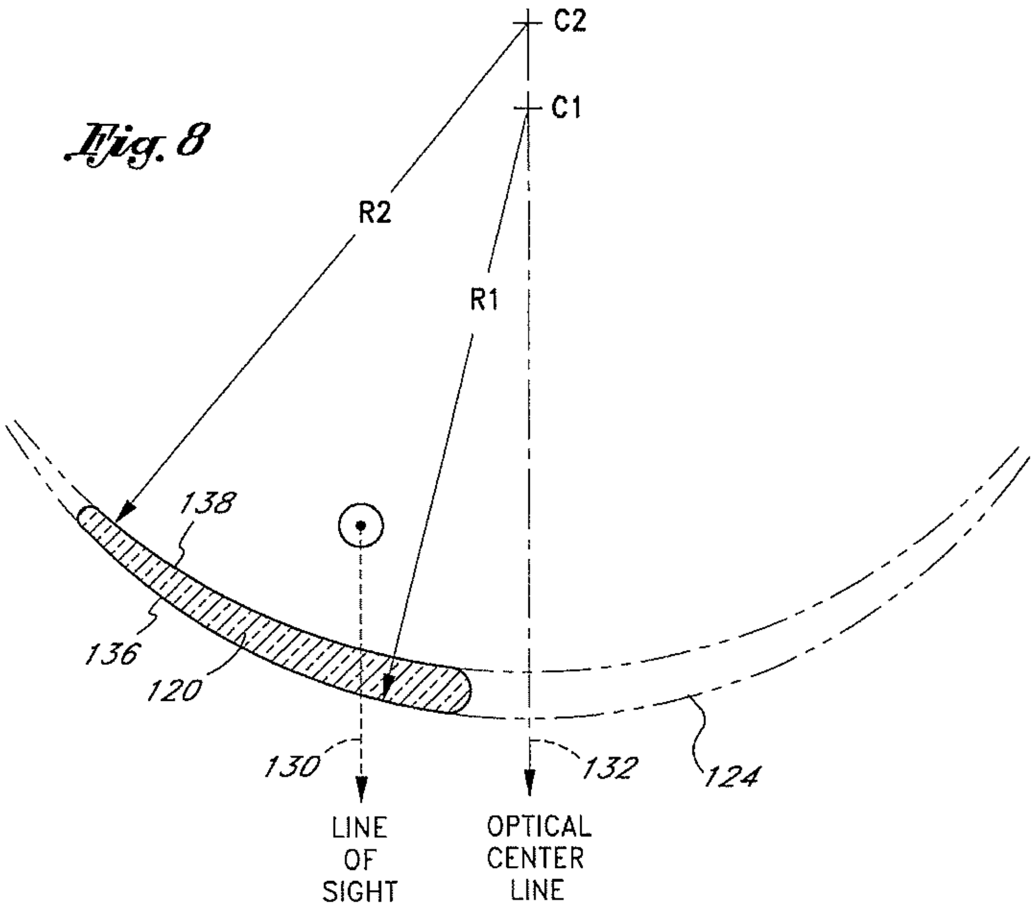


Fig. 9

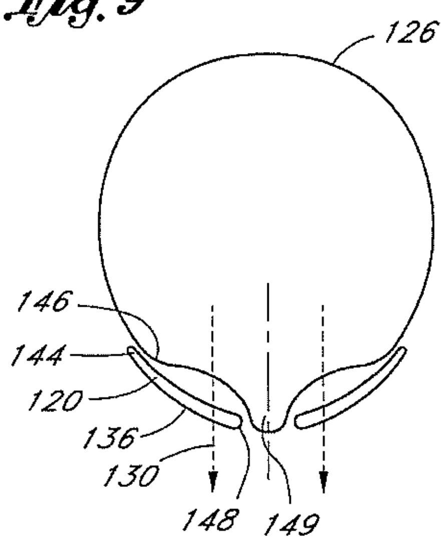


Fig. 10

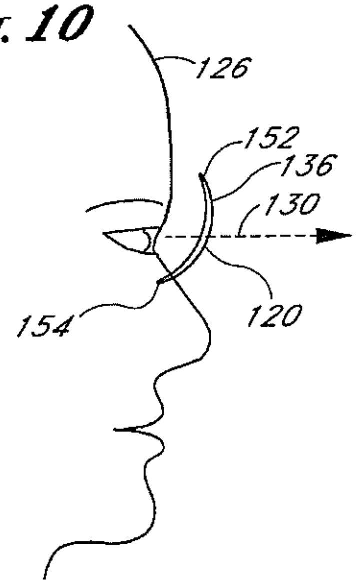


Fig. 11

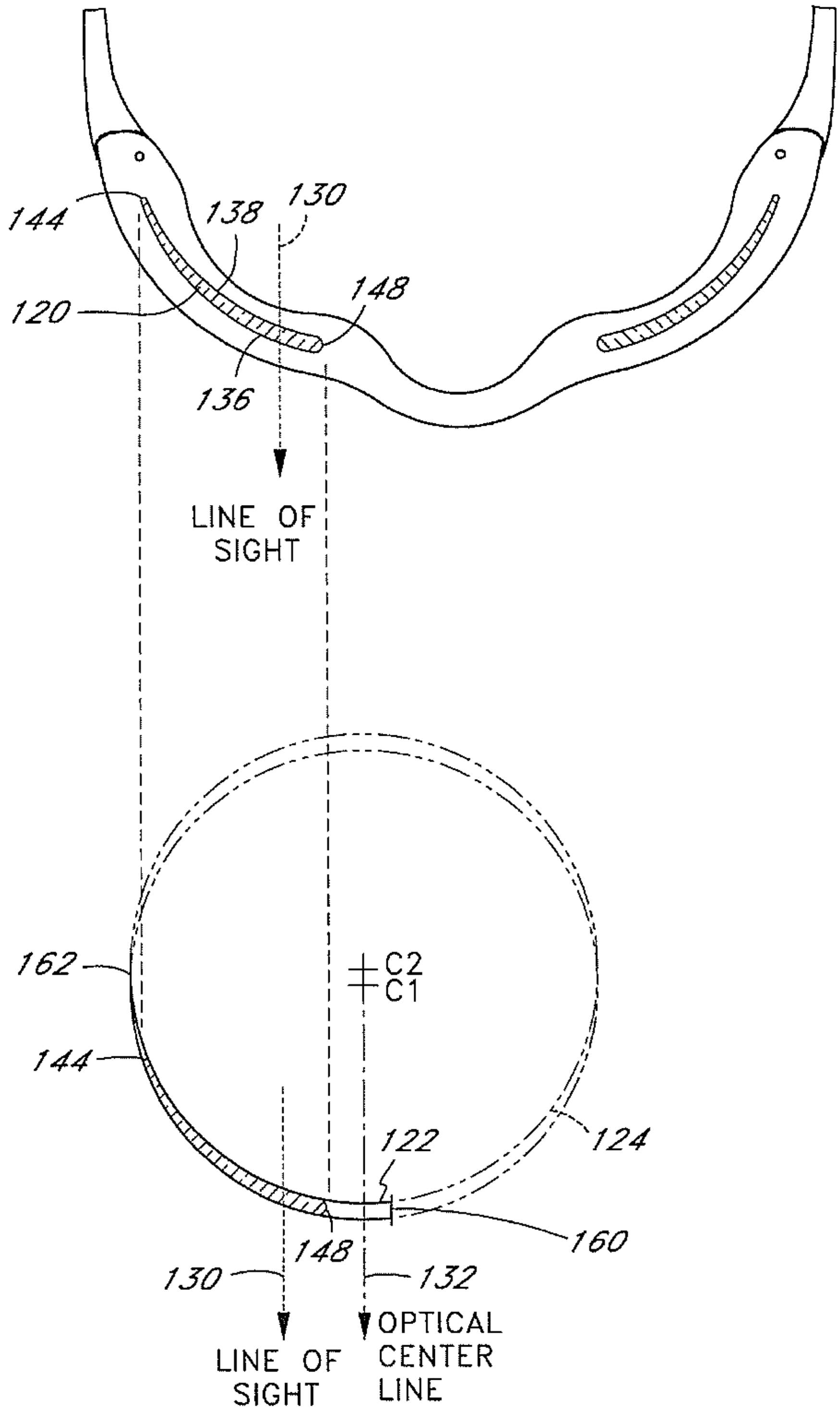
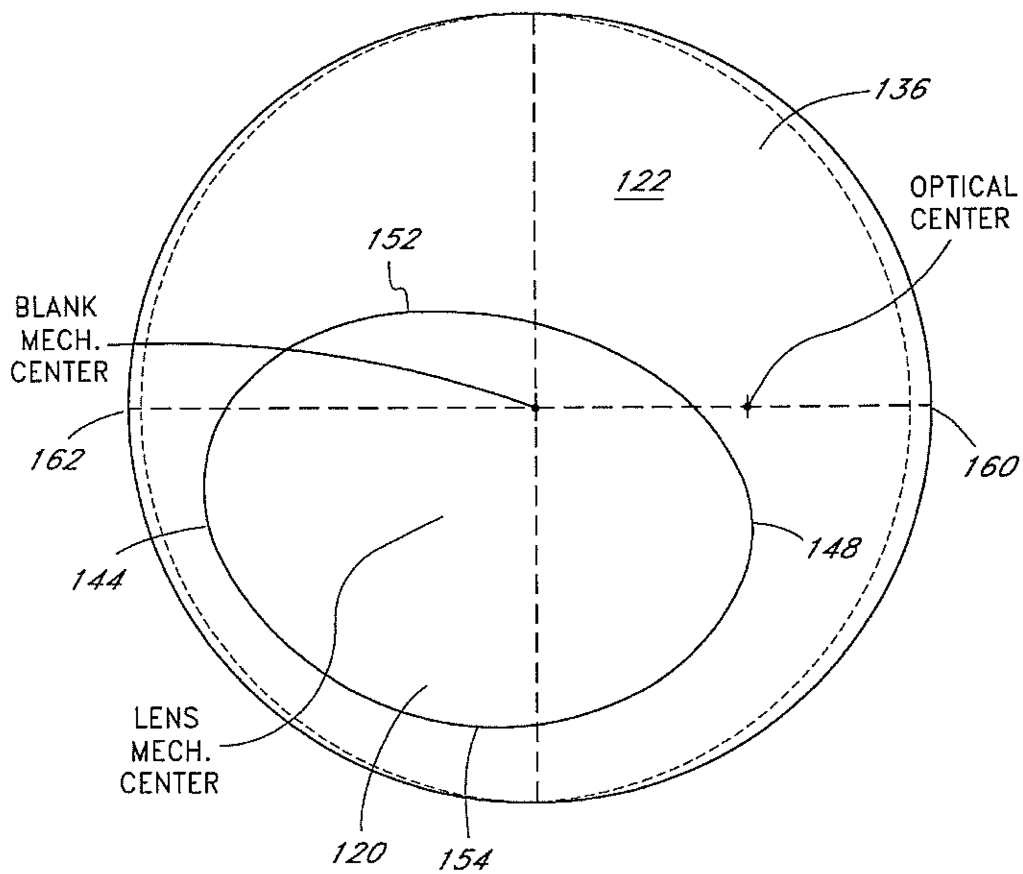

144
138
130
120
148
136
LINE OF SIGHT
162
C2
C1
144
122
124
160
148
130
132
LINE OF SIGHT
OPTICAL CENTER LINE

Fig. 12


136
122
OPTICAL
CENTER
152
BLANK
MECH.
CENTER
162
160
144
148
LENS
MECH.
CENTER
120
154

DECENTERED NONCORRECTIVE LENS FOR EYEWEAR

This application is a continuation of U.S. patent application Ser. No. 08/567,434, filed Dec. 5, 1995 now U.S. Pat. No. 5,648,832.

BACKGROUND OF THE INVENTION

A wide variety of improvements have been made in recent years in the eyewear field, particularly with respect to eyewear intended for use in active sports or as fashion sunglasses. These improvements have been incorporated into eyewear having a unitary lens, such as the "Blades®" design (Oakley, Inc.) the "M Frame®" line (Oakley, Inc.), and the "Zero®" line also produced by Oakley, Inc. These eyewear designs accomplish a variety of functional advantages, such as maximizing interception of peripheral light, reducing optical distortion and increasing the wearer's comfort level, compared to previous active sport eyewear.

The unitary lens of the "Blades®" eyewear incorporates the cylindrical geometry disclosed, for example, in U.S. Pat. No. 4,859,048, issued to Jannard. This geometry allows the lens to closely conform to the wearer's face and intercept light, wind, dust, etc. from directly in front of the wearer (anterior direction) and peripherally (lateral direction). See also U.S. Pat. No. 4,867,550 to Jannard (toroidal lens geometry).

Although the early unitary lens systems provided a full side-to-side range of vision and good lateral eye protection, the potential for optical distortion still exists. In a unitary lens system, for example, the angle of incidence from the wearer's eye to the posterior lens surface changes as the wearer's sight line turns in the lateral direction. This results in disparate refraction between light entering closer to the front of the lens and peripheral light entering at the lateral ends. To address this source of prismatic distortion, U.S. Pat. No. 4,859,048 discloses tapering the thickness of the lens from the medial portion toward the lateral edge.

Prior art eyewear has also employed dual lens systems in which two separate lenses are mounted along a front frame. In the early dual lens eyeglass systems, each of the right and left lenses were roughly co-planar in the as-worn configuration. Thus, the sight line of the wearer, when looking straight ahead, generally crossed the posterior surface of the lens at a normal to the lens surface in the optical zone. One of the disadvantages of this lens configuration was that the eyeglasses provided essentially no lateral eye protection without the use of special modifications, such as vertically elongated earstems or side attachments.

Dual lens systems were thereafter developed in which the lateral edge of each lens curved rearwardly from the frontal plane, and around the side of the wearer's head to provide a lateral wrap similar to that achieved by the high wrap unitary lens systems. Although the dual lens eyeglasses with significant wrap provided lateral eye protection, the lens curvature generally introduced measurable prismatic distortion through the wearer's angular range of vision. This was particularly pronounced in lenses comprising low index of refraction materials. In addition, although high base curvatures (e.g. base 6 or higher) are sometimes desirable to optimize wrap while maintaining a low profile, such lenses have not been practical in the past due to the relatively high level of prismatic distortion.

Thus, there remains a need for a high base nonprescription lens for use in dual lens eyewear which can intercept light over essentially the full angular range of vision while at the same time minimize optical distortion throughout that range.

SUMMARY OF THE INVENTION

There is provided in accordance with one aspect of the present invention, an eyeglass lens for use in noncorrective dual lens eyewear. The eyeglass lens is utilized in combination with a frame to support the lens in the path of the wearer's normal line of sight.

The lens comprises a lens body, having a front surface, a rear surface, and a thickness therebetween.

The front surface of the lens conforms to a portion of the surface of a solid geometric shape. Preferably, the front surface of the lens conforms substantially to a portion of the surface of a first sphere having a first center. The rear surface of the lens conforms substantially to a portion of the surface of a solid geometric shape, which may be the same or different than that conforming to the front surface. Preferably, the rear surface conforms substantially to a portion of the surface of a second sphere having a second center.

The first and second centers are offset from one another to taper the lens thickness. The lens is mounted in the frame such that a line drawn through the first and second centers is maintained substantially parallel with the wearer's normal line of sight.

The lens may be cut from a lens blank, or formed directly into its final configuration such as by injection molding or other techniques known in the art. Preferably, the lens is oriented on the head of a wearer by the eyeglass frame such that the normal sight line of the wearer crosses the anterior surface of the lens at an angle of greater than about 95°, and preferably within the range of from about 100° to about 120°, while maintaining the optical centerline of the lens in a substantially parallel relationship with the normal sight line of the wearer. The optical centerline of the lens may or may not pass through the lens.

Methods of making the lens of the present invention are also disclosed.

Further features and advantages of the present invention will become apparent from the detailed description of preferred embodiments which follows, when considered together with the attached claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of eyewear incorporating taper corrected lenses made in accordance with an embodiment of the present invention.

FIG. 2 is a cross-sectional view taken along the lines 2—2 of FIG. 1.

FIG. 3 is a schematic horizontal cross-sectional view of a prior art untapered lens for a dual lens eyewear system.

FIG. 4 is a schematic horizontal cross-sectional view of a tapered lens for a dual lens eyewear system.

FIG. 5 is a cross-sectional view like that in FIG. 2, showing taper corrected lenses having a greater base curvature, in accordance with another embodiment of the present invention.

FIG. 6 is a perspective view of a lens blank conforming to a portion of the surface of a sphere, showing a lens profile to be cut from the blank in accordance with a preferred embodiment of the present invention.

FIG. 7 is a perspective cutaway view of the hollow, tapered wall spherical shape, lens blank, and lens of FIG. 6.

FIG. 8 is a horizontal cross-sectional view of a lens constructed in accordance with a preferred embodiment of the present invention.

FIG. 9 is a top plan view of the lens of FIG. 8 showing a high wrap in relation to a wearer.

FIG. 10 is a right side elevational cross-section of the lens and wearer of FIG. 9, showing lens rake.

FIG. 11 schematically illustrates the projection of the lens profile from a desired orientation within an eyewear frame to the lens blank in accordance with a preferred embodiment of the present invention.

FIG. 12 is a front elevational view of the lens and lens blank of FIG. 6, rotated to project the mechanical centerline of the blank normal to the page.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Although the preferred embodiments will be discussed below in terms of lenses having "spherical" front and rear surfaces (surfaces which conform substantially to a portion of the surface of a sphere), it will be understood by those having ordinary skill in the art that the invention may also be applicable to lenses having different surface geometries. Additionally, it will be understood that the present invention has application to lenses of many front elevational shapes and orientations in the as worn position beyond those illustrated herein.

Referring to FIGS. 1 and 2, there is illustrated an eyeglass **10**, such as a sunglass having first and second lenses **12**, **14** constructed in accordance with an embodiment of the present invention. Although the invention is illustrated in the context of an eyeglass design marketed by Oakley under the Eye Jackets™ name, the present invention relates solely to the lens curvature, taper, and orientation on the head of the wearer. Therefore the particular lens shape revealed in FIG. 1 is not critical to the invention. Rather, lenses of many other shapes and configurations may be constructed which incorporate the present invention as will become apparent based upon the disclosure herein.

Similarly, the particular mounting frame **16** shown is not essential to the present invention. The frame **16** may bound only the bottom edge(s) of the lenses **12**, **14**, only the top edges, or the entire lenses as illustrated. Alternatively, the frame **16** can bound any other portions of the lenses as will be evident to those of skill in the art. Frameless eyeglasses can also be constructed in accordance with the present invention, as long as the lens orientation on the head of the wearer is substantially maintained in a predetermined relationship to the normal sight line as will be discussed below. Preferably, though, the lenses **12**, **14** are each mounted in an annular orbital as shown.

A pair of earstems **20**, **22** pivotally attach to the frame **16**. Alternatively, the earstems **20**, **22** may attach directly to the lenses **12**, **14**. The frame may comprise of any of a variety of metals, composites or relatively rigid, molded thermoplastic materials which are well known in the art, and may be transparent or any of a variety of colors. Injection molding, machining and other construction techniques are well known in the art.

Lenses in accordance with the present invention can be manufactured by any of a variety of processes well known in the art.

Typically, high optical quality lenses are cut from a preformed injection molded lens blank. Since the right and left lenses are preferably mirror images of each other, only the right lens will generally be discussed below. Alternatively, the lens can be molded directly into its final shape and size, to eliminate the need for post molding cutting steps.

Preferably, the lens, or the lens blank from which it is cut, is injection molded and comprises a relatively rigid and optically acceptable material, such as polycarbonate. Other polymeric lens materials can also be used, such as CR-39 and a variety of high index plastics which are known in the art. The decentered taper correction of the present invention may also be applicable to glass lenses, although the need for correction in the present context is generally more pronounced in nonglass materials.

If the lens is to be cut from a lens blank, the taper and curvature of a carefully preselected portion of the molded lens blank is transferred to the lens in accordance with a preferred manufacturing process described below. Preferably, the frame is provided with a slot or other attachment structure that cooperates with the molded curvature of the lens to minimize deviation from, and even improve retention of the as-molded curvature.

Alternatively, the lens or lens blank can be stamped or cut from generally planar tapered sheet stock and then bent into the curved configuration in accordance with the present invention. This curved configuration can then be maintained by the use of a relatively rigid, curved frame, or by heating the curved sheet to retain its curved configuration, as is well known in the thermoforming art.

Most preferably, the curvature of both surfaces of the lens are created in the lens blank molding and polishing processes, and the lens shape is cut from the blank in accordance with the invention as described below.

Referring to FIG. 2, the lens **14** of the present invention is characterized in a horizontal plane by a generally arcuate shape, extending from a medial edge **24** throughout at least a portion and preferably substantially all of the wearer's range of vision to a lateral edge **26**. The arc length of the lens from the medial edge **24** to the lateral edge **26** in a dual lens system will generally be within the range of from about 1½ inches to about 3½ inches, and preferably within the range of from about 2 inches to about 3 inches. In one preferred embodiment, the arc length of the lens is about 2⅜ inches.

Although the outer surfaces of the lenses **12**, **14** appear to be illustrated as lying on a common circle **31**, the right and left lenses will generally be canted such that the medial edge of each lens will fall outside of the circle **31** and the lateral edges will fall inside of the circle **31**. such canting of the lens increases the angle θ (FIG. **2**) and increases the desirability of the optical correction achieved by the present invention.

When worn, the lens **14** should at least extend across the wearer's normal line of sight **27**, and preferably substantially across the wearer's peripheral zones of vision. As used herein, the wearer's normal line of sight shall refer to a line projecting straight ahead of the wearer's eye, with substantially no angular deviation in either the vertical or horizontal planes as illustrated by line **130** in FIGS. **9** and **10**.

The lens **14** is provided with an anterior surface **28**, a posterior surface **30**, and a varying thickness therebetween. The thickness of the lens **14** in the region of the medial edge **24** for a polycarbonate lens is generally within the range of from about 1 mm to about 2.5 mm, and preferably in the range of from about 1.5 mm to about 1.8 mm. In a preferred embodiment, the thickest portion of the lens **14** is at or about the optical centerline, and is about 1.65 mm.

Preferably, the thickness of the lens **14** tapers smoothly, though not necessarily linearly, from the maximum thickness proximate the medial edge **24** to a relatively lesser thickness at the lateral edge **26**. The thickness of the lens near the lateral edge **26** is generally within the range of from about 0.635 mm to about 1.52 mm, and, preferably, within the range of from about 0.762 mm to about 1.27 mm. In one preferred polycarbonate embodiment, the lens has a minimum thickness in the lateral zone of about 1.15 mm. The minimum thickness at lateral edge **26** is generally governed by the desired impact resistance of the lens.

FIG. **3** schematically illustrates refraction in a prior art lens **41** with circular inside and outside surface horizontal cross-sections, having a uniform thickness **44**. With such a lens **41**, the angle of incidence of rays from the lens **41** to the eye **46** changes throughout the angular range of vision. For example, a ray which shall be referred to for descriptive purposes as a medial light ray **50** strikes the lens **41** at an angle a α to the normal at the point of incidence. As is well known in this art, bending of light at transmitting surfaces depends in part upon the angle of incidence of light rays. The ray **50** is refracted or bent in opposite directions at each of an outer surface **52** and an inner surface **54** of the lens **41**, resulting in a transmitted ray **56** parallel to the incident ray **50**. The transmitted ray **50** is laterally displaced, relative to the path of the incident ray **50**, by a distance **58**. This displacement represents a first order source of optical distortion.

Furthermore, refractory displacement is even more pronounced at a lateral end **60** due to a greater angle of incidence β. A peripheral incident ray **62** experiences greater displacement **64** than the medial incident ray **50**, in accordance with Snell's Law, as will be understood by those of ordinary skill in the optical arts. The discrepancy between the peripheral ray displacement **64** and the medial ray displacement **58** results in a second order of optical distortion. This second order of distortion may cause substantial warping of an image seen through relatively lateral portions of the lens **41**.

FIG. **4** schematically illustrates a lens **71** of tapered thickness, to compensate for the greater angle of incidence at the lateral ends **60** of the lens **41** (FIG. **3**), as disclosed in the context of unitary lens systems in U.S. Pat. No. 4,859,048, issued to Jannard. Tapering produces a smaller lens thickness **74** at a lateral end **76**, relative to a lens thickness **78** at a more medial point **80**. This smaller thickness **74** reduces an amount of peripheral ray displacement **82**, relative to the peripheral ray displacement **64** through the untapered lens **41** of FIG. **4**. In other words, lesser lens thickness **74** near the lateral end **76** of the tapered lens **71** compensates to some extent for a greater angle of incidence α', relative to the thickness **78** and angle of incidence β' at the more medial point **80**.

The resulting difference between peripheral ray displacement **82** and medial ray displacement **84** on the same lens **71** is not as great as the corresponding difference in FIG. **3**, reducing the second order optical distortion. Note that the degree of correction of the second order distortion depends upon a relationship between the manner and degree of tapering from the apex **85** to each lateral end **76** and the manner in which the angle of incidence changes over the same range.

The lens **71** of FIG. **4** is illustrated as though it were mounted within a frame (not shown) such that the wearer's normal line of sight **86** passes perpendicularly through the lens **71** at the lens apex or mechanical center **85**. In other words, the angle of incidence to the lens normal is zero for the wearer's normal line of sight. The outer and inner surfaces of lens **71** in the cross-sectional illustration conform to offset, equal-radius circles represented by centerpoints **87** and **88**, respectively. A line drawn through centerpoints **87** and **88**, referred to herein as the optical centerline of the lens, is collinear with the normal line of sight in the as-worn orientation. This conventional configuration shall be defined as a centrally oriented lens, for ease of description. Circumferentially clockwise or counterclockwise of the normal line of sight **86**, the angle of incidence to the lens normal increases in a regular fashion from zero at the lens apex **85**.

A high degree of wrap may be desirable for aesthetic styling reasons, for lateral protection of the eyes from flying debris, or for interception of peripheral light. Wrap may be attained by utilizing lenses of tight horizontal curvature (high base), such as small-radius spherical lenses, or by mounting each lens in a position which is canted laterally and rearwardly relative to centrally oriented dual lenses. Such canting shifts the normal line of sight **86** out of a collinear relationship with the optical centerline, and changes the optics of the lens. As a result, prior art dual lens eyewear with substantial "wrap" around the sides of a wearer's face has generally been accompanied by some degree of prismatic distortion.

In accordance with the present invention, there is provided an improved optical configuration and method for minimizing prismatic distortion. Though the present invention may be applied to a wide variety of lens shapes and orientations, the invention has particular utility for dual lens eyewear using high base curvature and demonstrating a high degree of wrap in the as-worn orientation.

Referring to FIGS. **2** and **5**, the illustrated eyewear incorporates canted lenses **12** and **14** or **102** and **104**, mounted in a position rotated laterally relative to conventional centrally oriented dual lens mountings. A canted lens may be conceived as having an orientation, relative to the wearer's head, which would be achieved by starting with conventional dual lens eyewear having centrally oriented lenses and bending the frame inwardly at the temples to wrap around the side of the head.

As a consequence of the increased wrap, the wearer's normal line of sight **27** no longer strikes the lens **14** perpendicularly, as illustrated in FIG. **4**. Instead, the angle of incidence θ FIG. **2** for the wearer's line of sight **27** is generally greater than 90°, and to achieve good wrap it may be greater than about 95°, preferably is within the range of from about 100° to about 135°, and in one 9.5 base embodiment is about 101.75°. Lower base lenses generally will exhibit a larger angle θ in the as worn orientation, and the angle θ in an embodiment having a base of 6.5 was about 113.4°. In a base 4 embodiment having a pupillary distance of 2.8 inches, the angle θ was about 119.864°.

FIG. **5** illustrates the horizontal cross-section of an eyeglass **100** in accordance with an embodiment of the present invention, similar in style to that illustrated in FIG. **2**, except having lenses **102** and **104** of tighter curvature (higher base) as well as possibly greater wrap. When the eyeglass **100** is worn, a lateral edge **106** of the lens **104** wraps significantly around and comes in close proximity to the wearer's temple to provide significant lateral eye protection as has been discussed.

An anterior (front) surface **108** of the lens of the present invention will generally conform to a portion of the surface of a regular geometric solid, such as a sphere **110**, shown here in horizontal cross-section. The front surfaces of spherical lenses **102** and **104** of the illustrated embodiment can, therefore, be characterized by a radius. By convention in the industry, the curvature may also be expressed in terms of a base value, such that the radius (R) in millimeters of the anterior surface of the lens is equal to 530 divided by the base curve, or

$$R = \frac{530}{B} \qquad (1)$$

The present invention provides the ability to construct dual lens eyeglass systems having relatively high wrap using lens blanks having a base curve of 6 or greater, preferably between about 7-½ and 10-½, more preferably between about 8 and 9-½, and, in one embodiment between about 8-¾ and 9. The radius of the circle conforming to the anterior surface of a base 8-¾ lens, for example, is about 60.57 millimeters. For comparison, the radius of the circle which characterizes the anterior surface of a base 3 lens is about 176.66 millimeters.

The embodiment of the present invention illustrated in FIG. 5 may be cut from a base 8¾ lens blank having a thickness of about 0.0649 inches at the optical centerline and about 0.053 inches at reference a point two inches along the outer circumference of the lens from the optical centerline. Alternatively, the lens can be molded directly into its final shape and configuration.

FIG. 6 is a perspective view of a lens blank 122, a convex outside surface 136 of which generally conforms to a portion of the surface of a three-dimensional geometric shape 124. It will be understood by those of skill in this art that lenses in accordance with the present invention may conform to any of a variety of geometric shapes.

Preferably, the outside surface of the lens will conform to a shape having a smooth, continuous surface having a constant horizontal radius (sphere or cylinder) or progressive curve (ellipse, toroid or ovoid) in either the horizontal or vertical planes. The geometric shape 124 of the preferred embodiments herein described, however, generally approximates a sphere.

The sphere 124 illustrated in FIGS. 6 and 7 is an imaginary three-dimensional solid, a portion of the wall of which is suitable from which to cut a lens 20. As is known in the art, precision lens cutting is often accomplished by producing a lens blank 122 from which a lens 120 is ultimately cut. However, it should be clear to those of skill in the art from the illustrations of FIGS. 6 and 7, that the use of a separate lens blank is optional, and the lens 120 may be molded directly into its final shape and configuration if desired.

It can also be seen from FIGS. 6 and 7 that the lens 120 and/or the lens blank 122 can be positioned at any of a variety of locations along the sphere 124. For the purpose of the present invention, the optical centerline 132 operates as a reference line for orientation of the lens 120 with respect to the sphere 124. In the illustrated embodiment, wherein both the outside surface and the inside surface conform to a portion of a sphere, the optical centerline is defined as the line 132 which joins the two centers C1 and C2. The analogous reference line for the purpose of nonspherical lens geometry may be formed in a manner different than connection of the two geometric centers of the spheres, as will be apparent to one of skill in the art.

The lens 120 is ultimately formed in such a manner that it retains the geometry of a portion of the wall of the sphere as illustrated in FIG. 7. The location of the lens 120 on the sphere 124 is selected such that when the lens 120 is oriented in the eyeglass frame, the normal line of sight 130 of the wearer through the lens will be maintained substantially parallel to the optical centerline 132 of the geometric configuration from which the lens 120 was obtained. In the illustration of FIGS. 6 and 7, the lens 120 is a right lens which has a significant degree of wrap, as well as some degree of rake. A lens having a different shape, or a lesser degree of wrap may overlap the optical centerline 132 of the imaginary sphere 124 from which the lens was formed. However, whether the optical centerline of the imaginary sphere 124 crosses through the lens 120 or not is unimportant, so long as the line of sight 130 in the lens 120 is maintained substantially parallel in the as-worn orientation with the optical centerline 132.

For purposes of the present invention, "substantially parallel" shall mean that the line of sight 130 when the lens 120 is oriented in the as worn position generally does not deviate within the horizontal plane by more than about ±15° from parallel to the optical centerline 132. Preferably, the normal line of sight 130 should not deviate by more than about ±10° from the optical centerline 132, more preferably the normal line of sight 130 deviates by no more than about ±5° and most preferably no more than about ±2° from parallel to the optical centerline 132. Optimally, the line of sight 130 is parallel to the optical centerline in the as worn orientation. Typically, an eyewear frame has a vertical plane of symmetry which is substantially parallel to the line of sight 130. Accordingly, the optical centerline 132 will be substantially parallel to the frame's vertical plane of symmetry.

Variations from parallel in the horizontal plane generally have a greater negative impact on the lens than variations from parallel in the vertical plane. Accordingly, the solid angle between the line of sight 130 and optical centerline 132 in the vertical plane may exceed the ranges set forth above, for some eyewear, as long as the horizontal component of the angle of deviation is within the above-mentioned ranges of deviation from the parallel orientation. Preferably, the line of sight 130 deviates in the vertical plane no more than about ±10° and, more preferably, no more than about ±3° from the optical centerline in the as worn orientation.

FIG. 7 is a cutaway view of the lens 120, lens blank 122, and geometric shape 124 of FIG. 6. This view shows that the preferred geometric shape 124 is hollow with walls of varying thickness, as revealed by a horizontal cross-section 134 at the optical centerline of the geometric shape 124.

The tapered walls of the preferred geometric shape 124 result from two horizontally offset spheres, represented by their center points C1 and C2 and radii R1 and R2. An outer surface 136 of the preferred lens blank 122 conforms to one sphere (of radius R1) while an inner surface 138 of the lens blank 122 conforms to the other sphere (of radius R2). By adjusting the parameters which describe the two spheres, the nature of the taper of the lens blank 122 may also be adjusted.

In particular, the parameters for the two spheres to which the lens blank outer surface 136 and inner surface 138 conform is preferably chosen to produce zero refractive power, or non-prescription lenses. Where CT represents a chosen center thickness (maximum thickness of the wall of the hollow geometric shape 124), n is an index of refraction of the lens blank material, R1 is set by design choice for the curvature of the outer surface 136, R2 may be determined according to the following equation:

$$R_2 = R_1 - CT + \frac{CT}{n} \qquad (2)$$

CT/n represents the separation of the spherical centers C1 and C2. For example, where a base 6 lens is desired as a matter of design choice, the center thickness is chosen to be

3 mm, and the index of refraction of the preferred material (polycarbonate) is 1.586, R2 may be determined as follows:

$$R_2\frac{530}{6} - 3 + \frac{3}{1.586} = 87.225\text{mm} \quad (3)$$

For this example, the radius R1 of the outer surface **136** is equal to 88.333 mm, the radius R2 of the inner surface **138** is equal to 87.225 mm, and the spherical centers C1 and C2 are separated by 1.892 mm. These parameters describe the curvature of the lens blank **122** of the preferred embodiment.

In the case of the preferred embodiment, the optical centerline **132** is that line which passes through both center points C1 and C2 of the offset spheres. This happens to pass through the thickest portion of the preferred geometrical shape **124** walls at an optical center **140**, though this may not be true for alternative nonspherical embodiments. The optical center **140** happens to pass through surface **136** of the illustrated lens blank **122**, although this is not necessary. The optical center **140** does not happen to lie on the lens **120**, although it may for larger lenses or lenses intended to exhibit less wrap in the as-worn orientation.

FIG. **8** illustrates a horizontal cross-section of the preferred lens **120**, showing in phantom the geometric shape **124** to which the outer surface **136** and inner surface **138** conform. The lens blank **122** is omitted from this drawing. In accordance with the present invention, the optical centerline **132** associated with the chosen taper is aligned to be parallel with the normal line of sight **130** of the wearer as the lens **120** is to be mounted in an eyeglass frame.

Furthermore, although the preferred embodiments are circular in both horizontal and vertical cross-section, a variety of lens configurations in both planes are possible in conjunction with the present invention. Thus, for example, the outer surface of the lens of the present invention may generally conform to a spherical shape as shown in FIGS. **6** and **7**. Alternatively the lens may conform to a right circular cylinder, a frusto-conical, an elliptic cylinder, an ellipsoid, an ellipsoid of revolution, or any of a number of other three dimensional shapes. Regardless of the particular vertical or horizontal curvature of the outer surface, however, the inner surface should be chosen such as to smoothly taper the lens thickness at least in the horizontal plane.

FIGS. **9–12** will aid in describing a method of choosing a location on the lens blank **122** from which to cut the right lens **120**, in accordance with a preferred embodiment of the present invention. It will be understood that a similar method would be used to construct the left lens for the dual lens eyewear of the preferred embodiment.

As a first step, a desired general curvature of the lens outer surface **136** may be chosen. For the preferred lens **120**, this choice determines the base value of the lens blank **122**. As noted elsewhere herein, a number of other curvatures may be utilized in conjunction with the present invention. A choice of lens thickness may also be preselected. In particular, the minimum thickness may be selected such that the lens will withstand a preselected impact force.

A desired lens shape may also be chosen. For example, FIG. **12** illustrates an example of a front elevational shape for the lens **120**. The particular shape chosen is generally not relevant to the decentered lens optics disclosed herein.

A desired as-worn orientation for the lens should also be chosen, relative to the normal line of sight **130** of the wearer **126**. As mentioned above, preferred orientations may provide significant lateral wrap for lateral protection and interception of peripheral light, and for aesthetic reasons. For example, the embodiment illustrated in FIGS. **6–12** uses a canted lens **120** to achieve wrap. Alternatively, wrap may be achieved through use of a higher base lens and a more conventional (non-canted) orientation. FIGS. **9** and **10** illustrate more plainly how the orientations may be related to the line of sight **130** of the wearer.

The eyewear designer may also choose a degree of rake, or vertical tilt, as will be understood from FIG. **10**, schematically illustrating the vertical orientation of the lens **120** relative to the head of the wearer **126**, and relative in particular to the normal line of sight **130**. A downward rake, as illustrated, is desirable for a variety of reasons, including improved conformity to common head anatomy. As will be apparent to those of skill in the art, a lens **120** having a mechanical center point which falls below the horizontal plane intersecting the optical centerline **132** (see FIG. **7**) will tend to have a downward rake as illustrated in FIG. **10**. This is because the lens **120** will have been formed below the equator of the sphere relative to the optical centerline. Since the orientation of the lens **120** to the optical centerline **132** in the imaginary sphere should be the same as the orientation between the lens **120** and a parallel to the normal line of sight **130** in the as-worn condition, any lens cut from this sphere below the optical centerline **132** should exhibit a corresponding degree of downward rake.

Referring now to FIG. **11**, a mapping of the horizontal orientation of the lens **120** onto the lens blank **122** is illustrated. The normal line of sight **130**, with respect to which the chosen orientation is measured, is maintained substantially parallel to the optical centerline **132**.

Once the aesthetic design such as that illustrated in FIG. **11** has been determined, and the lens blank **122** formed having a suitable base curvature for fitting within the aesthetic design, the aesthetic design may be "projected" onto the surface of the sphere to reveal that portion of the sphere which is suitable for use as the lens **120**. The projection of the lens shape onto the sphere should be moved about the surface of the sphere until it is positioned such that the lens cut from the sphere at that location will exhibit the appropriate wrap and rake for the aesthetic design without any rotation of the lens **120** out of its orientation in which the optical centerline of the sphere is substantially parallel to the normal line of sight in the as-worn orientation.

Although not illustrated, it will be understood that a similar projection may be performed for the vertical orientation chosen, as depicted in FIG. **10**, for instance. FIG. **10** provides reference points in the form of the lens top edge **152** and bottom edge **154** in relation to the line of sight **130**. The projection may then be shifted up or down until the top edge **152** and the bottom edge are both simultaneously aligned with corresponding points on the outer surface **136** of the lens blank, while maintaining the line of sight **130** substantially parallel with the optical centerline **132**.

Projection of both the horizontal profile and the vertical profile may be performed simultaneously, locating a unique position on the lens blank **122** corresponding to the desired three-dimensional shape of the lens (including the front elevational shape shown in FIG. **12**) at which the line of sight **130** is parallel to the optical centerline **132** or other reference line of the lens blank **122**. Of course, it will be understood that the lines **130** and **132** may be substantially parallel, that is, within the acceptable range of angular deviation set forth above.

This shape may then be cut from the blank **122** or molded directly in the final lens configuration. The resultant lens **120** not only conforms to the desired shape, but also minimizes prismatic distortion.

FIG. **12** illustrates a lens blank **122**, such as that shown conforming to a portion of the surface of the sphere in FIGS.

6 and 7. In FIG. 12, the lens blank 122 has been rotated such that the mechanical center of the blank is illustrated in the center of the drawing. The illustrated lens 120 has a medial edge 148, a lateral edge 144, an upper edge 152 and a lower edge 154. At least a portion of the right lens 120 lies in the lower left-hand (third) quadrant of the lens blank 122. Preferably, in an embodiment of the invention exhibiting both wrap and downward rake, at least about half of the lens area will fall within the third quadrant of the lens blank 122. Preferably all or substantially all of the area of the lens 120 will lie below and to the left of the optical center as illustrated. Lenses exhibiting a similar degree of rake but lesser wrap may be positioned on the lens blank 122 such that as much as 50% or more of the lens area is within the lower right (second) quadrant of the lens blank 122.

The present invention thus provides a precise method of furnishing the correct correspondence between taper and the varying angle of incidence from the wearer's eye to the surface of a lens. By recognizing a novel relationship among the wearer's line of sight and the form of taper, the present invention allows use of any of a variety of lens designs while minimizing prismatic distortion. For example, a designer may choose a desirable orientation and curvature for the lens, relative to a wearer's line of sight. The orientation and curvature may be chosen from a wide range of rake (i.e., vertical "tilt" of the lens), horizontal cant, base value and proximity to a wearer's face, including those parameters resulting in a high degree of wrap. The form of taper may then be chosen, by the method of the present invention, such that the prismatic distortion is minimized.

Although the foregoing invention has been described in terms of certain preferred embodiments, other embodiments will become apparent to those of ordinary skill in the art in view of the disclosure herein. Accordingly, the present invention is not intended to be limited by the recitation of preferred embodiments, but is intended to be defined solely by reference to the appended claims.

What is claimed:

1. An oriented, optically corrected non-prescription dual lens to eyeglass, comprising:

a left non-glass lens body and a right non-glass lens body, said left lens body having a left mechanical center and said right lens body having a right mechanical center;

a frame for supporting the right lens in the path of a wearer's normal line of sight from a right eye and the left lens in the path of a wearer's normal line of sight from a left eye, each lens exhibiting an amount of wrap and an amount of rake in an as worn orientation with respect to the wearer's right and left normal lines of sight;

a front surface and a rear surface on each of the right and left lens bodies, defining a lens thickness therebetween for each of the right and left lenses;

each of the front surface and rear surface of the right lens conforming substantially to portions of the surfaces of a front right sphere having a first center and a rear right sphere having a second center, respectively, such that the thickness of the right lens is tapered in both horizontal and vertical planes;

each of the front surface and rear surface of the left lens conforming substantially to portions of the surfaces of a front left sphere having a third center and a rear left sphere having a fourth center, respectively, such that the thickness of the left lens is tapered in both horizontal and vertical planes;

each of said first, second, third and fourth centers offset from one another;

a right optical centerline extending through the first and second centers of the right lens;

a left optical centerline extending through the third and fourth centers of the left lens;

wherein the right mechanical center is offset both horizontally and vertically from the right optical centerline, by a vertical distance which corresponds to the amount of rake exhibited by the right lens in the as worn orientation and by a horizontal distance which corresponds to the amount of wrap exhibited by the right lens in the as worn orientation, and the left mechanical center is offset both horizontally and vertically from the left optical centerline, by a vertical distance which corresponds to the amount of rake exhibited by the left lens in the as worn orientation, and by a horizontal distance which corresponds to the amount of wrap exhibited by the left lens in the as worn orientation to produce eyewear which is optically corrected for prismatic error which would otherwise have been induced by said rake and wrap.

2. An eyeglass as in claim 1, wherein each of said front right sphere and said front left sphere has a base curve of greater than about base 6.

3. An eyeglass as in claim 2, wherein each of said front right sphere and said front left sphere has a base curve of greater than about base 8.

4. An eyeglass as in claim 3, wherein each of said front right sphere and said front left sphere has a base curve within the range of from about 7.5 to about 10.5.

5. An eyeglass as in claim 4, wherein a horizontal component of the wearer's normal line of sight from each eye deviates in the as worn orientation by no more than about ±10° from parallel with a horizontal component of the corresponding optical centerline.

6. An eyeglass as in claim 5, wherein the horizontal component of the wearer's normal line of sight from each eye deviates in the as worn orientation by no more than about ±5° from parallel with the horizontal component of the corresponding optical centerline.

7. An eyeglass as in claim 6, wherein the horizontal component of the wearer's normal line of sight from each eye is parallel in the as worn orientation with the horizontal component of the corresponding optical centerline.

8. An eyeglass as in claim 4, wherein a vertical component of the wearer's normal line of sight from each eye in a vertical plane deviates in an as worn orientation by no more than about ±10° from parallel with a vertical component of the corresponding optical centerline.

9. An eyeglass as in claim 8, wherein the vertical component of the wearer's normal line of sight from each eye is within about ±3° from parallel in an as worn orientation to the vertical component of the corresponding optical centerline.

10. An eyeglass as in claim 1, wherein the wearer's normal line of sight from each eye crosses the rear surface of the corresponding lens at an angle within the range of from about 100° to about 135°.

11. An eyeglass as in claim 1, wherein the wearer's normal line of sight from each eye crosses the rear surface of the lens at an angle which is greater than about 95°.

12. An eyeglass as in claim 1, wherein each of said right and left lenses comprises polycarbonate.

13. An eyeglass as in claim 1, wherein each of the right and left lenses is cut from a lens blank.

14. An eyeglass as in claim 1, wherein each of the right and left lenses has a maximum horizontal arc length within the range of from about 1 ½ inches to about 3 ½ inches.

15. An eyeglass as in claim 14, wherein each of the right and left lenses has a maximum horizontal arc length within the range of from about 2 inches to about 3 inches.

16. An eyeglass as in claim 1, wherein the right and left lenses are canted such that a medial edge of each of said right and left lenses falls outside of a circle and a lateral edge of each of the right and left lenses falls inside of said circle.

17. An eyeglass as in claim 1, wherein the medial edge of each of the right and left lenses has a thickness within the range of from about 1 mm to about 2.5 mm.

18. An eyeglass as in claim 17, wherein the medial edge of each of the right and left lenses has a thickness within the range of from about 1.5 mm to about 1.8 mm.

19. An eyeglass as in claim 1, wherein the radius of the front right sphere and the radius of the front left sphere are each about 60.57 mm.

20. An eyeglass as in claim 1, wherein the eyeglass has a vertical plane of symmetry which is substantially parallel to the wearer's right and left normal lines of sight.

21. An eyeglass as in claim 1, wherein the right optical centerline crosses the right lens at a point which is offset both horizontally and vertically from the wearer's right eye normal line of sight, and the left optical centerline crosses the left lens at a point which is offset both horizontally and vertically from the wearer's left eye normal line of sight.

22. An eyeglass as in claim 21, wherein the right optical centerline is substantially parallel with the wearer's right eye normal line of sight, and the left optical centerline is substantially parallel with the wearer's left eye normal line of sight.

23. A dual lens optically corrected eyeglass, comprising:

a first non-glass lens and a second non-glass lens;

a dual lens frame for supporting the first and second lenses in front of a wearer's first normal line of sight corresponding to one eye of the user and the wearer's second normal line of sight corresponding to the other eye of the user respectively, in an as worn orientation, each lens exhibiting a degree of wrap and a degree of downward rake in the as worn orientation such that each of the wearer's first and second normal lines of sight cross the rear surface of the first and second lenses respectively, at a non normal angle in each of horizontal and vertical planes;

each lens having a posterior surface with a posterior center of curvature, an anterior surface with a separate and distinct anterior center of curvature, a thickness between the posterior and anterior surfaces, and a separate and distinct optical centerline passing through the respective posterior and anterior centers of curvature;

the thickness of each lens being vertically tapered on either side of a horizontal plane which includes the corresponding optical centerline, and horizontally tapered on at least one side of a vertical plane which includes the corresponding optical centerline, for optical correction of each lens in the as worn orientation,

wherein a mechanical center of each lens is spaced below the horizontal plane by a distance which corresponds to the degree of downward rake of each lens in the as worn orientation thereby minimizing prismatic shift which would have been induced by mounting each lens with said degree of downward rake.

24. An eyeglass as in claim 23, wherein each lens has a base curve within the range of from about 7.5 to about 10.5.

25. An eyeglass as in claim 24, wherein each lens has a base curve within the range of from about 8 to about 9.5.

26. An eyeglass as in claim 24, wherein each lens is oriented such that the corresponding straight ahead normal line of sight crosses the lens at an angle of greater than about 95° in the as worn orientation.

27. An eyeglass as in claim 26, wherein each normal line of sight crosses the corresponding lens at an angle within the range of from about 100° to about 135°.

* * * * *

US006010218A

United States Patent [19]

Houston et al.

[11] Patent Number: 6,010,218

[45] Date of Patent: *Jan. 4, 2000

[54] DECENTERED NONCORRECTIVE LENS FOR EYEWEAR

[75] Inventors: **Malcolm Neal Houston**, Foothill Ranch, Calif.; **James H. Jannard**, Eastsound, Wash.; **Carlos D. Reyes**, Gardnerville, Nev.

[73] Assignee: **Oakley, Inc.**, Foothill Ranch, Calif.

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/745,162**

[22] Filed: **Nov. 7, 1996**

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/567,434, Dec. 5, 1995, Pat. No. 5,648,832.

[51] **Int. Cl.**[7] **G02C 7/02**; G02C 1/13

[52] **U.S. Cl.** **351/159**; 351/41

[58] **Field of Search** 351/159, 158, 351/41, 43–47

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Primary Examiner—Georgia Epps
Assistant Examiner—Jordan M. Schwartz
Attorney, Agent, or Firm—Knobbe, Martens, Olson & Bear, LLP

[57] **ABSTRACT**

Disclosed are optically corrected lenses for nonprescription dual lens eyeglasses. Left and right lenses are each vertically and horizontally tapered, and are each characterized by optical centerlines. The lenses are mounted in dual lens eyewear frames with rake and wrap, with the optical centerlines each vertically displaced from the normal line of sight in an as-worn orientation. The vertical displacement corresponds to the degree of rake in a manner resulting in optical correction of the lenses. Lenses are thus provided which have improved optics when mounted in the raked and wrapped as-worn orientation.

11 Claims, 11 Drawing Sheets

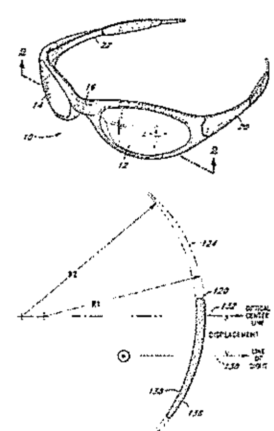

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Fig. 1

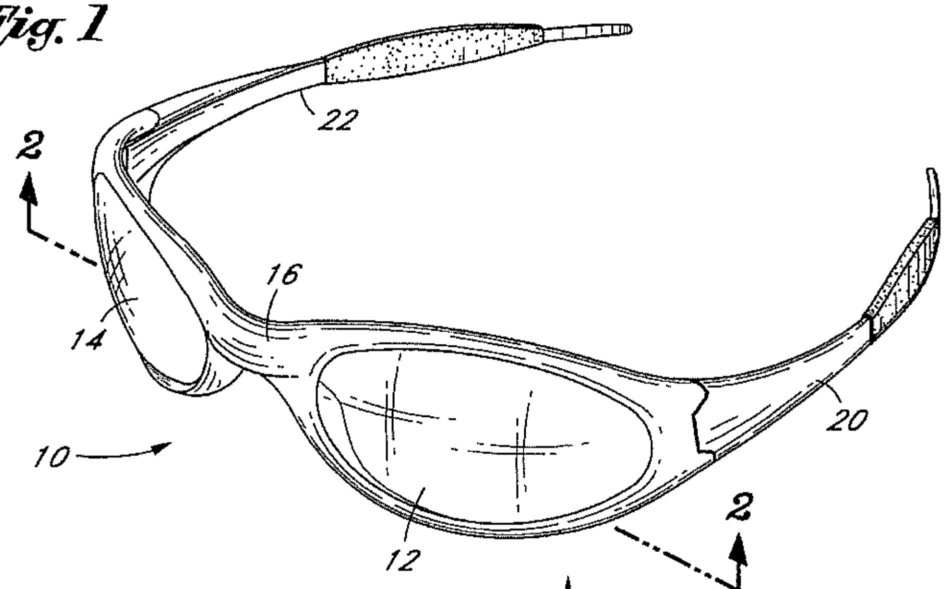


Fig. 2

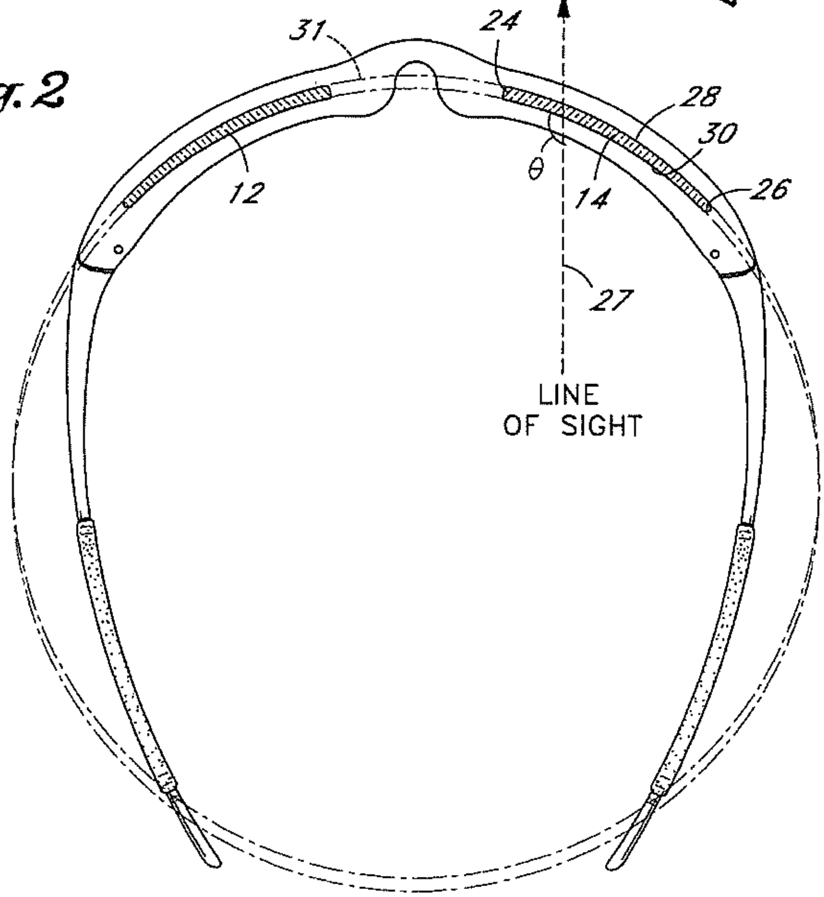


Fig. 3
(PRIOR ART)

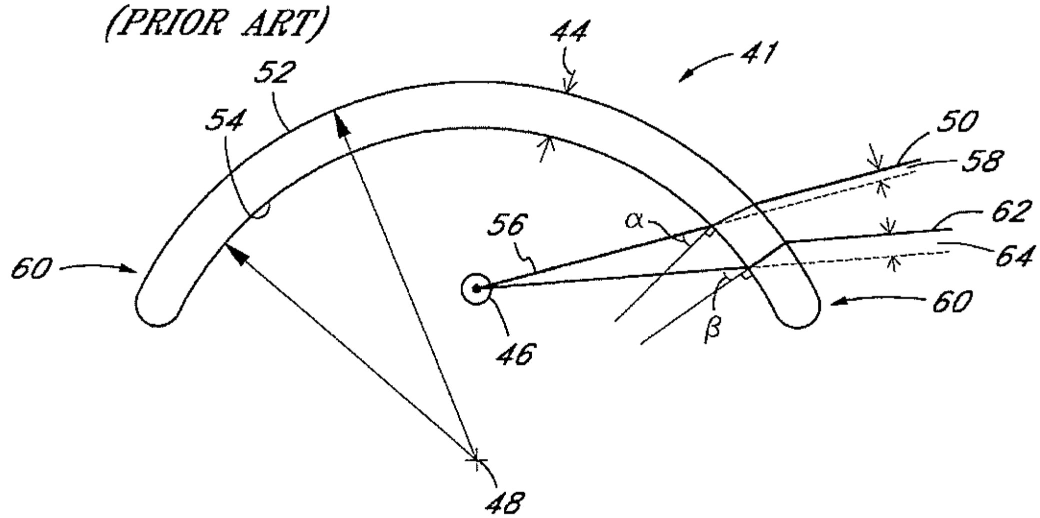


Fig. 4

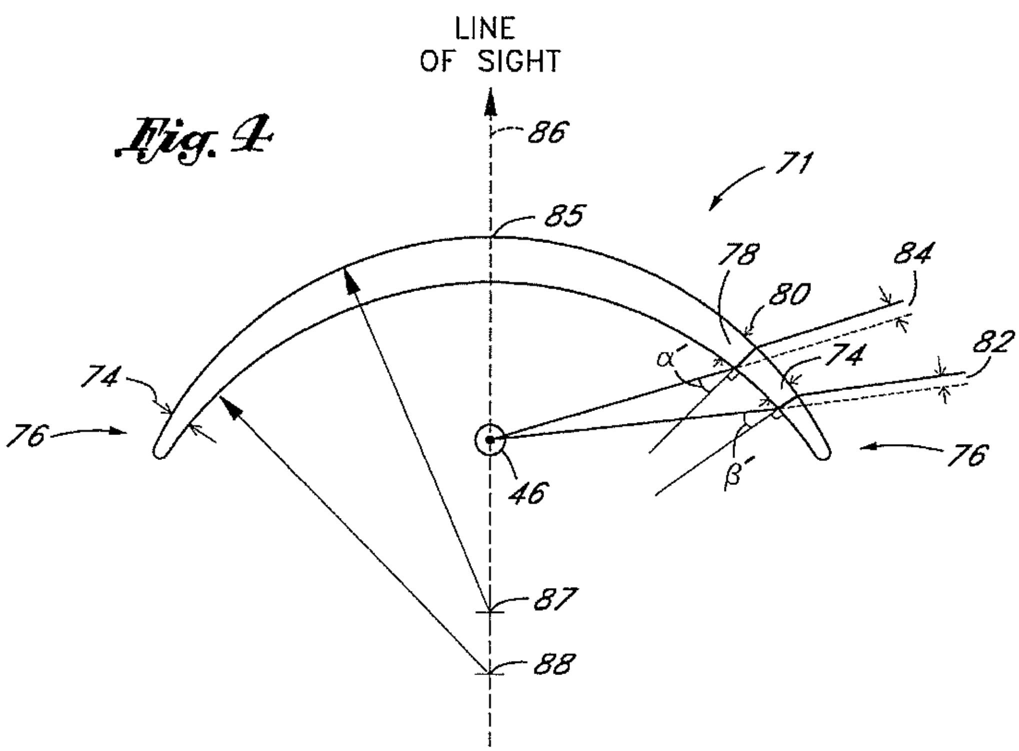
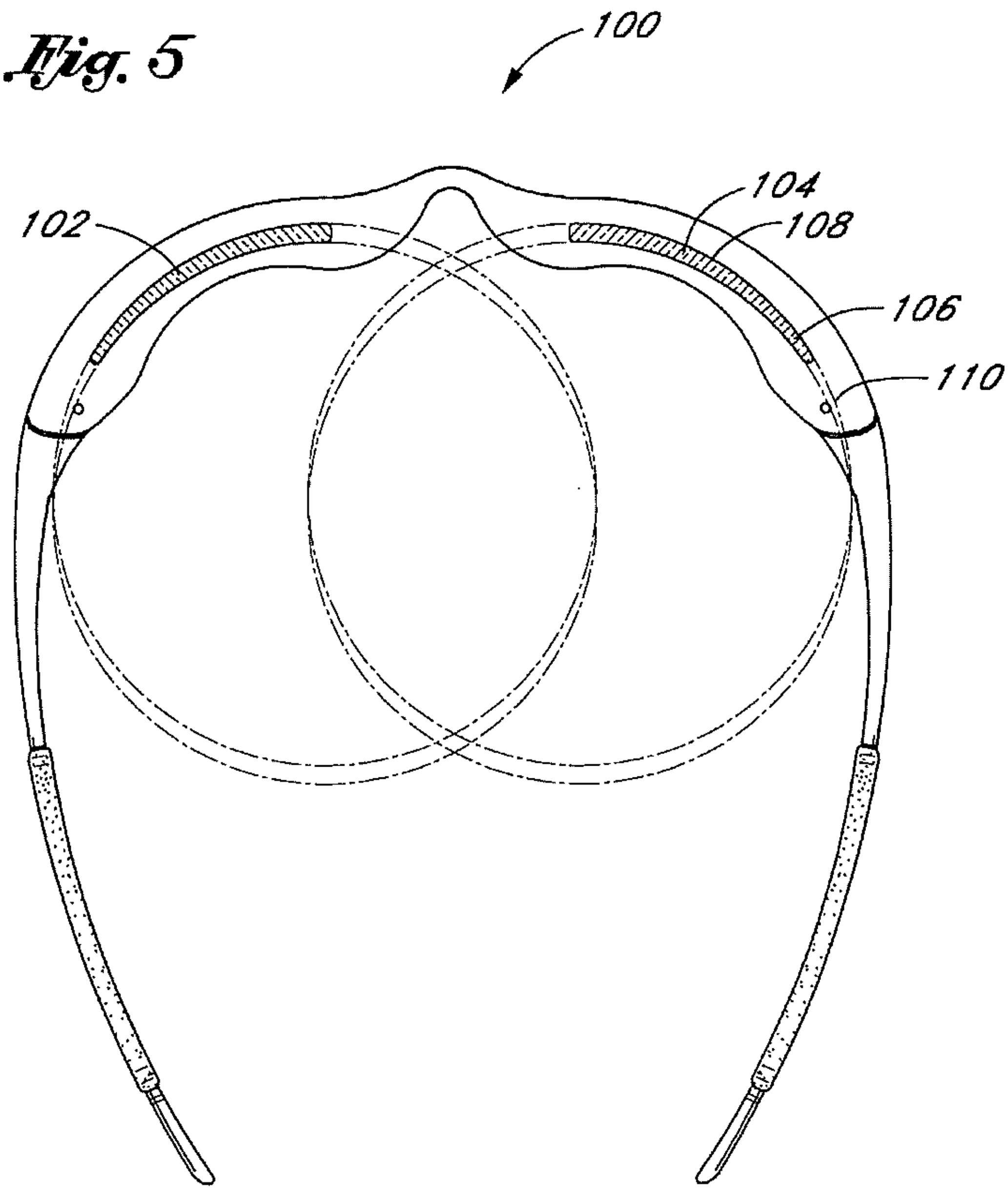


Fig. 5



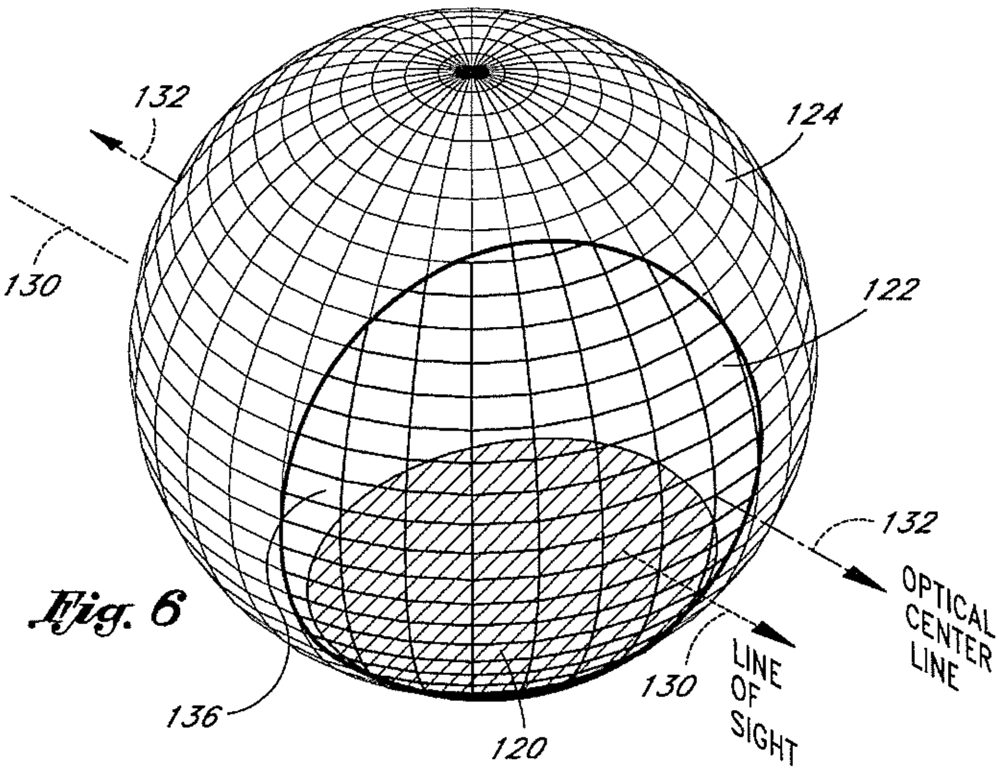

132
124
130
122
132
OPTICAL CENTER LINE
LINE OF SIGHT
130
136
120

Fig. 6

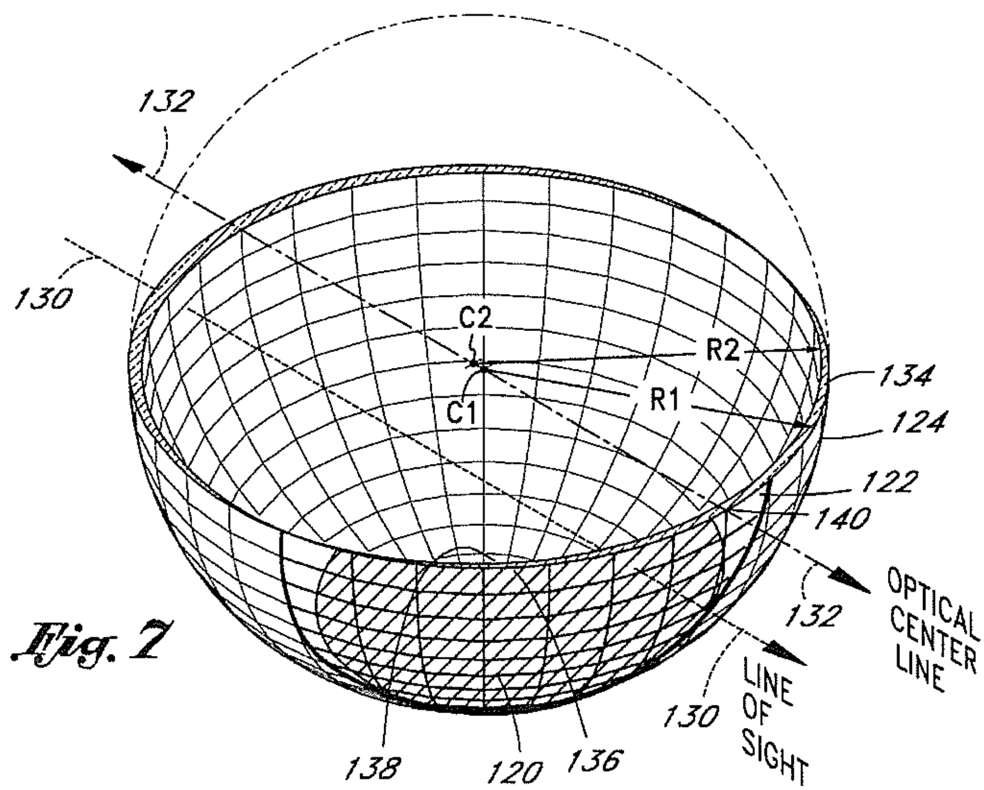

132
130
C2
R2
134
C1
R1
124
122
140
OPTICAL CENTER LINE
132
LINE OF SIGHT
130
138
120
136

Fig. 7

Fig. 8

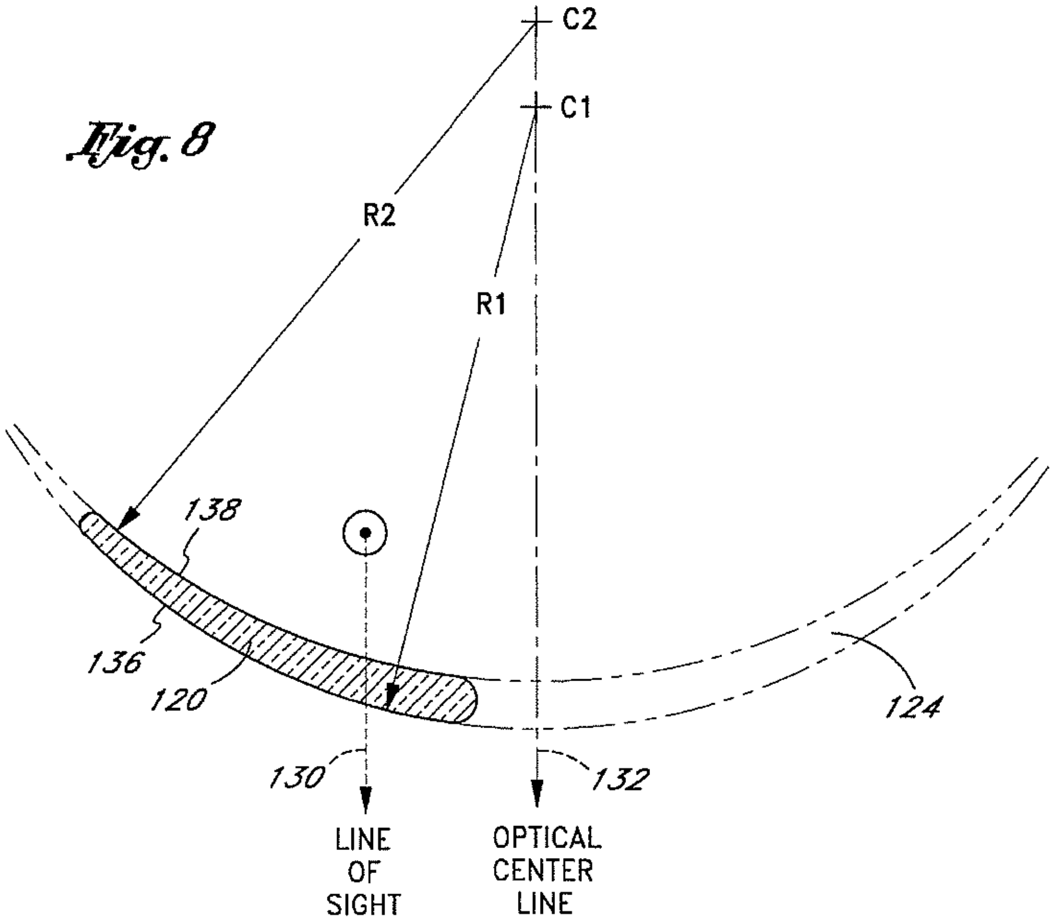
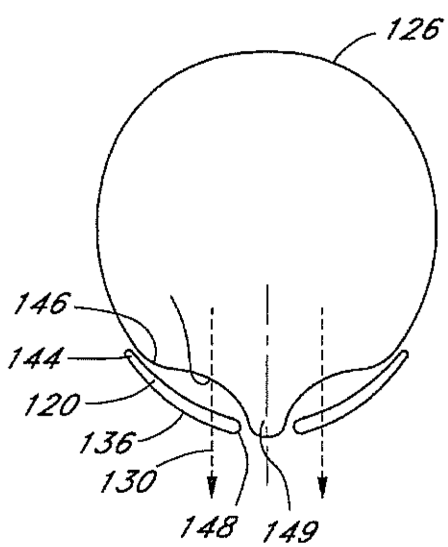

C2
C1
R2
R1
138
136
120
124
130
132
LINE OF SIGHT
OPTICAL CENTER LINE

Fig. 9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146
144
120
136
130
148
149

Fig. 8A

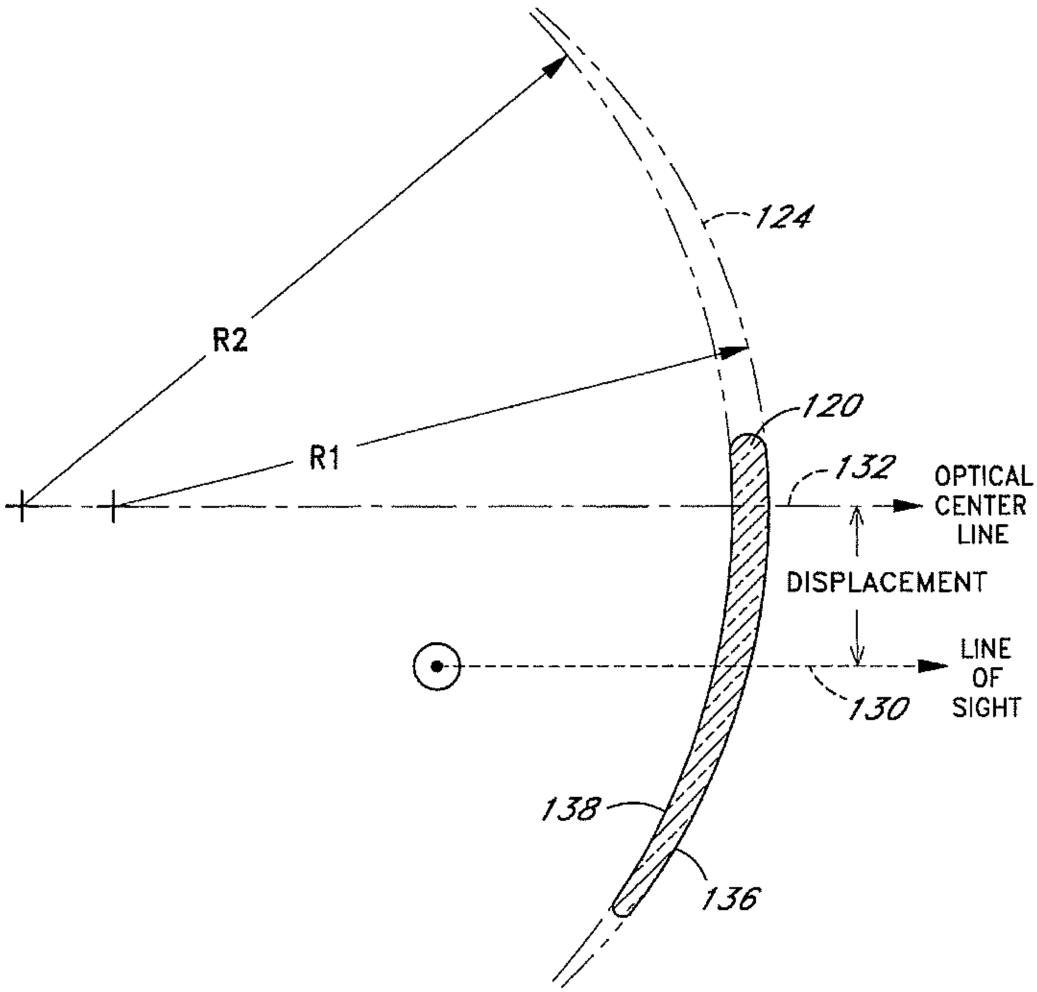

124
R2
R1
120
132
OPTICAL
CENTER
LINE
DISPLACEMENT
LINE
OF
SIGHT
130
138
136

Fig. 10C

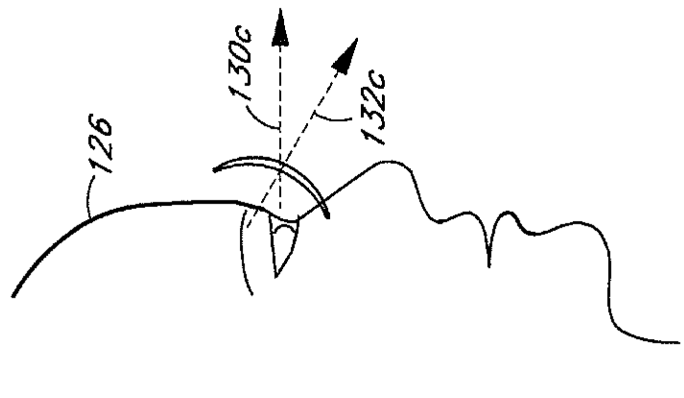


Fig. 10B

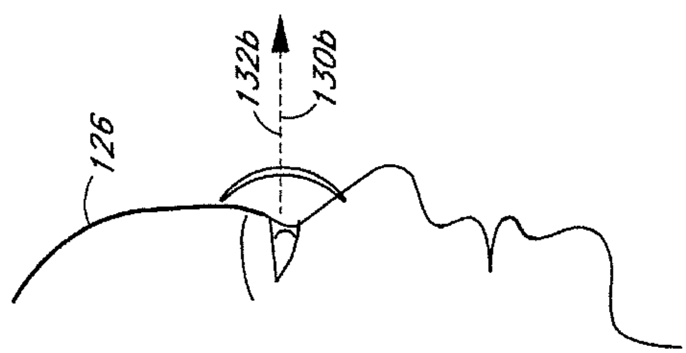


Fig. 10A

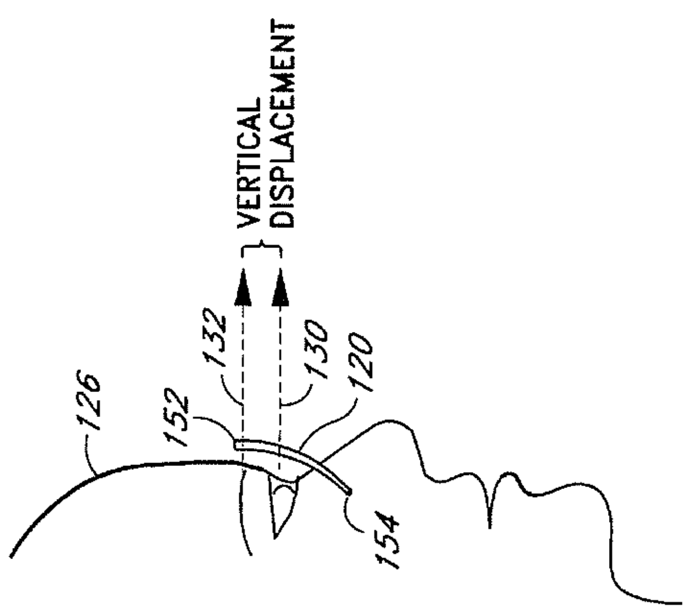
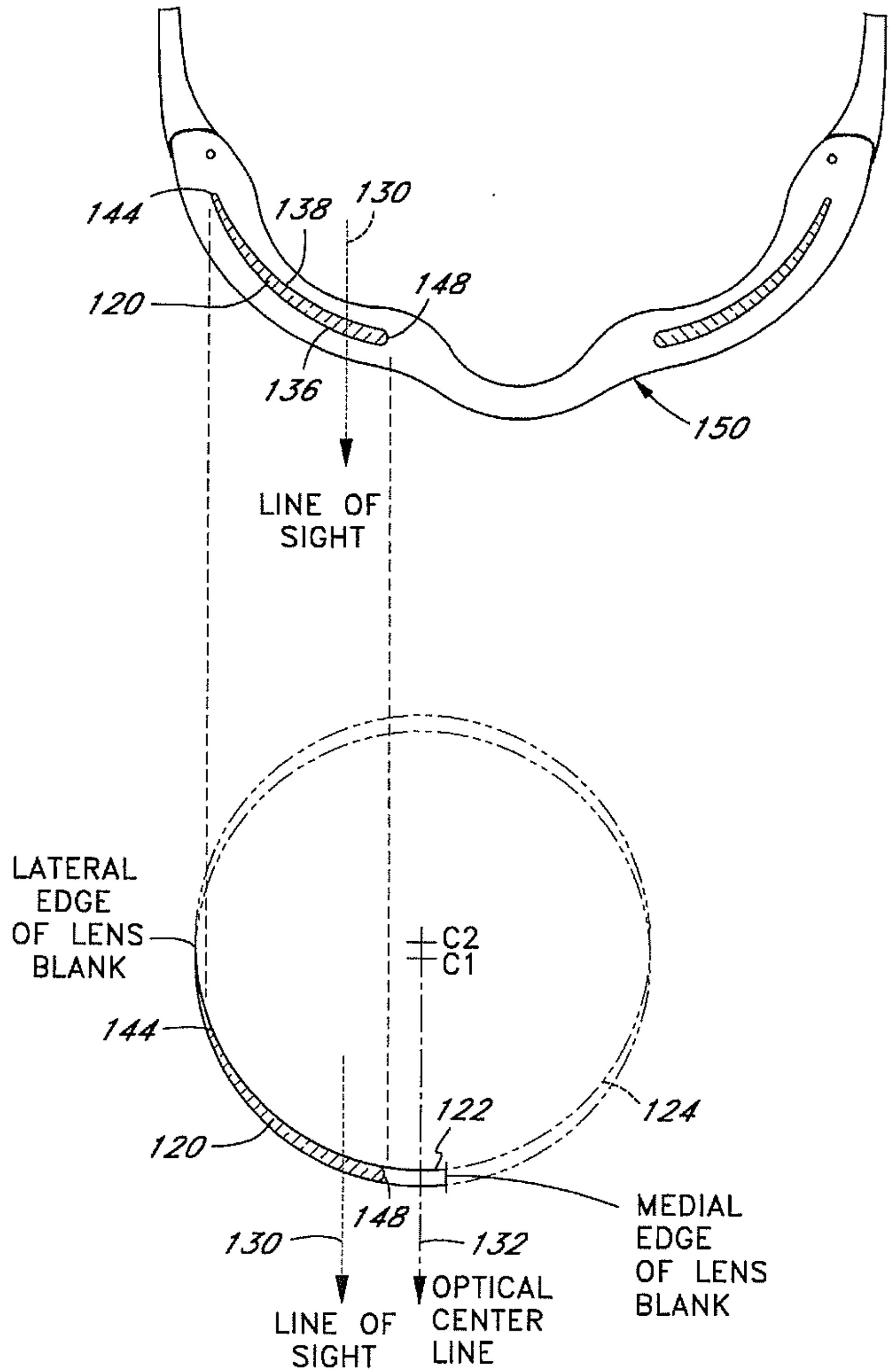


Fig. 11


144
138
130
120
148
136
150
LINE OF SIGHT
LATERAL EDGE OF LENS BLANK
C2
C1
144
122
124
120
148
130
132
MEDIAL EDGE OF LENS BLANK
LINE OF SIGHT
OPTICAL CENTER LINE

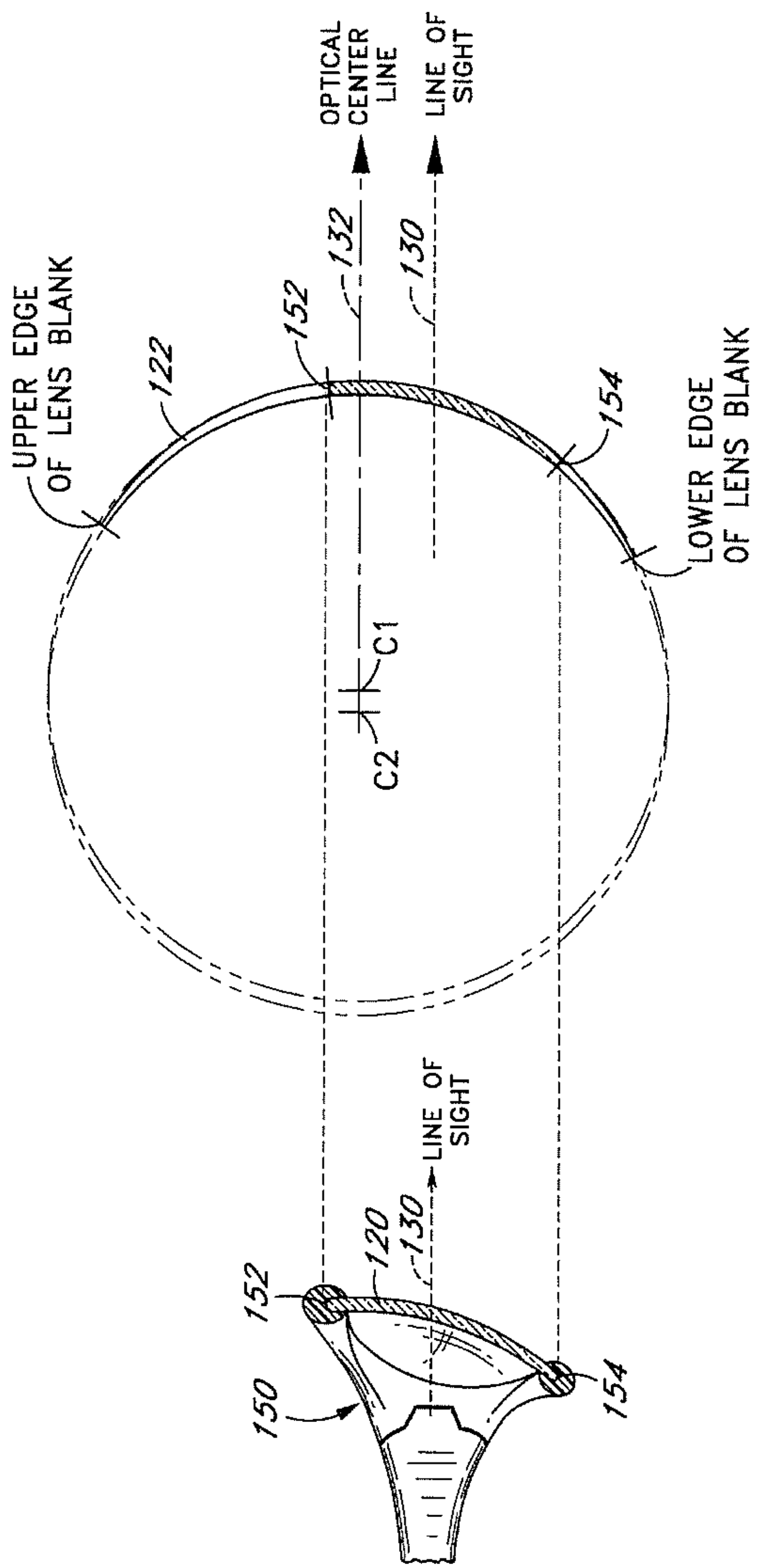

OPTICAL CENTER LINE
LINE OF SIGHT
UPPER EDGE OF LENS BLANK
122
152
132
130
154
LOWER EDGE OF LENS BLANK
C1
C2
LINE OF SIGHT
120
130
152
150
154

Fig. 11A

Fig. 12

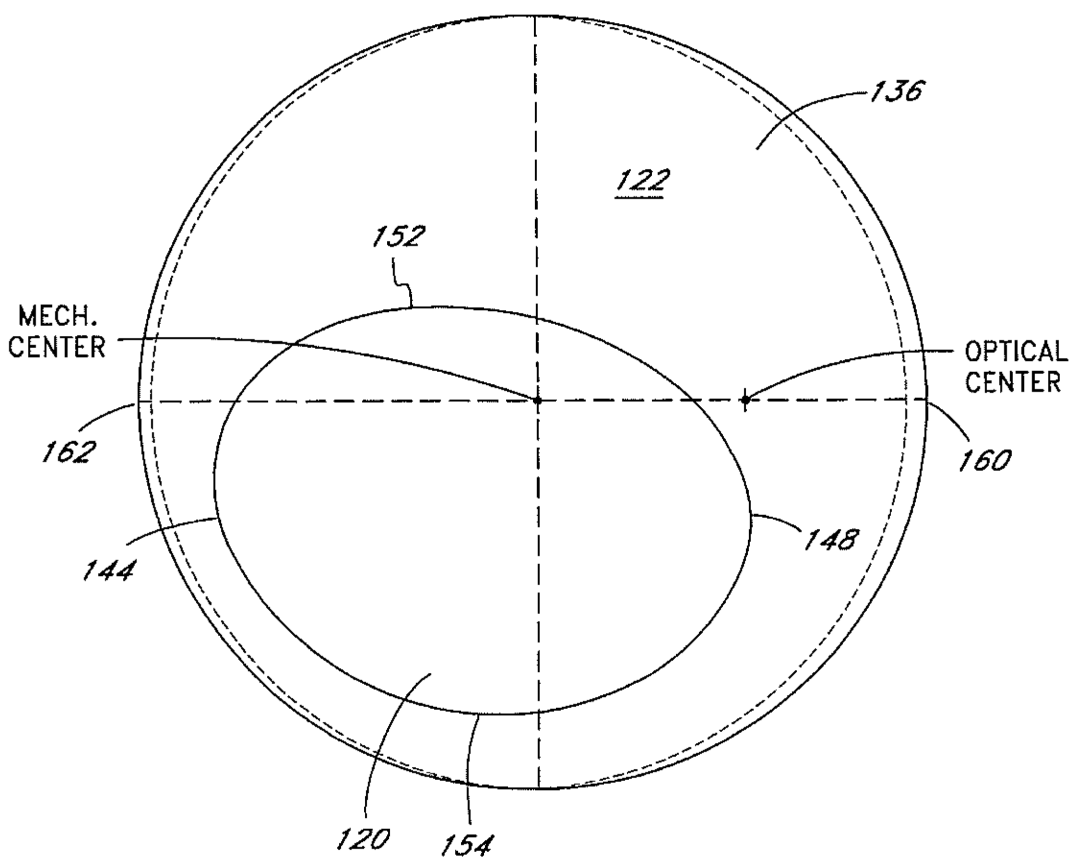
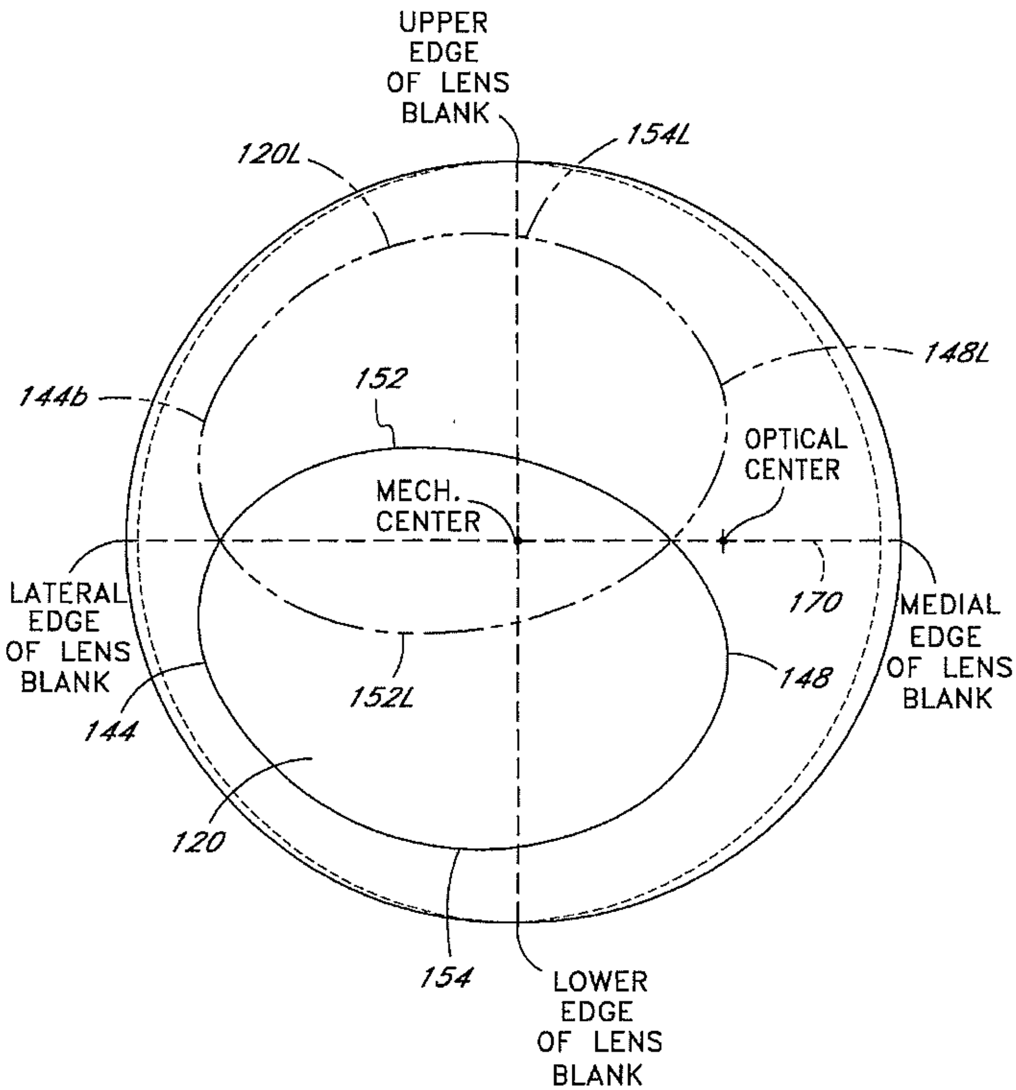

136
122
152
MECH.
CENTER
OPTICAL
CENTER
162
160
144
148
120
154

Fig. 12A


UPPER EDGE OF LENS BLANK
154L
120L
148L
144b
152
OPTICAL CENTER
MECH. CENTER
LATERAL EDGE OF LENS BLANK
170
MEDIAL EDGE OF LENS BLANK
148
152L
144
120
154
LOWER EDGE OF LENS BLANK

DECENTERED NONCORRECTIVE LENS FOR EYEWEAR

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation-in-part of the U.S. patent application entitled "DECENTERED NON-CORRECTIVE LENS FOR EYEWEAR," having Ser. No. 08/567,434, filed Dec. 5, 1995, now U.S. Pat. No. 5,648,832 and assigned to the assignee of the present application.

FIELD OF THE INVENTION

The present invention relates generally to lenses used in eyewear, and more particularly to a decentered, noncorrective lens configured and oriented to reduce optical distortion.

BACKGROUND OF THE INVENTION

A wide variety of improvements have been made in recent years in the eyewear field, particularly with respect to eyewear intended for use in active sports or as fashion sunglasses. These improvements have been incorporated into eyewear having a unitary lens, such as the "Blades®" design (Oakley, Inc.) the "M Frame®" line (Oakley, Inc.), and the "Zero®" line also produced by Oakley, Inc. These eyewear designs accomplish a variety of functional advantages, such as maximizing interception of peripheral light, reducing optical distortion and increasing the wearer's comfort level, compared to previous active sport eyewear.

The unitary lens of the "Blades®" eyewear incorporates the cylindrical geometry disclosed, for example, in U.S. Pat. No. 4,859,048, issued to Jannard. This geometry allows the lens to closely conform to the wearer's face and intercept light, wind, dust, etc. from directly in front of the wearer (anterior direction) and peripherally (lateral direction). See also U.S. Pat. No. 4,867,550 to Jannard (toroidal lens geometry).

Although the early unitary lens systems provided a full side-to-side range of vision and good lateral eye protection, the potential for optical distortion still exists. In a unitary lens system, for example, the angle of incidence from the wearer's eye to the posterior lens surface changes as the wearer's sight line turns in either the vertical or horizontal planes. This results in disparate refraction between light entering closer to the front of the lens and peripheral light entering at the lateral ends. To address this source of prismatic distortion, U.S. Pat. No. 4,859,048 discloses tapering the thickness of the lens from the medial portion toward the lateral edge.

Prior art eyewear has also employed dual lens systems in which two separate lenses are mounted along a front frame. In the early dual lens eyeglass systems, each of the right and left lenses were roughly co-planar in the as-worn configuration. Thus, the sight line of the wearer, when looking straight ahead, generally crossed the posterior surface of the lens at a normal to the lens surface in the optical zone. One of the disadvantages of this lens configuration was that the eyeglasses provided essentially no lateral eye protection without the use of special modifications, such as vertically elongated earstems or side attachments.

Dual lens systems were thereafter developed in which the lateral edge of each lens curved rearwardly from the frontal plane, and around the side of the wearer's head to provide a lateral wrap similar to that achieved by the high wrap unitary lens systems. Although the dual lens eyeglasses with significant wrap provided lateral eye protection, the lens curvature generally introduced measurable prismatic distortion through the wearer's angular range of vision. This was particularly pronounced in lenses comprising high index of refraction materials. In addition, although high base curvatures (e.g. base 6 or higher) are sometimes desirable to optimize wrap while maintaining a low profile, such lenses have not been practical in the past due to the relatively high level of prismatic distortion.

Thus, there remains a need for a high base nonprescription lens for use in dual lens eyewear of the type exhibiting wrap and rake, which can intercept light throughout an angular range of vision while at the same time minimize optical distortion throughout that range.

SUMMARY OF THE INVENTION

There is provided in accordance with one aspect of the present invention, an eyeglass lens for use in noncorrective dual lens eyewear. The eyeglass lens is utilized in combination with a frame to support the lens in the path of the wearer's normal line of sight.

The lens comprises a lens body, having a front surface, a rear surface, and a thickness therebetween.

The front surface of the lens conforms to a portion of the surface of a solid geometric shape. In one embodiment, the front surface of the lens conforms substantially to a portion of the surface of a first sphere having a first center. The rear surface of the lens conforms substantially to a portion of the surface of a solid geometric shape, which may be the same or different than that conforming to the front surface. In one embodiment, the rear surface conforms substantially to a portion of the surface of a second sphere having a second center.

The first and second centers are offset from one another to taper the lens thickness. The lens is mounted in the frame in an orientation such that a line drawn through the first and second centers is maintained generally in parallel with a preselected reference such as the wearer's normal straight ahead line of sight.

The lens may be cut from a lens blank, or formed directly into its final configuration such as by injection molding or other techniques known in the art. Preferably, the lens is oriented on the head of a wearer by the eyeglass frame such that the normal sight line of the wearer crosses the anterior surface of the lens at an angle of greater than about 95°, and preferably within the range of from about 100° to about 120°, while maintaining the optical centerline of the lens in a generally parallel relationship with the normal sight line of the wearer. The optical centerline of the lens may or may not pass through the lens.

Methods of making the lens of the present invention are also disclosed.

Further features and advantages of the present invention will become apparent from the detailed description of preferred embodiments which follows, when considered together with the attached claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of eyewear incorporating taper corrected lenses made in accordance with an embodiment of the present invention.

FIG. 2 is a cross-sectional view taken along the lines 2—2 of FIG. 1.

FIG. 3 is a schematic horizontal cross-sectional view of a prior art untapered lens for a dual lens eyewear system.

FIG. 4 is a schematic horizontal cross-sectional view of a tapered lens for a dual lens eyewear system.

FIG. 5 is a cross-sectional view like that in FIG. 2, showing taper corrected lenses having a greater base curvature, in accordance with another embodiment of the present invention.

FIG. 6 is a perspective view of a lens blank conforming to a portion of the surface of a sphere, showing a lens profile to be cut from the blank in accordance with a preferred embodiment of the present invention.

FIG. 7 is a perspective cutaway view of the hollow, tapered wall spherical shape, lens blank, and lens of FIG. 6.

FIG. 8 is a horizontal cross-sectional view of a lens constructed in accordance with a preferred embodiment of the present invention.

FIG. 8A is a vertical cross-sectional view of a lens constructed in accordance with a preferred embodiment of the present invention.

FIG. 9 is a top plan view of the lens of FIG. 8 showing a high wrap in relation to a wearer.

FIGS. 10A–10C are right side elevational views of lenses of various configurations and orientations relative to a wearer.

FIG. 10A illustrates the profile of a properly configured and oriented lens for use in an eyeglass having downward rake, in accordance with a preferred embodiment of the present invention.

FIG. 10B illustrates the profile of a centrally oriented lens with no rake.

FIG. 10C illustrates a lens exhibiting downward rake but which is not configured and oriented to minimize prismatic distortion for the straight ahead line of sight.

FIG. 11 schematically illustrates the projection of the lens horizontal profile from a desired orientation within an eyewear frame to the lens blank, in accordance with a preferred embodiment of the present invention.

FIG. 11A schematically illustrates the projection of the lens vertical profile from a desired orientation within an eyewear frame to the lens blank, in accordance with a preferred embodiment of the present invention.

FIG. 12 is a top plan view of the right lens and front (convex surface) of the lens blank of FIG. 6, rotated to project the mechanical centerline of the blank normal to the page.

FIG. 12A is a top plan view, like that of FIG. 12, additionally showing the position from which a left lens could have been cut from the same lens blank.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Although the preferred embodiments will be discussed below in terms of lenses having "spherical" front and rear surfaces (surfaces which conform substantially to a portion of the surface of a sphere), it will be understood by those having ordinary skill in the art that the invention may also be applicable to lenses having different surface geometries. Additionally, it will be understood that the present invention has application to lenses of many front elevational shapes and orientations in the as-worn position beyond those illustrated herein.

Referring to FIGS. 1 and 2, there is illustrated an eyeglass 10, such as a sunglass having first and second lenses 12, 14 constructed in accordance with an embodiment of the present invention. Although the invention is illustrated as though it were incorporated into an eyeglass design marketed by Oakley under the Eye Jackets™ name, the present invention relates solely to the lens curvature, taper, and orientation on the head of the wearer. Therefore the particular lens or frame shape revealed in FIG. 1 is not critical to the invention. Rather, lenses of many other shapes and configurations may be constructed which incorporate the configuration and orientation of the present invention, as will become apparent based upon the disclosure herein.

Similarly, the mounting frame 16 having continuous orbitals is not essential to the present invention. The orbitals may bound only the bottom edge(s) of the lenses 12, 14, only the top edges, or the entire lenses as illustrated. Alternatively, the frame 16 can bound any other portions of the lenses as will be evident to those of skill in the art. Frameless eyeglasses can also be constructed in accordance with the present invention, as long as the lens orientation on the head of the wearer is substantially maintained in a predetermined relationship to a preselected sight line as will be discussed below. Preferably, though, the lenses 12, 14 are each mounted in an annular orbital as shown.

A pair of earstems 20, 22 pivotally attach to the frame 16. Alternatively, the earstems 20, 22 may attach directly to the lenses 12, 14. The frame may comprise any of a variety of metals, composites or relatively rigid, molded thermoplastic materials which are well known in the art, and may be transparent or any of a variety of colors. Injection molding, machining and other construction techniques are well known in the art.

Lenses in accordance with the present invention can be manufactured by any of a variety of processes well known in the art.

Typically, high optical quality lenses are cut from a preformed injection molded lens blank. Since the right and left lenses are preferably mirror images of each other, only the right lens will generally be described for most of the discussion below. In describing a method of cutting lenses from preformed lens blanks, however, the manner in which a left lens differs from the right lens will be related to the degree of rake and wrap chosen for the as-worn lens orientation. Alternatively, the lens can be molded directly into its final shape and size, to eliminate the need for post molding cutting steps.

Preferably, the lens, or the lens blank from which it is cut, is injection molded and comprises a relatively rigid and optically acceptable material, such as polycarbonate. Other polymeric lens materials can also be used, such as CR-39 and a variety of high index plastics which are known in the art. The decentered taper correction of the present invention may also be applicable to glass lenses, although the need for correction in the present context is generally more pronounced in currently popular nonglass materials.

If the lens is to be cut from a lens blank, the taper and curvature of a carefully preselected portion of the lens blank is transferred to the lens in accordance with a preferred orientation process described below. Preferably, the frame is provided with a slot or other attachment structure that cooperates with the molded curvature of the lens to minimize deviation from, and even improve retention of the as-molded curvature.

Alternatively, the lens or lens blank can be stamped or cut from generally planar tapered sheet stock and then bent into the curved configuration in accordance with the present invention. This curved configuration can then be maintained by the use of a relatively rigid, curved frame, or by heating the curved sheet to retain its curved configuration, as is well known in the thermoforming art.

Most preferably, the curvature of both surfaces of the lens are created in the lens blank molding and polishing processes, and the lens shape is cut from the blank in accordance with the invention as described below.

Referring to FIG. 2, the lens 14 of the present invention is characterized in a horizontal plane by a generally arcuate shape, extending from a medial edge 24 throughout at least a portion and preferably substantially all of the wearer's range of vision to a lateral edge 26. The arc length of the lens from the medial edge 24 to the lateral edge 26 in a dual lens system will generally be within the range of from about 1½ inches to about 3½ inches, and preferably within the range of from about 2 inches to about 3 inches. In one preferred embodiment, the arc length of the lens is about 2⅜ inches.

Although the outer surfaces of the lenses 12, 14 appear to be illustrated as lying on a common circle 31, the right and left lenses in a high wrap eyeglass will generally be canted such that the medial edge of each lens will fall outside of the circle 31 and the lateral edges will fall inside of the circle 31. Such canting of the lens increases the angle θ (FIG. 2) and increases the desirability of the optical correction achieved by the present invention.

When worn, the lens 14 should at least extend across the wearer's normal straight ahead line of sight 27, and preferably substantially across the wearer's peripheral zones of vision. As used herein, the wearer's normal line of sight shall refer to a line projecting straight ahead of the wearer's eye, with substantially no angular deviation in either the vertical or horizontal planes as illustrated by line 130 in FIGS. 9 and 10.

The lens 14 is provided with an anterior surface 28, a posterior surface 30, and a varying thickness therebetween. The thickness of the lens 14 in the region of the medial edge 24 for a polycarbonate lens is generally within the range of from about 1 mm to about 2.5 mm, and preferably in the range of from about 1.5 mm to about 1.8 mm. In a preferred embodiment, the thickest portion of the lens 14 is at or about the intersection of the lens with the optical centerline, and is about 1.65 mm.

Preferably, the thickness of the lens 14 tapers smoothly, though not necessarily linearly, from the maximum thickness proximate the medial edge 24 to a relatively lesser thickness at the lateral edge 26. The thickness of the lens near the lateral edge 26 is generally within the range of from about 0.635 mm to about 1.52 mm, and, preferably, within the range of from about 0.762 mm to about 1.27 mm. In one preferred polycarbonate embodiment, the lens has a minimum thickness in the lateral zone of about 1.15 mm. The minimum thickness at lateral edge 26 is generally governed by the desired impact resistance of the lens.

FIG. 3 schematically illustrates refraction in a prior art lens 41 with circular inside and outside surface horizontal cross-sections, having a uniform thickness 44. With such a lens 41, the angle of incidence of rays from the lens 41 to the eye 46 changes throughout the angular range of vision. For example, a ray which shall be referred to for descriptive purposes as a medial light ray 50 strikes the lens 41 at an angle α to the normal at the point of incidence. As is well known in this art, bending of light at transmitting surfaces depends in part upon the angle of incidence of light rays. The ray 50 is refracted or bent in opposite directions at each of an outer surface 52 and an inner surface 54 of the lens 41, resulting in a transmitted ray 56 parallel to the incident ray 50. The transmitted ray 50 is laterally displaced, relative to the path of the incident ray 50, by a distance 58. This displacement represents a first order source of (prismatic) optical distortion.

Furthermore, refractory displacement is even more pronounced at a lateral end 60 due to a greater angle of incidence β. A peripheral incident ray 62 experiences greater displacement 64 than the medial incident ray 50, in accordance with Snell's Law, as will be understood by those of ordinary skill in the optical arts. The discrepancy between the peripheral ray displacement 64 and the medial ray displacement 58 results in a second order of optical distortion. This second order of distortion may cause substantial warping of an image seen through relatively lateral portions of the lens 41.

FIG. 4 schematically illustrates a lens 71 of tapered thickness, to compensate for the greater angle of incidence at the lateral ends 60 of the lens 41 (FIG. 3), similar in ways to that disclosed in the context of unitary lens systems in U.S. Pat. No. 4,859,048, issued to Jannard. Tapering produces a smaller lens thickness 74 at a lateral end 76, relative to a lens thickness 78 at a more medial point 80. This smaller thickness 74 reduces an amount of peripheral ray displacement 82, relative to the peripheral ray displacement 64 through the untapered lens 41 of FIG. 4. In other words, lesser lens thickness 74 near the lateral end 76 of the tapered lens 71 compensates to some extent for a greater angle of incidence β', relative to the thickness 78 and angle of incidence α'at the more medial point 80.

The resulting difference between peripheral ray displacement 82 and medial ray displacement 84 on the same lens 71 is not as great as the corresponding difference in FIG. 3, reducing the second order optical distortion. Note that the degree of correction of the second order distortion depends upon a relationship between the manner and degree of tapering from the apex 85 to each lateral end 76 and the manner in which the angle of incidence changes over the same range.

The lens 71 of FIG. 4 is illustrated as though it were mounted within a frame (not shown) such that the wearer's normal line of sight 86 passes perpendicularly through the lens 71 at the lens apex or mechanical center 85. In other words, the angle of incidence to the lens normal is zero for the wearer's normal line of sight. The outer and inner surfaces of lens 71 in the cross-sectional illustration conform to offset, equal-radius circles represented by centerpoints 87 and 88, respectively. A line drawn through centerpoints 87 and 88, referred to herein as the optical centerline of the lens, is collinear with the normal line of sight in the as-worn orientation. This conventional configuration shall be defined as a centrally oriented lens, for ease of description. Circumferentially clockwise or counterclockwise of the normal line of sight 86, the angle of incidence to the lens normal increases in a regular fashion from zero at the lens apex 85.

A degree of wrap may be desirable for aesthetic styling reasons, for lateral protection of the eyes from flying debris, or for interception of peripheral light. Wrap may be attained by utilizing lenses of tight horizontal curvature (high base), such as spherical lenses, and/or by mounting each lens in a position which is canted laterally and rearwardly relative to centrally oriented dual lenses. Such canting shifts the normal line of sight 86 out of a collinear relationship with the optical centerline, and changes the optics of the lens. As a result, prior art dual lens eyewear with substantial "wrap" around the sides of a wearer's face has generally been accompanied by some degree of prismatic distortion.

Similarly, a high degree of rake or vertical tilting may be desirable for aesthetic reasons and for intercepting light, wind, dust or other debris from below the wearer's eyes. Just as wrap tends to shift the normal line of sight 86 out of a collinear relationship with a horizontal component of the optical centerline, mounting the lens with rake shifts the normal line of sight out of a collinear relationship with a vertical component of the optical centerline. Prior art dual lens eyewear with substantial rake generally also display a degree of prismatic distortion.

In accordance with the present invention, there is provided an improved optical configuration and method for minimizing prismatic distortion in a lens having rake and/or wrap in the as-worn orientation. Though the present invention may be applied to a wide variety of lens shapes and orientations, the invention has particular utility for dual lens eyewear using high base curvature and demonstrating a high degree of wrap and/or rake in the as-worn orientation.

Referring to FIGS. 2 and 5, the illustrated eyewear incorporates canted lenses 12 and 14 or 102 and 104, mounted in a position rotated laterally relative to conventional centrally oriented dual lens mountings. A canted lens may be conceived as having an orientation, relative to the wearer's head, which would be achieved by starting with conventional dual lens eyewear having centrally oriented lenses and bending the frame inwardly at the temples to wrap around the side of the head.

As a consequence of the increased wrap, the wearer's normal line of sight 27 no longer strikes the lens 14 perpendicularly, as illustrated in FIG. 4. Instead, the angle of incidence θ° (FIG. 2) for the wearer's line of sight 27 is generally greater than 90°, and to achieve good wrap it may be greater than about 95°, preferably is within the range of from about 100° to about 135°, and in one 9.5 base embodiment is about 101.75°. Lower base lenses generally will exhibit a larger angle θ in the as-worn orientation, and the angle θ in an embodiment having a base of 6.5 was about 113.4°. In a base 4 embodiment having a pupillary distance of 2.8 inches, the angle θ was about 119.864°.

FIG. 5 illustrates the horizontal cross-section of an eyeglass 100 in accordance with an embodiment of the present invention, similar in style to that illustrated in FIG. 2, except having lenses 102 and 104 of tighter curvature (higher base) as well as possibly greater wrap. When the eyeglass 100 is worn, a lateral edge 106 of the lens 104 wraps significantly around and comes in close proximity to the wearer's temple to provide significant lateral eye protection as has been discussed.

An anterior (front) surface 108 of the lens of the present invention will generally conform to a portion of the surface of a regular geometric solid, such as a sphere 110, shown here in horizontal cross-section. The front surfaces of spherical lenses 102 and 104 of the illustrated embodiment can, therefore, be characterized by a radius. By convention in the industry, the curvature may also be expressed in terms of a base value, such that the radius (R) in millimeters of the anterior surface of the lens is equal to 530 divided by the base curve, or

$$R = \frac{530}{B} \tag{1}$$

The present invention provides the ability to construct dual lens eyeglass systems having relatively high wrap using lens blanks having a base curve of 6 or greater, preferably between about 7½ and 10½, more preferably between about 8 and 9½, and, in one embodiment between about 8¾ and 9. The radius of the circle conforming to the anterior surface of a base 8¾ lens, for example, is about 60.57 millimeters. For comparison, the radius of the circle which characterizes the anterior surface of a base 3 lens is about 176.66 millimeters.

The embodiment of the present invention illustrated in FIG. 5 may be cut from a base 8¾ lens blank having a thickness of about 0.0649 inches at the optical centerline and about 0.053 inches at a reference point two inches along the outer circumference of the lens from the optical centerline. Alternatively, the lens can be molded directly into its final shape and configuration.

FIG. 6 is a perspective view of a lens blank 122, a convex outside surface 136 of which generally conforms to a portion of the surface of a three-dimensional geometric shape 124. It will be understood by those of skill in this art that lenses in accordance with the present invention may conform to any of a variety of geometric shapes.

Preferably, the outside surface of the lens will conform to a shape having a smooth, continuous surface having a constant horizontal radius (sphere or cylinder) or progressive curve (ellipse, toroid or ovoid) or other aspheric shape in either the horizontal or vertical planes. The geometric shape 124 of the preferred embodiments herein described, however, generally approximates a sphere.

The sphere 124 illustrated in FIGS. 6 and 7 is an imaginary three-dimensional solid walled structure, a portion of the wall of which is suitable from which to cut a lens 120. As is known in the art, precision lens cutting is often accomplished by producing a lens blank 122 from which a lens 120 is ultimately cut. However, it should be clear to those of skill in the art from the illustrations of FIGS. 6 and 7, that the use of a separate lens blank is optional, and the lens 120 may be molded directly into its final shape and configuration if desired.

It can also be seen from FIGS. 6 and 7 that the lens 120 and/or the lens blank 122 can be positioned at any of a variety of locations along the sphere 124. For the purpose of the present invention, the optical centerline 132 operates as a reference line for orientation of the lens 120 with respect to the sphere 124. In the illustrated embodiment, wherein both the outside surface and the inside surface conform to a portion of a sphere, the optical centerline is defined as the line 132 which joins the two centers C1 and C2. The analogous reference line for the purpose of nonspherical lens geometry may be formed in a manner different than connection of the two geometric centers of the spheres, as will be apparent to one of skill in the art.

The lens 120 is ultimately formed in such a manner that it retains the geometry of a portion of the wall of the sphere as illustrated in FIG. 7. The location of the lens 120 on the sphere 124 is selected such that when the lens 120 is oriented in the eyeglass frame, the normal line of sight 130 of the wearer through the lens will be maintained generally in parallel to the optical centerline 132 of the geometric configuration from which the lens 120 was obtained. In the illustration of FIGS. 6 and 7, the lens 120 is a right lens which has a significant degree of wrap, as well as some degree of downward rake (indicated by the as-worn normal line of sight crossing the sphere 124 below the optical centerline 130). A lens having a different shape, or a lesser degree of wrap may overlap the optical centerline 132 of the imaginary sphere 124 from which the lens was formed. However, whether the optical centerline of the imaginary sphere 124 crosses through the lens 120 or not is unimportant, so long as the line of sight 130 in the lens 120 is maintained generally in parallel in the as-worn orientation with the optical centerline 132.

Similarly, if the lens is to have no rake or upward rake in the as-worn orientation, the normal line of sight (and the entire lens) would cross the sphere 124 at or above the central horizontal meridian which contains the optical centerline. The spatial distance and position of the ultimate normal line of sight 130 relative to the optical centerline 132 therefore indicates the degree of wrap (by horizontal distance) and rake (by vertical distance). However, regardless of the distances involved, the lens will exhibit minimal optical distortion as long as the normal line of sight 130 is offset from but maintained substantially parallel to the optical centerline 132 preferably in both the horizontal and vertical planes.

For purposes of the present invention, "substantially parallel" shall mean that the preselected line of sight 130 when the lens 120 is oriented in the as-worn position generally does not deviate within the horizontal or vertical plane by more than about ±15° from parallel to the optical centerline 132. Preferably, the normal line of sight 130 should not deviate by more than about ±10° from the optical centerline 132, more preferably the normal line of sight 130 deviates by no more than about ±5° and most preferably no more than about ±2° from parallel to the optical centerline 132. Optimally, the line of sight 130 is parallel to the optical centerline in the as-worn orientation.

Variations from parallel in the horizontal plane generally have a greater negative impact on the optics than variations from parallel in the vertical plane. Accordingly, the solid angle between the line of sight 130 and optical centerline 132 in the vertical plane may exceed the ranges set forth above, for some eyewear, as long as the horizontal component of the angle of deviation is within the above-mentioned ranges of deviation from the parallel orientation. Preferably, the line of sight 130 deviates in the vertical plane no more than about ±10° and, more preferably, no more than about ±3° from the optical centerline in the as-worn orientation.

FIG. 7 is a cutaway view of the lens 120, lens blank 122, and geometric shape 124 of FIG. 6. This view shows that the preferred geometric shape 124 is hollow with walls of varying thickness, as revealed by a horizontal cross-section 134 at the optical centerline of the geometric shape 124.

The tapered walls of the preferred geometric shape 124 result from two horizontally offset spheres, represented by their center points C1 and C2 and radii R1 and R2. An outer surface 136 of the preferred lens blank 122 conforms to one sphere (of radius R1) while an inner surface 138 of the lens blank 122 conforms to the other sphere (of radius R2). By adjusting the parameters which describe the two spheres, the nature of the taper of the lens blank 122 may also be adjusted.

In particular, the parameters for the two spheres to which the lens blank outer surface 136 and inner surface 138 conform is preferably chosen to produce minimal or zero refractive power, or non-prescription lenses. Where CT represents a chosen center thickness (maximum thickness of the wall of the hollow geometric shape 124), n is an index of refraction of the lens blank material, R1 is set by design choice for the curvature of the outer surface 136, R2 may be determined according to the following equation:

$$R_2 = R_1 - CT + \frac{CT}{n} \tag{2}$$

CT/n represents the separation of the spherical centers C1 and C2. For example, where a base 6 lens is desired as a matter of design choice, the center thickness is chosen to be 3 mm, and the index of refraction of the preferred material (polycarbonate) is 1.586, R2 may be determined as follows:

$$R_2 = \frac{530}{6} - 3 + \frac{3}{1.586} = 87.225 \text{ mm} \tag{3}$$

For this example, the radius R1 of the outer surface 136 is equal to 88.333 mm, the radius R2 of the inner surface 138 is equal to 87.225 mm, and the spherical centers C1 and C2 are separated by 1.892 mm. These parameters describe the curvature of the lens blank 122 of a preferred decentered spherical embodiment.

In the case of the preferred embodiment, the optical centerline 132 is that line which passes through both center points C1 and C2 of the offset spheres. This happens to pass through the thickest portion of the preferred geometrical shape 124 walls at an optical center 140, though this may not be true for alternative nonspherical embodiments. The optical center line 132 happens to pass through surface 136 of the illustrated lens blank 122, although this is not necessary. The optical center 140 does not happen to lie on the lens 120, although it may for larger lenses or lenses intended to exhibit less wrap in the as-worn orientation.

FIG. 8 illustrates a horizontal cross-section of a lens 120, showing in phantom the geometric shape 124 to which the outer surface 136 and inner surface 138 conform. The lens blank 122 is omitted from this drawing. In accordance with the present invention, the optical centerline 132 associated with the chosen orientation is aligned to be generally parallel to but offset from the straight ahead normal line of sight 130 of the wearer as the lens 120 is to be mounted in an eyeglass frame.

FIG. 8A illustrates a vertical cross-section of the lens 120, also showing in phantom the geometric shape 124 to which the outer surface 136 and inner surface 138 conform. Unlike the horizontal view of FIG. 8, the projection of the optical centerline 132 onto a vertical plane (i.e., the vertical component of the optical centerline 132) appears to pass through the vertical profile of the preferred lens 120. In any case, the vertical component of the optical centerline 132 associated with the chosen taper is also aligned to be generally parallel with the normal line of sight 130 of the wearer in the as-worn orientation.

Thus, in addition to providing optically correct lenses for dual lens eyewear with a high degree of wrap, the present invention may provide optically corrected lenses for eyewear characterized by a degree of rake. The terms "rake" and "optically correct" are further defined below.

In general, "rake" will be understood to describe the condition of a lens, in the as-worn orientation, for which the normal line of sight 130 (see FIG. 8A) strikes a vertical tangent to the lens 120 at a non-perpendicular angle. For optically corrected eyewear in accordance with the preferred embodiment, however, the normal line of sight to a raked lens is generally parallel to and vertically offset from the optical centerline. Therefore, the degree of rake in a correctly oriented lens may be measured by the distance which the normal line of sight is vertically displaced from the optical centerline.

For a centrally oriented lens, as shown in FIG. 10B, the wearer's line of sight coincides with the optical centerline, thus displaying no vertical displacement. While such a lens may be optically corrected (as defined below) in the as-worn orientation, the lens does not have rake, unlike the preferred embodiment of the present invention. FIG. 10C shows a lens orientation which is downwardly tilted or raked, but for which the optical centerline and the normal line of sight are highly divergent such that no "displacement" could meaningfully be measured. While such a lens may have downward rake in a conventional sense, advantageously providing downward protection for the eye and conforming to the wearer's face, it is not optically corrected.

In contrast, the normal line of sight through a raked lens, made in accordance with the preferred embodiment, is characterized by a finite vertical displacement from the optical centerline, preferably a downward displacement for downward rake. Where the optical centerline diverges from the normal line of sight within the acceptable angular ranges set forth above, this displacement should be measured at or near the lens surface. The displacement may range from about any non-zero displacement to about 8.0 inches. Lenses of lower base curvature may require a greater displacement in order to achieve good rake. The vertical displacement for a lens of base 6 curvature, however, should be between about 0.1 inch and about 2.0 inches. More preferably, the vertical displacement is between about 0.1 inch and about 1.0 inch, particularly between about 0.25 inch and about 0.75 inch, and most preferably about 0.5 inch.

"Optically correct," as that term has been used in the present description, refers to a lens which demonstrates relatively low distortion as measured by one or more of the following values in the as-worn orientation: prismatic distortion, refractive power and astigmatism. Raked lenses in accordance with the preferred embodiment demonstrate at least as low as ¼ diopters or 3/16 diopters and typically less than about ⅛ diopters prismatic distortion, preferably less than about 1/16 diopters, and more preferably less than about 1/32 diopters. Refractive power and astigmatism for lenses in accordance with the present invention are also preferably low. Each of refractive power and astigmatism are also at least as low as ¼ diopters or 3/16 diopters and preferably less than about ⅛ diopters, more preferably less than about 1/16 diopters and most preferably less than about 1/32 diopters.

It will be understood by the skilled artisan that the advantages in minimizing optical distortion apply to both the horizontal and the vertical dimensions. Particular advantage is derived by applying the principles taught herein to both vertical and horizontal dimensions of the lens, enabling the combination of lateral and lower peripheral protection of the eyes (through wrap and rake) with excellent optical quality over the wearer's full angular range of vision.

Furthermore, although the principal embodiments described herein are of constant radius in both the horizontal and vertical cross-section, a variety of lens configurations in both planes are possible in conjunction with the present invention. Thus, for example, either the outer or the inner or both surfaces of the lens of the present invention may generally conform to a spherical shape as shown in FIGS. 6 and 7. Alternatively either the outer or the inner or both surfaces of the lens may conform to a right circular cylinder, a frusto-conical, an elliptic cylinder, an ellipsoid, an ellipsoid of revolution, other asphere or any of a number of other three dimensional shapes. Regardless of the particular vertical or horizontal curvature of one surface, however, the other surface should be chosen such as to minimize one or more of power, prism and astigmatism of the lens in the mounted and as-worn orientation.

FIGS. 9–12 will aid in describing a method of choosing a location on the lens blank **122** from which to cut the right lens **120**, in accordance with a preferred embodiment of the present invention. It will be understood that a similar method would be used to construct the left lens for the dual lens eyewear of the preferred embodiment.

As a first step, a desired general curvature of the lens inner or outer surface **138**, **136** may be chosen. For the preferred lens **120**, this choice determines the base value of the lens blank **122**. As noted elsewhere herein, a number of other curvatures may be utilized in conjunction with the present invention. A choice of lens thickness may also be preselected. In particular, the minimum thickness may be selected such that the lens will withstand a preselected impact force.

A desired lens shape may also be chosen. For example, FIG. **12** illustrates an example of a front elevational shape for the lens **120**. The particular shape chosen is generally not relevant to the oriented decentered lens optics disclosed herein.

A desired as-worn orientation for the lens should also be chosen, relative to the normal line of sight **130** of the wearer **126**. As mentioned above, preferred orientations may provide significant lateral wrap for lateral protection and interception of peripheral light, and for aesthetic reasons, and also some degree of downward rake. For example, the embodiment illustrated in FIGS. **6–12** uses a canted lens **120** to achieve wrap. Alternatively, wrap may be achieved through use of a higher base lens and a more conventional (non-canted) orientation. FIGS. **9** and **10** illustrate more plainly how the orientations may be related to the line of sight **130** of the wearer.

The eyewear designer may also choose a degree of rake, or vertical tilt, as will be understood from FIGS. **10A–10C**, schematically illustrating various vertical as-worn orientations of a lens, relative to the head of the wearer **126**. FIG. **10A** illustrates the preferred orientation of the lens **120** relative to the head of the wearer **126**, and relative in particular to the straight ahead normal line of sight **130**. A downward rake, as illustrated in FIG. **10A**, is desirable for a variety of reasons, including improved conformity to common head anatomy. As will be apparent to those of skill in the art in view of the disclosure herein, a lens **120** having a mechanical center point which falls below the horizontal plane intersecting the optical centerline **132** (see FIG. **7**) will permit the lens to be oriented with a downward rake as illustrated in FIG. **10** and yet preserve a generallv parallel relationship between the optical centerline and the straight ahead line of sight. Since the orientation of the lens **120** to the optical centerline **132** in the imaginary sphere should be the same as the orientation between the lens **120** and a parallel to the normal line of sight **130** in the as-worn orientation any lens cut from this sphere below the optical centerline **132** can be mounted with a corresponding degree of downward rake and achieve the optical correction of the present invention.

Accordingly, the desired degree of rake may be chosen by specifying a vertical component of the displacement between the normal line of sight **130** and the optical centerline **132**, as illustrated in FIG. **10A**. Either way, the greater the displacement, the greater the downward rake. In general, the vertical displacement in accordance with the present invention will be greater than zero. Generally it will be from about 0.1 inches to about 2 inches depending upon base curvature. Preferably, vertical displacement will be from about 0.1 inches to about one inch, or about 0.2 inches or greater. More preferably, it will be from about 0.25 inches to about 0.75 inches and in one embodiment it was about 0.5 inches.

Alternatively, a general profile may be chosen which fixes an orientation of the normal line of sight relative to the curvature of the lens (not accounting for the thickness of the lens). For instance, both FIG. **10A** provides reference points of a top edge **152** and a bottom edge **154** relative to the normal line of sight **130**. This relationship may then be utilized to determine the position on a lens blank from which to cut the lens, as will be clear from the discussion of FIG. **11A** below.

Referring now to FIG. 11, a mapping of the horizontal orientation of the lens 120 onto the lens blank 122 is illustrated. The normal line of sight 130, with respect to which the chosen orientation is measured, is maintained substantially parallel to and offset from the optical centerline 132. The horizontal component of the displacement will generally be within the range of from about 0.1 inches to about 8 inches for lower base curvatures.

Once the aesthetic design and desired rake and wrap orientation such as that illustrated in FIG. 11 has been determined (such as by the chosen frame 150), and the lens blank 122 formed having a suitable base curvature for fitting within the aesthetic design, the aesthetic design may be "projected" graphically or mathematically onto the surface of the theoretical sphere or blank to reveal that portion of the sphere which is suitable for use as the lens 120. The projection of the lens shape onto the sphere should be moved about the surface of the sphere until it is positioned such that the lens cut from the sphere at that location will exhibit the appropriate wrap and rake for the aesthetic design without any rotation of the lens 120 out of its orientation in which the optical centerline of the sphere is generally parallel to the desired normal line of sight in the as-worn orientation.

A similar simultaneous projection may be performed for the vertical orientation chosen, as depicted in FIG. 11A. FIG. 11A schematically represents the projection from the chosen frame 150 to a position on the lens blank 122. The frame 150 (or a conceptual configuration such as provided by FIG. 10A) provides reference points in the form of the lens top edge 152 and bottom edge 154 in relation to the line of sight 130. The projection may then be shifted up or down until the top edge 152 and the bottom edge 154 are both simultaneously aligned with corresponding points on the outer surface 136 of the lens blank, while maintaining the line of sight 130 substantially parallel with the optical centerline 132.

Projection of both the horizontal profile and the vertical profile may be performed simultaneously, locating a unique position on the lens blank 122 corresponding to the desired three-dimensional shape of the lens (including the front elevational shape shown in FIG. 12) at which the line of sight 130 is parallel to the optical centerline 132 or other reference line of the lens blank 122. Of course, it will be understood that the lines 130 and 132 may be substantially parallel, that is, within the acceptable range of angular deviation set forth above.

This shape may then be cut from the blank 122 or molded directly in the final lens configuration. The resultant lens 120 not only conforms to the desired shape, but also minimizes prismatic distortion when in the as-worn orientation.

FIG. 12 illustrates a lens blank 122, concave towards the page such as that shown conforming to a portion of the surface of the sphere in FIGS. 6 and 7. In FIG. 12, the lens blank 122 has been formed on the theoretical sphere such that the mechanical center of the blank is illustrated in the center of the drawing on the central horizontal meridian. The illustrated lens profile 120 has a medial edge 148, a lateral edge 144, an upper edge 152 and a lower edge 154. The medial edge 148 of the right lens 120 lies close to the optical center of the lens blank 122.

At least a portion of the right lens 120 lies in the lower left-hand (third) quadrant of the lens blank 122. Preferably, in an embodiment of the invention exhibiting both wrap and downward rake, at least about half of the lens area will fall within the third quadrant of the lens blank 122. Preferably all or substantially all of the area of the lens 120 will lie below and to the left of the optical center as illustrated. Lenses exhibiting a similar degree of rake but lesser wrap may be positioned on the lens blank 122 such that as much as 50% or more of the lens area is within the lower right (second) quadrant of the lens blank 122.

FIG. 12A illustrates the position on the same lens blank 122 from which a left lens 120L could be cut. The left lens 120L has a medial edge 148L, a lateral edge 144L, an upper edge 152L and a lower edge 154L. The left lens 120L is drawn in phantom because both the right lens 120 and the left lens 120L for the illustrated profile cannot be cut from the same lens blank 122. Rather, the illustrated left lens 120L would be cut from the position shown on a second lens blank which is identical to the first lens blank 122.

As the left lens 120L should be symmetrically opposite to the right lens 120, the left lens 120L is a mirror image of the right lens 120. For example, the image of the right lens 120 may be flipped across a vertical plane through which the optical centerline 130 and poles of the sphere 124 pass. The lens blank upon which that image would be projected may be identical to the illustrated lens blank 122, but rotated 180° about the mechanical center.

Alternatively, the left lens 120L position may also be considered the mirror image of the right lens 120 across an axis of vertical symmetry. As illustrated in FIG. 12B, the left lens 120L is upsidedown relative to the right lens 120. For the preferred lens blank 122, the axis of vertical symmetry is a central horizontal meridian 170 which divides the lens blank 122 into upper and lower halves, each of which conform to upper and lower hemispheres of the sphere 124 (FIGS. 6 and 7). Thus, the horizontal position (i.e., distance from the medial or lateral edge of the lens blank 122) for each of the medial edge 148L, lateral edge 144L, upper edge 152L and lower edge 154L, is the same for corresponding points of the right lens 120. Corresponding points on the left and right lenses are also the same vertical distance from the horizontal meridian 170, but in the opposite directions. For example, the upper edge 152L of the left lens 120L is about the same distance above the horizontal meridian 170 as the upper edge 152 of the right lens 120 is below the horizontal meridian 170.

Thus, the left lens 120L of any raked dual lens embodiment is cut substantially from the upper half of preferred lens blank 122, while the right lens 120 is cut substantially from the lower half of an identical lens blank. Preferably, where a dual lens embodiment displays both wrap and rake, the left lens 120L is cut substantially from the upper left (fourth) quadrant of the preferred lens blank 122, while the right lens is cut substantially from the third quadrant. "Substantially," as used in this context, refers to more than 50% of the surface area of the lens 120 or 120L falling within the relevant half or quadrant of the preferred lens blank 122.

Of course, this description is limited to a lens blank 122, which is described by an optical centerline passing through the central horizontal meridian 170 (i.e., the lens blank 122 taper is vertically symmetrical) but not through the mechanical center (i.e., the lens blank 122 taper is horizontally asymmetrical). It will be understood that alternative lens blanks may utilize alternative tapering. The skilled artisan may adjust the positions from which to cut the right and left lenses such that the normal line of sight in the as-worn orientation is maintained substantially parallel to the optical centerline, regardless of the tapering symmetry.

The present invention thus provides a precise method of furnishing the correct correspondence between taper and the varying angle of incidence from the wearer's eye to the surface of a lens. By recognizing a novel relationship among the wearer's line of sight and the form of taper, the present invention allows use of any of a variety of lens designs while minimizing astigmatism, power and prismatic distortion. For example, a designer may choose a desirable orientation and curvature for the lens, relative to a wearer's line of sight. The orientation and curvature may be chosen from a wide range of rake, wrap, base value and proximity to a wearer's face. The form of taper and location of the lens profile on the theoretical sphere or other shape may then be chosen, by the method of the present invention, such that the prismatic distortion in the as-worn orientation is minimized.

Although the foregoing invention has been described in terms of certain preferred embodiments, other embodiments will become apparent to those of ordinary skill in the art in view of the disclosure herein. Accordingly, the present invention is not intended to be limited by the recitation of preferred embodiments, but is intended to be defined solely by reference to the appended claims.

What is claimed:

1. A dual lens eyeglass which is optically corrected in an as-worn orientation, comprising:

an eyeglass frame for suspending dual lenses in the as-worn orientation with respect to each of a wearer's right and left normal line of sight;

a left spherical, non-glass eyeglass lens attached to the frame to intercept the wearer's normal line of sight through the wearer's left eye in the as-worn orientation, said left lens being vertically and horizontally tapered;

a right spherical, non-glass eyeglass lens attached to the frame to intercept the wearer's normal line of sight through the wearer's right eye in the as-worn orientation, said right lens being vertically and horizontally tapered;

wherein each of said lenses exhibits both wrap and rake in the as-worn orientation; and

said right and left lenses having right and left non-coincident optical centerlines, respectively, said right and left optical centerlines displaced vertically at the front lens surface from the normal line of sight in the as worn orientation by a distance within the range of from about 0.25 to about 0.75 inches corresponding to the rake to correct prism otherwise induced by said rake; wherein

each of said lenses is oriented relative to the wearer's normal line of sight to exhibit no more than about ⅛ diopters prismatic distortion and no more than about ⅛ diopters refractive power in the as-worn orientation.

2. An eyeglass according to claim 1, wherein each of said lenses is oriented to exhibit no more than about 1/16 diopters prismatic distortion and no more than about 1/16 diopters refractive power in the as-worn orientation.

3. An eyeglass according to claim 1, wherein said displacement is about 0.5 inch in the as-worn orientation.

4. An eyeglass according to claim 1, wherein each of said lenses has a base of at least about 6.

5. An eyeglass according to claim 4, wherein each of said lenses has a base of at least about 7½.

6. An eyeglass according to claim 1, wherein each of said lenses is oriented such that the wearer's corresponding normal line of sight has an angle of incidence to the lens surface of greater than about 95°.

7. An eyeglass according to claim 6, wherein said angle of incidence is between about 100° and 135°.

8. A dual lens eyeglass which is optically corrected to minimize prismatic error induced by mounting the lenses with downward rake in an as-worn orientation, comprising:

an eyeglass frame for suspending lenses in the as-worn orientation; and

a left non-glass lens attached to the frame to intercept a wearer's normal line of sight from a left eye in the as-worn orientation, the left lens having a left spherical anterior surface and a left spherical posterior surface, the left spherical anterior and posterior surfaces having centers of curvature joined by a left optical centerline; and

a right non-glass lens attached to the frame to intercept the wearer's normal line of sight from a right eye in the as-worn orientation, the right lens having a right spherical anterior surface and a right spherical posterior surface, the right spherical anterior and posterior surfaces having centers of curvature joined by a right optical centerline, the right optical centerline non-coincident with the left optical centerline, the right optical centerline non-coincident with the left optical centerline;

wherein each of said right and left lenses is vertically and horizontally tapered with taper orientations related to the right and left optical centerlines, respectively;

each of said lenses exhibits both a degree of wrap and a degree of rake in the as-worn orientation, said degree of rake defined by a vertical displacement corresponding to said degree of rake between the normal line of sight from each eye and the corresponding optical centerline; and

each of said left and right lenses is oriented to exhibit no more than about 1/16 diopters prismatic distortion and no more than about 1/16 diopters refractive power in the as-worn orientation.

9. A dual lens eyeglass for intercepting a wearer's normal line of sight from each of two eyes in an as-worn orientation, comprising:

a frame;

a first tapered lens hang a first optical centerline, said first lens mounted to said frame for intercepting the wearer's first normal line of sight in the as-worn orientation; and

a second tapered lens having a second optical centerline, the second optical centerline non-coincident with the first optical centerline, said second lens mounted to said frame for intercepting the wearer's second normal line of sight in the as-worn orientation;

wherein each of said lenses exhibit a degree of rake in the as-worn orientation, said rake characterized by a vertical displacement of the corresponding optical centerline from the wearer's corresponding normal line of sight of between about 0.25 inch and about 0.75 inch;

each of said lenses exhibit a degree of wrap in the as-worn orientation, said wrap characterized by an angle of incidence between a lens surface and the wearer's corresponding normal line of sight of at least about 95°; and

each of said lenses is oriented to exhibit no more than about 1/16 diopters prismatic distortion in the as-worn orientation.

10. An eyeglass according to claim 9, wherein each of said lenses is oriented to exhibit no more than about 1/16 diopters refractive power in the as-worn orientation.

11. An eyeglass according to claim 9, wherein said angle of incidence is between about 100° and 135° in the as-worn orientation.

* * * * *

US006168271B1

(12) **United States Patent**
Houston et al.

(10) **Patent No.: US 6,168,271 B1**
(45) **Date of Patent: *Jan. 2, 2001**

(54) **DECENTERED NONCORRECTIVE LENS FOR EYEWEAR**

(75) Inventors: **Malcolm Neal Houston**, Foothill Ranch, CA (US); **James H. Jannard**, Eastsound, WA (US); **Carlos D. Reyes**, Mission Viejo, CA (US)

(73) Assignee: **Oakley, Inc.**, Foothill Ranch, CA (US)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **08/880,943**

(22) Filed: **Jun. 23, 1997**

Related U.S. Application Data

(63) Continuation of application No. 08/706,564, filed on Sep. 5, 1996, now Pat. No. 5,689,323, which is a continuation of application No. 08/567,434, filed on Dec. 5, 1995, now Pat. No. 5,648,832.

(51) **Int. Cl.**⁷ **G02C 13/00**
(52) **U.S. Cl.** 351/41; 351/178
(58) **Field of Search** 351/41, 44, 159, 351/177, 178

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Declaration of James H. Jannard.

Exhibit A–Computer generated drawing dated Jul. 13, 1995.

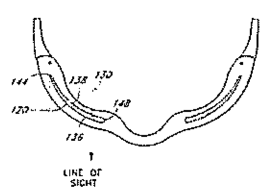
Exhibit B–Fax Message from Gentex Optics dated Jul. 14, 1995 to Oakley, C. Reyes in 2 pages.

Primary Examiner—Huy Mai
(74) *Attorney, Agent, or Firm*—Knobbe, Martens, Olson & Bear, LLP

(57) **ABSTRACT**

Disclosed is an optically corrected lens for nonprescription, dual lens eyeglasses. In a preferred embodiment, the anterior surface of the lens lies on a portion of a first sphere having a first center. The posterior surface of the lens lies on the surface of a second sphere having a second center. The first and second centers are offset from one another to provide a tapered lens. The lens is oriented on the head of the wearer by a frame that maintains the lens in a position such that a line drawn through the first and second centers is maintained substantially in parallel to the normal sight line of the wearer. Methods of making the lenses, and eyewear incorporating the lenses, are also disclosed.

51 Claims, 7 Drawing Sheets



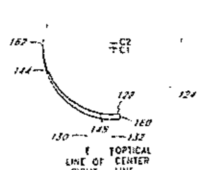


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Exhibit I –Data Chart for Ray Ban X–Rays, Ray Ban SS3 and Leader New Yorker eyeglasses.

Declaration of Alan W. Reichow with Exhibits 3A, 3B, 3C, 3D and 6, Dated Sep. 30, 1997.

Declaration of William D. Noonan (including exhibits).

Declaration of James H. Jannard (including exhibits).

Fig. 1

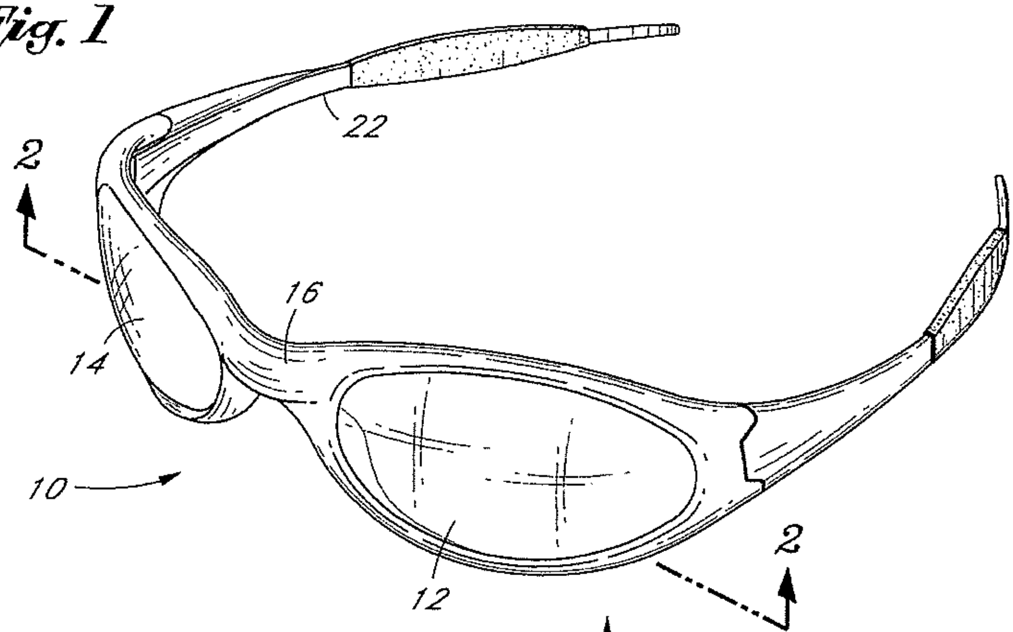


Fig. 2

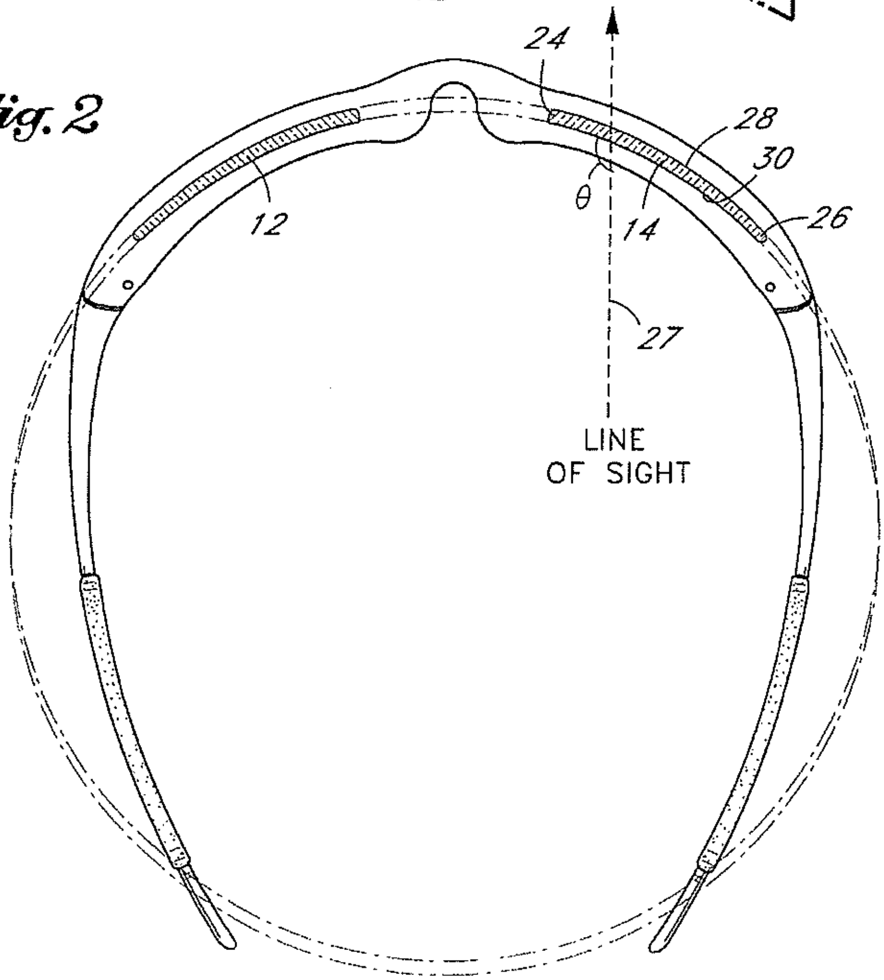


Fig. 3
(PRIOR ART)

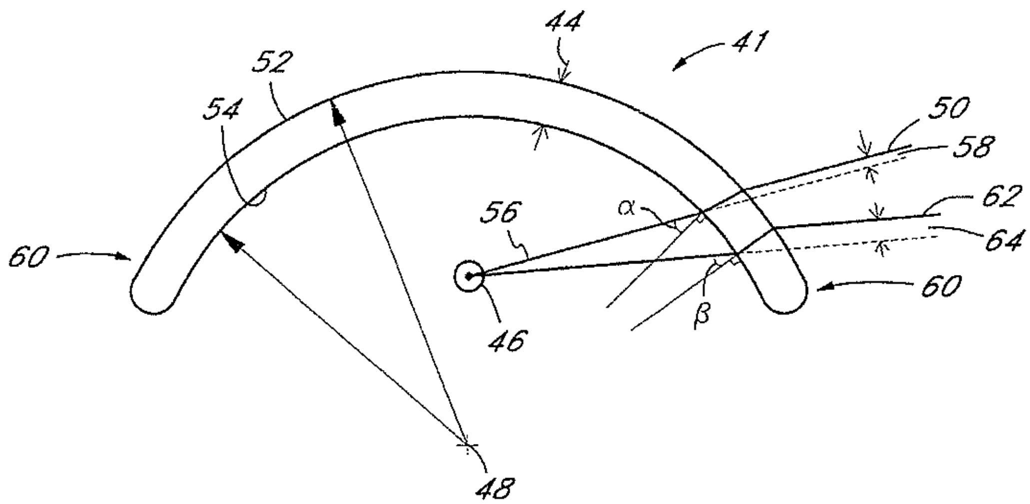


Fig. 4

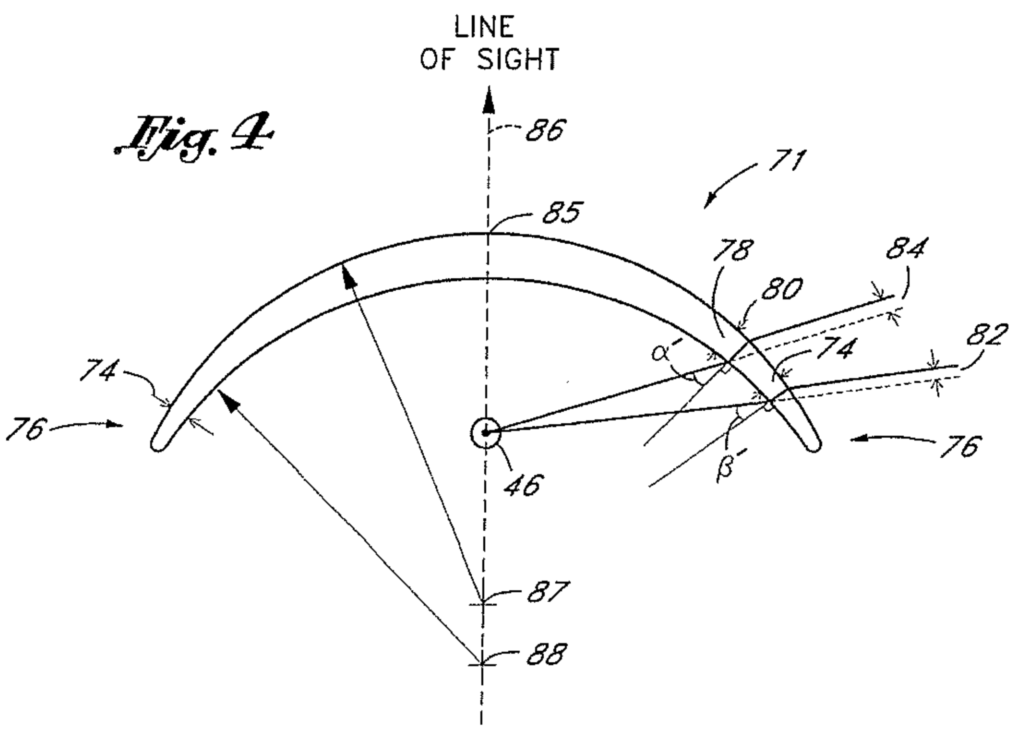
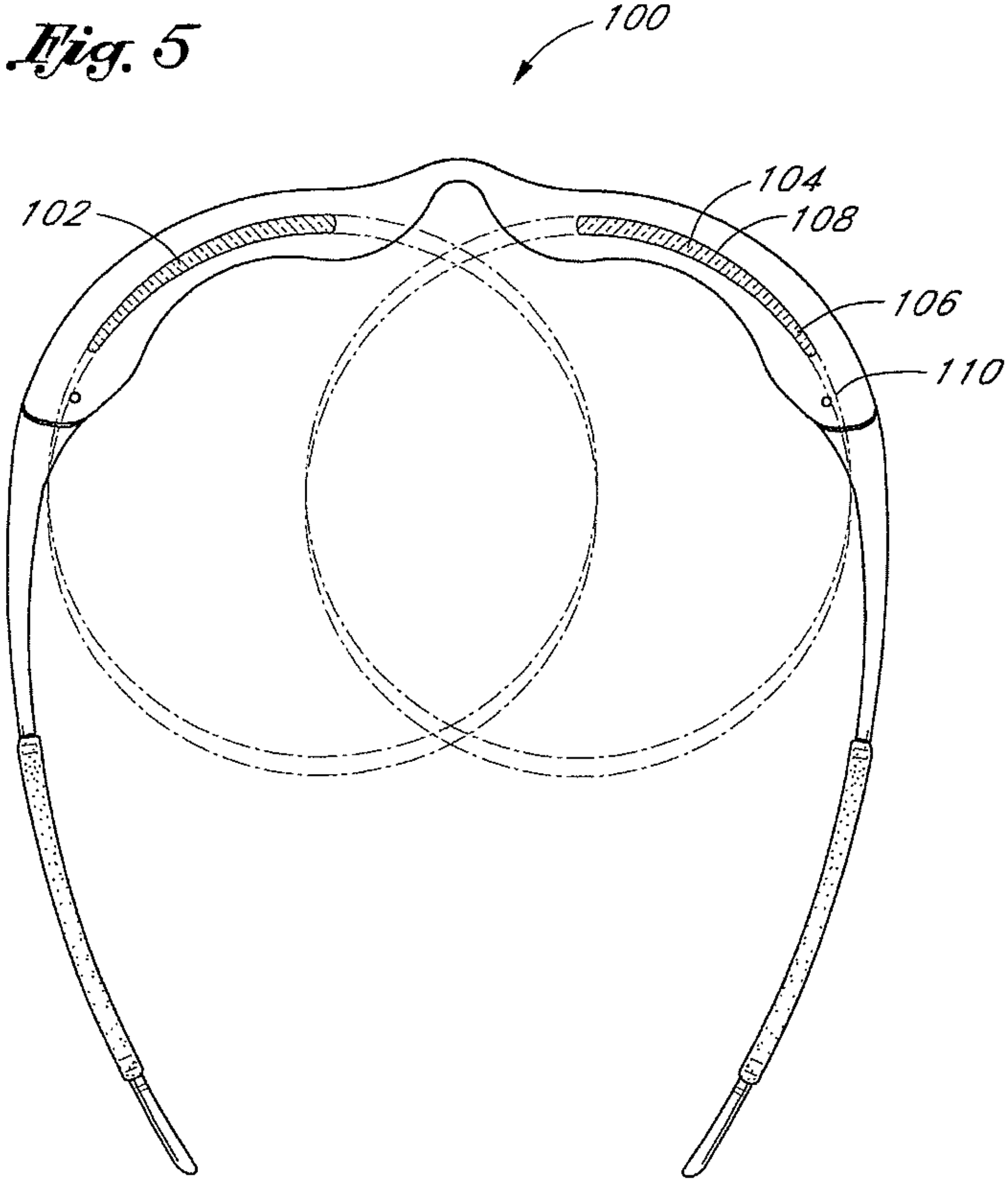


Fig. 5



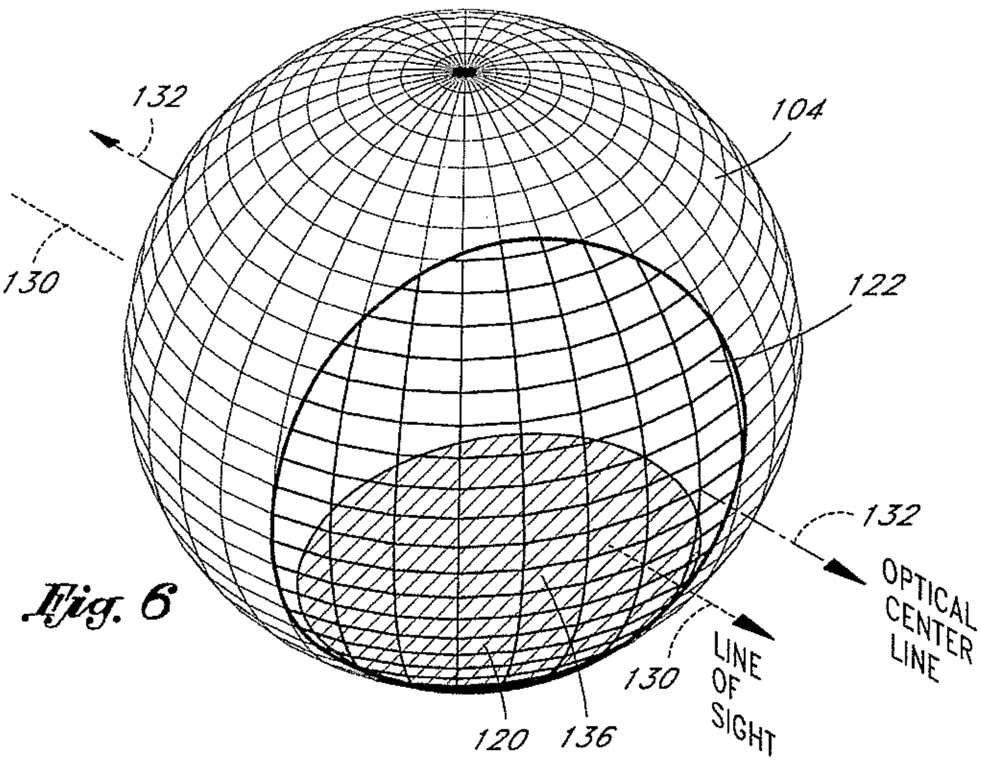

132
104
130
122
132
OPTICAL CENTER LINE
LINE OF SIGHT
130
120
136

Fig. 6

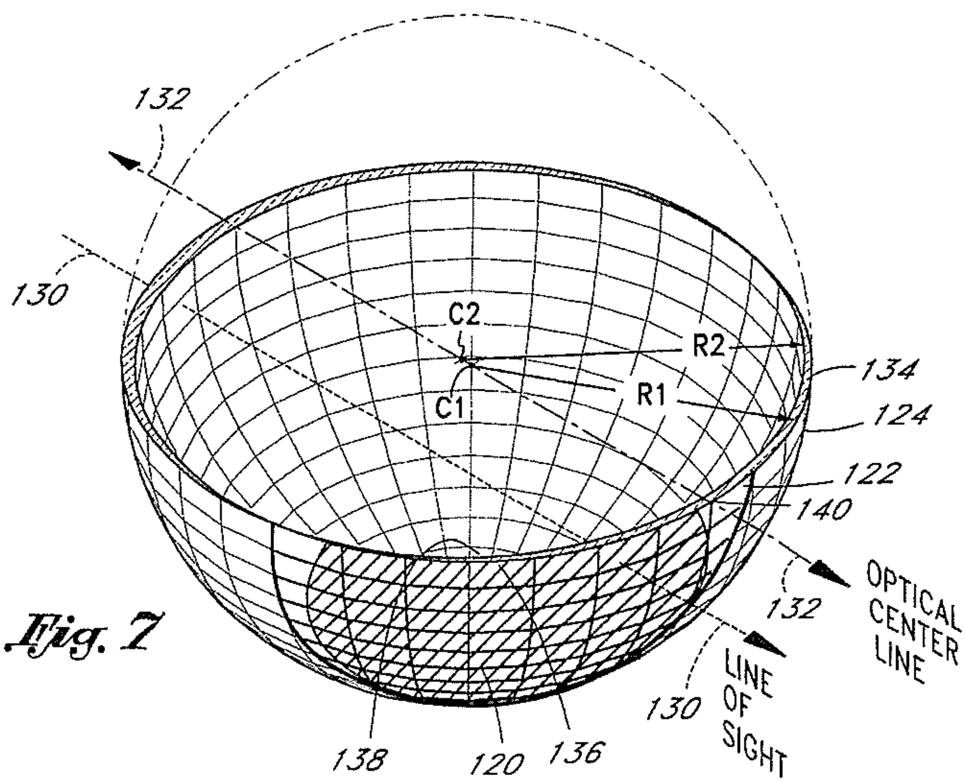

132
130
C2
C1
R2
R1
134
124
122
140
OPTICAL CENTER LINE
132
LINE OF SIGHT
130
138
120
136

Fig. 7

Fig. 8

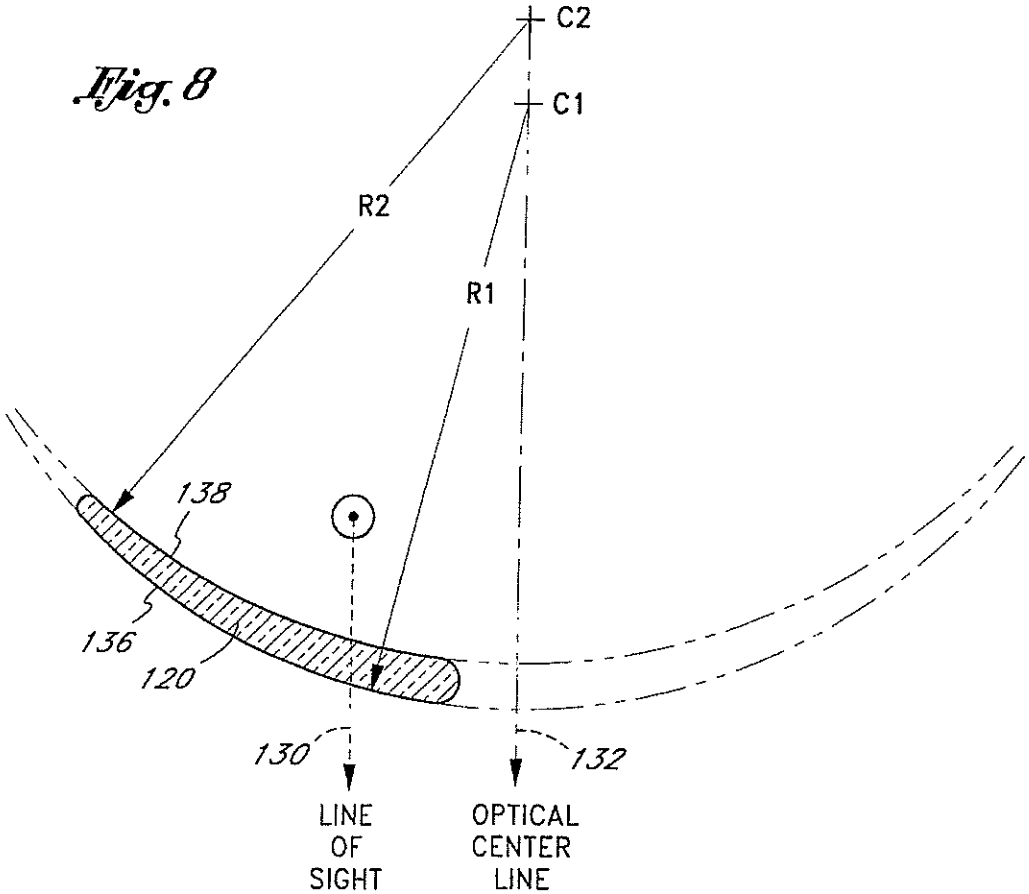


Fig. 9

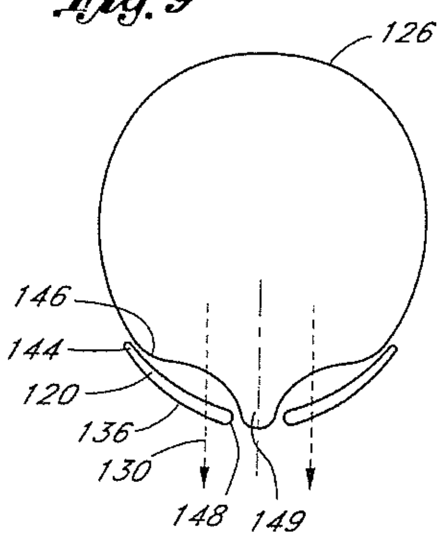


Fig. 10

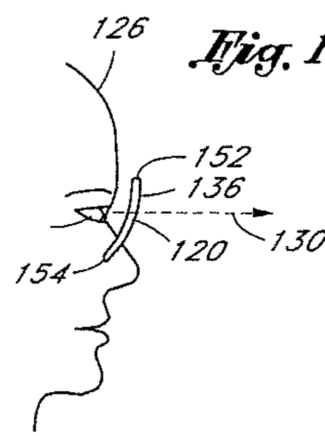


Fig. 11

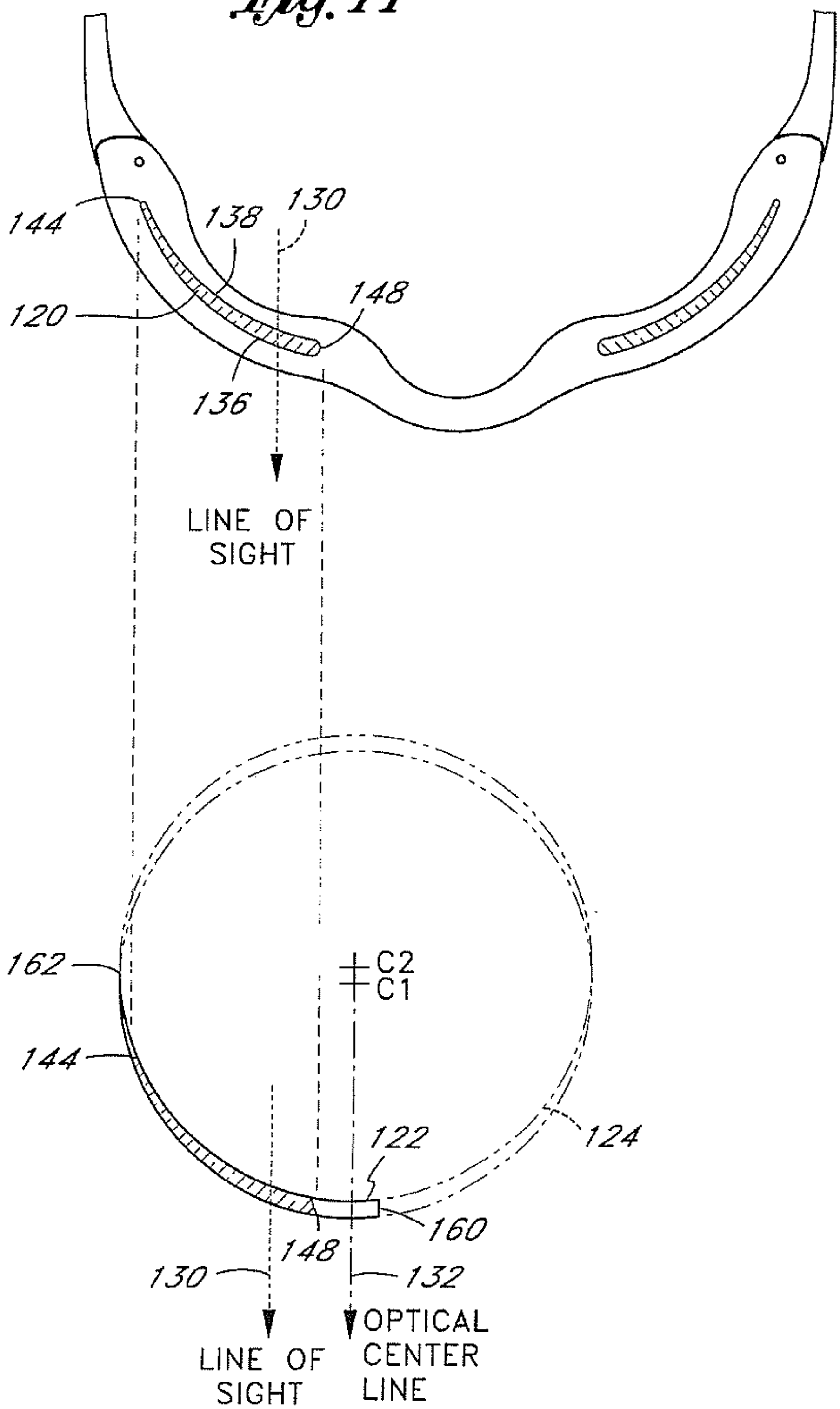
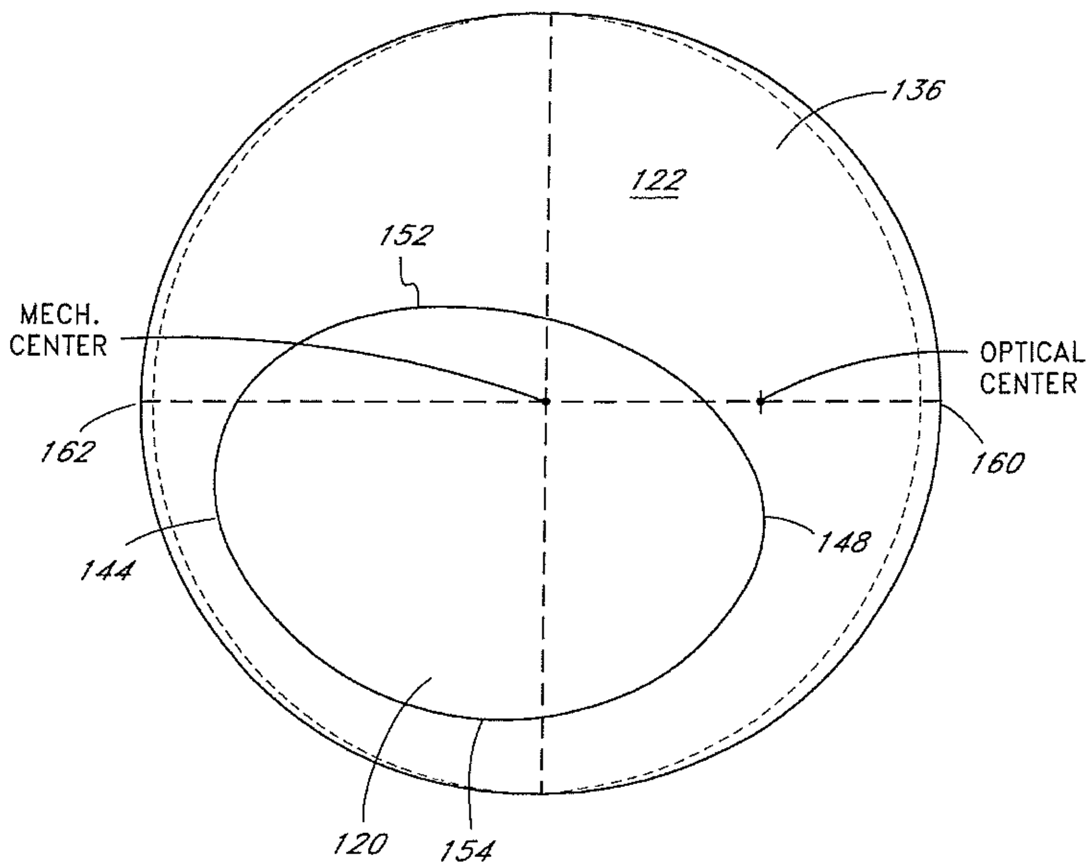

144
138
130
120
148
136
LINE OF
SIGHT
162
C2
C1
144
122
124
160
148
130
132
OPTICAL
CENTER
LINE
LINE OF
SIGHT

Fig. 12


136
122
152
MECH.
CENTER
OPTICAL
CENTER
162
160
144
148
120
154

DECENTERED NONCORRECTIVE LENS FOR EYEWEAR

This is a continuation of U.S. patent application Ser. No. 08/706,564, filed Sep. 5, 1996, now U.S. Pat. No. 5,689,323, which is a continuation of U.S. patent application Ser. No. 08/567,434, filed Dec. 5, 1995 now U.S. Pat. No. 5,648,832.

The present invention relates generally to lenses used in eyewear, and more particularly to a decentered, noncorrective lens to reduce optical distortion.

BACKGROUND OF THE INVENTION

A wide variety of improvements have been made in recent years in the eyewear field, particularly with respect to eyewear intended for use in active sports or as fashion sunglasses. These improvements have been incorporated into eyewear having a unitary lens, such as the "Blades®" design (Oakley, Inc.) the "M Frame®" line (Oakley, Inc.), and the "Zero®" line also produced by Oakley, Inc. These eyewear designs accomplish a variety of functional advantages, such as maximizing interception of peripheral light, reducing optical distortion and increasing the wearer's comfort level, compared to previous active sport eyewear.

The unitary lens of the "Blades®" eyewear incorporates the cylindrical geometry disclosed, for example, in U.S. Pat. No. 4,859,048, issued to Jannard. This geometry allows the lens to closely conform to the wearer's face and intercept light, wind, dust, etc. from directly in front of the wearer (anterior direction) and peripherally (lateral direction). See also U.S. Pat. No. 4,867,550 to Jannard (toroidal lens geometry).

Although the early unitary lens systems provided a full side-to-side range of vision and good lateral eye protection, the potential for optical distortion still exists. In a unitary lens system, for example, the angle of incidence from the wearer's eye to the posterior lens surface changes as the wearer's sight line turns in the lateral direction. This results in disparate refraction between light entering closer to the front of the lens and peripheral light entering at the lateral ends. To address this source of prismatic distortion, U.S. Pat. No. 4,859,048 discloses tapering the thickness the lens from the medial portion toward the lateral edge.

Prior art eyewear has also employed dual lens systems in which two separate lenses are mounted along a front frame. In the early dual lens eyeglass systems, each of the right and left lenses were roughly co-planar in the as-worn configuration. Thus, the sight line of the wearer, when looking straight ahead, generally crossed the posterior surface of the lens at a normal to the lens surface in the optical zone. One of the disadvantages of this lens configuration was that the eyeglasses provided essentially no lateral eye protection without the use of special modifications, such as vertically elongated earstems or side attachments.

Dual lens systems were thereafter developed in which the lateral edge of each lens curved rearwardly from the frontal plane, and around the side of the wearer's head to provide a lateral wrap similar to that achieved by the high wrap unitary lens systems. Although the dual lens eyeglasses with significant wrap provided lateral eye protection, the lens curvature generally introduced measurable prismatic distortion through the wearer's angular range of vision. This was particularly pronounced in lenses comprising low index of refraction materials. In addition, although high base curvatures (e.g. base 6 or higher) are sometimes desirable to optimize wrap while maintaining a low profile, such lenses have not been practical in the past due to the relatively high level of prismatic distortion.

Thus, there remains a need for a high base nonprescription lens for use in dual lens eyewear which can intercept light over essentially the full angular range of vision while at the same time minimize optical distortion throughout that range.

SUMMARY OF THE INVENTION

There is provided in accordance with one aspect of the present invention, an eyeglass lens for use in noncorrective dual lens eyewear. The eyeglass lens is utilized in combination with a frame to support the lens in the path of the wearer's normal line of sight.

The lens comprises a lens body, having a front surface, a rear surface, and a thickness therebetween.

The front surface of the lens conforms to a portion of the surface of a solid geometric shape. Preferably, the front surface of the lens conforms substantially to a portion of the surface of a first sphere having a first center. The rear surface of the lens conforms substantially to a portion of the surface of a solid geometric shape, which may be the same or different than that conforming to the front surface. Preferably, the rear surface conforms substantially to a portion of the surface of a second sphere having a second center.

The first and second centers are offset from one another to taper the lens thickness. The lens is mounted in the frame such that a line drawn through the first and second centers is maintained substantially parallel with the wearer's normal line of sight.

The lens may be cut from a lens blank, or formed directly into its final configuration such as by injection molding or other techniques known in the art. Preferably, the lens is oriented on the head of a wearer by the eyeglass frame such that the normal sight line of the wearer crosses the anterior surface of the lens at an angle of greater than about 95°, and preferably within the range of from about 100° to about 120°, while maintaining the optical centerline of the lens in a substantially parallel relationship with the normal sight line of the wearer. The optical centerline of the lens may or may not pass through the lens.

Methods of making the lens of the present invention are also disclosed.

Further features and advantages of the present invention will become apparent from the detailed description of preferred embodiments which follows, when considered together with the attached claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of eyewear incorporating taper corrected lenses made in accordance with an embodiment of the present invention.

FIG. 2 is a cross-sectional view taken along the lines 2—2 of FIG. 1.

FIG. 3 is a schematic horizontal cross-sectional view of a prior art untapered lens for a dual lens eyewear system.

FIG. 4 is a schematic horizontal cross-sectional view of a tapered lens for a dual lens eyewear system.

FIG. 5 is a cross-sectional view like that in FIG. 2, showing taper corrected lenses having a greater base curvature, in accordance with another embodiment of the present invention.

FIG. 6 is a perspective view of a lens blank conforming to a portion of the surface of a sphere, showing a lens profile to be cut from the blank in accordance with a preferred embodiment of the present invention.

FIG. 7 is a perspective cutaway view of the hollow, tapered wall spherical shape, lens blank, and lens of FIG. 6.

FIG. 8 is a horizontal cross-sectional view of a lens constructed in accordance with a preferred embodiment of the present invention.

FIG. 9 is a top plan view of the lens of FIG. 8 showing a high wrap in relation to a wearer.

FIG. 10 is a right side elevational cross-section of the lens and wearer of FIG. 9, showing lens rake.

FIG. 11 schematically illustrates the projection of the lens profile from a desired orientation within an eyewear frame to the lens blank in accordance with a preferred embodiment of the present invention.

FIG. 12 is a front elevational view of the lens and lens blank of FIG. 6, rotated to project the mechanical centerline of the blank normal to the page.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Although the preferred embodiments will be discussed below in terms of lenses having "spherical" front and rear surfaces (surfaces which conform substantially to a portion of the surface of a sphere), it will be understood by those having ordinary skill in the art that the invention may also be applicable to lenses having different surface geometries. Additionally, it will be understood that the present invention has application to lenses of many front elevational shapes and orientations in the as worn position beyond those illustrated herein.

Referring to FIGS. 1 and 2, there is illustrated an eyeglass 10, such as a sunglass having first and second lenses 12, 14 constructed in accordance with an embodiment of the present invention. Although the invention is illustrated in the context of an eyeglass design marketed by Oakley under the Eye Jackets™ name, the present invention relates solely to the lens curvature, taper, and orientation on the head of the wearer. Therefore the particular lens shape revealed in FIG. 1 is not critical to the invention. Rather, lenses of many other shapes and configurations may be constructed which incorporate the present invention as will become apparent based upon the disclosure herein.

Similarly, the particular mounting frame 16 shown is not essential to the present invention. The frame 16 may bound only the bottom edge(s) of the lenses 12, 14, only the top edges, or the entire lenses as illustrated. Alternatively, the frame 16 can bound any other portions of the lenses as will be evident to those of skill in the art. Frameless eyeglasses can also be constructed in accordance with the present invention, as long as the lens orientation on the head of the wearer is substantially maintained in a predetermined relationship to the normal sight line as will be discussed below. Preferably, though, the lenses 12, 14 are each mounted in an annular orbital as shown.

A pair of earstems 20, 22 pivotally attach to the frame 16. Alternatively, the earstems 20, 22 may attach directly to the lenses 12, 14. The frame may comprise of any of a variety of metals, composites or relatively rigid, molded thermoplastic materials which are well known in the art, and may be transparent or any of a variety of colors. Injection molding, machining and other construction techniques are well known in the art.

Lenses in accordance with the present invention can be manufactured by any of a variety of processes well known in the art.

Typically, high optical quality lenses are cut from a preformed injection molded lens blank. Since the right and left lenses are preferably mirror images of each other, only the right lens will generally be discussed below. Alternatively, the lens can be molded directly into its final shape and size, to eliminate the need for post molding cutting steps.

Preferably, the lens, or the lens blank from which it is cut, is injection molded and comprises a relatively rigid and optically acceptable material, such as polycarbonate. Other polymeric lens materials can also be used, such as CR-39 and a variety of high index plastics which are known in the art. The decentered taper correction of the present invention may also be applicable to glass lenses, although the need for correction in the present context is generally more pronounced in nonglass materials.

If the lens is to be cut from a lens blank, the taper and curvature of a carefully preselected portion of the molded lens blank is transferred to the lens in accordance with a preferred manufacturing process described below. Preferably, the frame is provided with a slot or other attachment structure that cooperates with the molded curvature of the lens to minimize deviation from, and even improve retention of the as-molded curvature.

Alternatively, the lens or lens blank can be stamped or cut from generally planar tapered sheet stock and then bent into the curved configuration in accordance with the present invention. This curved configuration can then be maintained by the use of a relatively rigid, curved frame, or by heating the curved sheet to retain its curved configuration, as is well known in the thermoforming art.

Most preferably, the curvature of both surfaces of the lens are created in the lens blank molding and polishing processes, and the lens shape is cut from the blank in accordance with the invention as described below.

Referring to FIG. 2, the lens 14 of the present invention is characterized in a horizontal plane by a generally arcuate shape, extending from a medial edge 24 throughout at least a portion and preferably substantially all of the wearer's range of vision to a lateral edge 26. The arc length of the lens from the medial edge 24 to the lateral edge 26 in a dual lens system will generally be within the range of from about 1½ inches to about 3½ inches, and preferably within the range of from about 2 inches to about 3 inches. In one preferred embodiment, the arc length of the lens is about 2⅜ inches.

Although the outer surfaces of the lenses 12, 14 appear to be illustrated as lying on a common circle 31, the right and left lenses will generally be canted such that the medial edge of each lens will fall outside of the circle 31 and the lateral edges will fall inside of the circle 31. Such canting of the lens increases the angle θ (FIG. 2) and increases the desirability of the optical correction achieved by the present invention.

When worn, the lens 14 should at least extend across the wearer's normal line of sight 27, and preferably substantially across the wearer's peripheral zones of vision. As used herein, the wearer's normal line of sight shall refer to a line projecting straight ahead of the wearer's eye, with substantially no angular deviation in either the vertical or horizontal planes as illustrated by line 130 in FIGS. 9 and 10.

The lens 14 is provided with an anterior surface 28, a posterior surface 30, and a varying thickness therebetween. The thickness of the lens 14 in the region of the medial edge 24 for a polycarbonate lens is generally within the range of from about 1 mm to about 2.5 mm, and preferably in the range of from about 1.5 mm to about 1.8 mm. In a preferred embodiment, the thickest portion of the lens 14 is at or about the optical centerline, and is about 1.65 mm.

Preferably, the thickness of the lens 14 tapers smoothly, though not necessarily linearly, from the maximum thickness proximate the medial edge 24 to a relatively lesser thickness at the lateral edge 26. The thickness of the lens near the lateral edge 26 is generally within the range of from about 0.635 mm to about 1.52 mm, and, preferably, within the range of from about 0.762 mm to about 1.27 mm. In one preferred polycarbonate embodiment, the lens has a minimum thickness in the lateral zone of about 1.15 mm. The minimum thickness at lateral edge 26 is generally governed by the desired impact resistance of the lens.

FIG. 3 schematically illustrates refraction in a prior art lens 41 with circular inside and outside surface horizontal cross-sections, having a uniform thickness 44. With such a lens 41, the angle of incidence of rays from the lens 41 to the eye 46 changes throughout the angular range of vision. For example, a ray which shall be referred to for descriptive purposes as a medial light ray 50 strikes the lens 41 at an angle α to the normal at the point of incidence. As is well known in this art, bending of light at transmitting surfaces depends in part upon the angle of incidence of light rays. The ray 50 is refracted or bent in opposite directions at each of an outer surface 52 and an inner surface 54 of the lens 41, resulting in a transmitted ray 56 parallel to the incident ray 50. The transmitted ray 50 is laterally displaced, relative to the path of the incident ray 50, by a distance 58. This displacement represents a first order source of optical distortion.

Furthermore, refractory displacement is even more pronounced at a lateral end 60 due to a greater angle of incidence β. A peripheral incident ray 62 experiences greater displacement 64 than the medial incident ray 50, in accordance with Snell's Law, as will be understood by those of ordinary skill in the optical arts. The discrepancy between the peripheral ray displacement 64 and the medial ray displacement 58 results in a second order of optical distortion. This second order of distortion may cause substantial warping of an image seen through relatively lateral portions of the lens 41.

FIG. 4 schematically illustrates a lens 71 of tapered thickness, to compensate for the greater angle of incidence at the lateral ends 60 of the lens 41 (FIG. 3), as disclosed in the context of unitary lens systems in U.S. Pat. No. 4,859,048, issued to Jannard. Tapering produces a smaller lens thickness 74 at a lateral end 76, relative to a lens thickness 78 at a more medial point 80. This smaller thickness 74 reduces an amount of peripheral ray displacement 82, relative to the peripheral ray displacement 64 through the untapered lens 41 of FIG. 4. In other words, lesser lens thickness 74 near the lateral end 76 of the tapered lens 71 compensates to some extent for a greater angle of incidence β', relative to the thickness 78 and angle of incidence α', at the more medial point 80.

The resulting difference between peripheral ray displacement 82 and medial ray displacement 84 on the same lens 71 is not as great as the corresponding difference in FIG. 3, reducing the second order optical distortion. Note that the degree of correction of the second order distortion depends upon a relationship between the manner and degree of tapering from the apex 85 to each lateral end 76 and the manner in which the angle of incidence changes over the same range.

The lens 71 of FIG. 4 is illustrated as though it were mounted within a frame (not shown) such that the wearer's normal line of sight 86 passes perpendicularly through the lens 71 at the lens apex or mechanical center 85. In other words, the angle of incidence to the lens normal is zero for the wearer's normal line of sight. The outer and inner surfaces of lens 71 in the cross-sectional illustration conform to offset, equal-radius circles represented by centerpoints 87 and 88, respectively. A line drawn through centerpoints 87 and 88, referred to herein as the optical centerline of the lens, is collinear with the normal line of sight in the as-worn orientation. This conventional configuration shall be defined as a centrally oriented lens, for ease of description. Circumferentially clockwise or counterclockwise of the normal line of sight 86, the angle of incidence to the lens normal increases in a regular fashion from zero at the lens apex 85. A high degree of wrap may be desirable for aesthetic styling reasons, for lateral protection of the eyes from flying debris, or for interception of peripheral light. Wrap may be attained by utilizing lenses of tight horizontal curvature (high base), such as small-radius spherical lenses, or by mounting each lens in a position which is canted laterally and rearwardly relative to centrally oriented dual lenses. Such canting shifts the normal line of sight 86 out of a collinear relationship with the optical centerline, and changes the optics of the lens. As a result, prior art dual lens eyewear with substantial "wrap" around the sides of a wearer's face has generally been accompanied by some degree of prismatic distortion.

In accordance with the present invention, there is provided an improved optical configuration and method for minimizing prismatic distortion. Though the present invention may be applied to a wide variety of lens shapes and orientations the invention has particular utility for dual lens eyewear using high base curvature and demonstrating a high degree of wrap in the as-worn orientation.

Referring to FIGS. 2 and 5, the illustrated eyewear incorporates canted lenses 12 and 14 or 102 and 104, mounted in a position rotated laterally relative to conventional centrally oriented dual lens mountings. A canted lens may be conceived as having an orientation, relative to the wearer's head, which would be achieved by starting with conventional dual lens eyewear having centrally oriented lenses and bending the frame inwardly at the temples to wrap around the side of the head.

As a consequence of the increased wrap, the wearer's normal line of sight 27 no longer strikes the lens 14 perpendicularly, as illustrated in FIG. 4. Instead, the angle of incidence θ (FIG. 2) for the wearer's line of sight 27 is generally greater than 90°, and to achieve good wrap it may be greater than about 95°, preferably is within the range of from about 100° to about 135°, and in one 9.5 base embodiment is about 101.75°. Lower base lenses generally will exhibit a larger angle θ in the as worn orientation, and the angle θ in an embodiment having a base of 6.5 was about 113.4°. In a base 4 embodiment having a pupillary distance of 2.8 inches, the angle θ was about 119.864°.

FIG. 5 illustrates the horizontal cross-section of an eyeglass 100 in accordance with an embodiment of the present invention, similar in style to that illustrated in FIG. 2, except having lenses 102 and 104 of tighter curvature (higher base) as well as possibly greater wrap. When the eyeglass 100 is worn, a lateral edge 106 of the lens 104 wraps significantly around and comes in close proximity to the wearer's temple to provide significant lateral eye protection as has been discussed.

An anterior (front) surface 108 of the lens of the present invention will generally conform to a portion of the surface of a regular geometric solid, such as a sphere 110, shown here in horizontal cross-section. The front surfaces of spherical lenses 102 and 104 of the illustrated embodiment can, therefore, be characterized by a radius. By convention in the industry, the curvature may also be expressed in terms of a base value, such that the radius (R) in millimeters of the anterior surface of the lens is equal to 530 divided by the base curve, or

$$R = \frac{530}{B} \quad (1)$$

The present invention provides the ability to construct dual lens eyeglass systems having relatively high wrap using lens blanks having a base curve of 6 or greater, preferably between about 7½ and 10½, more preferably between about 8 and 9½, and, in one embodiment between about 8¾ and 9. The radius of the circle conforming to the anterior surface of a base 8¾ lens, for example, is about 60.57 millimeters. For comparison, the radius of the circle which characterizes the anterior surface of a base 3 lens is about 176.66 millimeters.

The embodiment of the present invention illustrated in FIG. 5 may be cut from a base 8¾ lens blank having a thickness of about 0.0649 inches at the optical centerline and about 0.053 inches at reference a point two inches along the outer circumference of the lens from the optical centerline. Alternatively, the lens can be molded directly into its final shape and configuration.

FIG. 6 is a perspective view of a lens blank 122, a convex outside surface 136 of which generally conforms to a portion of the surface of a three-dimensional geometric shape 124. It will be understood by those of skill in this art that lenses in accordance with the present invention may conform to any of a variety of geometric shapes.

Preferably, the outside surface of the lens will conform to a shape having a smooth, continuous surface having a constant horizontal radius (sphere or cylinder) or progressive curve (ellipse, toroid or ovoid) in either the horizontal or vertical planes. The geometric shape 124 of the preferred embodiments herein described, however, generally approximates a sphere.

The sphere 124 illustrated in FIGS. 6 and 7 is an imaginary three-dimensional solid, a portion of the wall of which is suitable from which to cut a lens 120. As is known in the art, precision lens cutting is often accomplished by producing a lens blank 122 from which a lens 120 is ultimately cut. However, it should be clear to those of skill in the art from the illustrations of FIGS. 6 and 7, that the use of a separate lens blank is optional, and the lens 120 may be molded directly into its final shape and configuration if desired.

It can also be seen from FIGS. 6 and 7 that the lens 120 and/or the lens blank 122 can be positioned at any of a variety of locations along the sphere 124. For the purpose of the present invention, the optical centerline 132 operates as a reference line for orientation of the lens 120 with respect to the sphere 124. In the illustrated embodiment, wherein both the outside surface and the inside surface conform to a portion of a sphere, the optical centerline is defined as the line 132 which joins the two centers C1 and C2. The analogous reference line for the purpose of nonspherical lens geometry may be formed in a manner different than connection of the two geometric centers of the spheres, as will be apparent to one of skill in the art.

The lens 120 is ultimately formed in such a manner that it retains the geometry of a portion of the wall of the sphere as illustrated in FIG. 7. The location of the lens 120 on the sphere 124 is selected such that when the lens 120 is oriented in the eyeglass frame, the normal line of sight 130 of the wearer through the lens will be maintained substantially in parallel to the optical centerline 132 of the geometric configuration from which the lens 120 was obtained. In the illustration of FIGS. 6 and 7, the lens 120 is a right lens which has a significant degree of wrap, as well as some degree of rake. A lens having a different shape, or a lesser degree of wrap may overlap the optical centerline 132 of the imaginary sphere 124 from which the lens was formed. However, whether the optical centerline of the imaginary sphere 124 crosses through the lens 120 or not is unimportant, so long as the line of sight 130 in the lens 120 is maintained substantially in parallel in the as-worn orientation with the optical centerline 132.

For purposes of the present invention, "substantially parallel" shall mean that the line of sight 130 when the lens 120 is oriented in the as worn position generally does not deviate within the horizontal plane by more than about ±15° from parallel to the optical centerline 132. Preferably, the normal line of sight 130 should not deviate by more than about ±10° from the optical centerline 132, more preferably the normal line of sight 130 deviates by no more than about ±5° and most preferably no more than about ±2° from parallel to the optical centerline 132. Optimally, the line of sight 130 is parallel to the optical centerline in the as worn orientation. Typically, an eyewear frame has a vertical plane of symmetry which is substantially parallel to the line of sight 130. Accordingly, the optical centerline 132 will be substantially parallel to the frame's vertical plane of symmetry.

Variations from parallel in the horizontal plane generally have a greater negative impact on the lens than variations from parallel in the vertical plane. Accordingly, the solid angle between the line of sight 130 and optical centerline 132 in the vertical plane may exceed the ranges set forth above, for some eyewear, as long as the horizontal component of the angle of deviation is within the above-mentioned ranges of deviation from the parallel orientation. Preferably, the line of sight 130 deviates in the vertical plane no more than about ±10° and, more preferably, no more than about ±3° from the optical centerline in the as worn orientation.

FIG. 7 is a cutaway view of the lens 120, lens blank 122, and geometric shape 124 of FIG. 6. This view shows that the preferred geometric shape 124 is hollow with walls of varying thickness, as revealed by a horizontal cross-section 134 at the optical centerline of the geometric shape 124.

The tapered walls of the preferred geometric shape 124 result from two horizontally offset spheres, represented by their center points C1 and C2 and radii R1 and R2. An outer surface 136 of the preferred lens blank 122 conforms to one sphere (of radius R1) while an inner surface 138 of the lens blank 122 conforms to the other sphere (of radius R2). By adjusting the parameters which describe the two spheres, the nature of the taper of the lens blank 122 may also be adjusted.

In particular, the parameters for the two spheres to which the lens blank outer surface 136 and inner surface 138 conform is preferably chosen to produce zero refractive power, or non-prescription lenses. Where CT represents a chosen center thickness (maximum thickness of the wall of the hollow geometric shape 124), n is an index of refraction of the lens blank material, R1 is set by design choice for the curvature of the outer surface 136, R2 may be determined according to the following equation:

selecting a desired lens shape for dual lens eyewear, the lens shape having a mechanical center point;

selecting a desired lens orientation relative to a wearer's normal line of sight from one eye, the orientation including both a degree of horizontal wrap and a degree of vertical rake;

identifying a position on the lens blank where the desired lens shape cut from that position places the mechanical center point offset horizontally from the optical center of the lens blank and vertically below the equatorial line, said offset by an amount which corresponds to the degree of wrap and the degree of rake to reduce prismatic shift; and

cutting the desired lens shape from the position.

11. A method as in claim **10**, wherein the selecting a desired lens orientation step comprises selecting a lens orientation such that an angle of incidence at which the normal line of sight passes through a posterior surface of the lens is greater than about 90°.

12. A method as in claim **11**, wherein the angle of incidence is greater than about 95°.

13. A method as in claim **12**, wherein the angle of incidence is within the range of from about 100° to about 135°.

14. A method as in claim **10**, wherein the obtaining a tapered non-glass lens blank step comprises obtaining a lens blank having a base curvature within the range of from about 8¾ to about 9.

15. A method as in claim **10**, wherein said cutting the desired lens shape step produces a lens having a horizontal arc length within the range of from about 1½ to about 3½ inches.

16. A method as in claim **10**, wherein the identifying a position on the lens blank step comprises identifying a position on the lens blank where the desired lens shape cut from that position, when mounted in the desired lens orientation, aligns the optical centerline with respect to the wearer's normal line of sight such that the optical centerline deviates in a horizontal meridian from the normal line of sight by no more than about ±5°.

17. A method as in claim **16**, wherein the deviation in the horizontal meridian is no more than about ±2°.

18. A method as in claim **16**, wherein the optical centerline deviates in a vertical meridian from the wearer's normal line of sight by no more than about ±3°.

19. A method as in claim **10**, further comprising the step of mounting the lens in eyewear in the desired orientation.

20. A method of cutting a nonpowered lens from a decentered lens blank, said lens for use in a dual lens eyeglass frame in which the lens will exhibit both wrap and rake and optical correction in an as-worn orientation, comprising the steps of:

designing a dual lens eyeglass frame at least to the point of determining a desired rake and wrap of each lens relative to a corresponding normal line of sight through each lens in the as-worn orientation, said desired rake and wrap such that an angle of incidence at which the normal line of sight passes through a posterior surface of the lens is greater than about 95°;

obtaining a decentered, tapered spherical lens blank having an anterior surface with a base curvature of at least about 7½ and an optical centerline passing through the thickest portion of the lens blank;

selecting a vertical and horizontal position on the lens blank, relative to the optical centerline, for cutting the lens such that the lens cut from the selected position will exhibit substantially the same three dimensional angular orientation with respect to the optical centerline as it will exhibit with respect to the corresponding normal line of sight once mounted in the dual lens eyeglass frame with said desired rake and wrap in the as-worn orientation, wherein the selected vertical position depends upon said desired rake and the selected horizontal position depends upon said desired wrap; and

cutting the lens from said location on the lens blank.

21. A method of manufacturing a right lens for dual lens optically corrected non prescription eyewear exhibiting wrap and a degree of downward rake in the as-worn orientation, the method comprising:

providing a derentered lens blank having an optical centerline, the lens blank having a thickness which is vertically tapered on either side of a horizontal meridian and horizontally tapered from a relatively greater thickness at an optical center located between the geometric center of the blank and a medial edge of the blank to a relatively lesser thickness at a lateral edge of the blank, the optical centerline passing through the lens blank at the optical center which lies on the horizontal meridian; and

cutting the right lens from the lens blank such that greater than 50% of the right lens is cut from below the horizontal meridian, the amount of the right lens cut from below the horizontal meridian corresponding to the degree of downward rake to reduce induced prismatic shift in the vertical plane when the lens is mounted with said degree of downward rake.

22. The method of claim **21**, wherein greater than about 50% of the lens is cut from a lower lateral quadrant.

23. The method of claim **21**, wherein the optical center lies outside of the right lens.

24. The method of claim **21**, wherein the horizontal meridian is the central horizontal meridian.

25. The method of claim **21**, wherein the lens blank has a base curvature of at least about 7½.

26. The method of claim **21**, wherein the lens blank has a base curvature within the range of from about 8 to about 9½.

27. A method of manufacturing dual lens eyewear having wrap and rake with minimal optical distortion in an as-worn orientation, the method comprising:

designing a dual lens eyeglass, including defining a lens shape, a degree of wrap and a degree of rake in the as-worn orientation for each of a left lens and a right lens;

providing a plurality of spherical lens blanks, each having a base curvature of at least about 6, a vertically and horizontally tapered thickness and an optical centerline;

identifying a horizontal position on one of the lens blanks relative to the optical centerline, at which the lens shape will exhibit the defined degree of wrap while minimizing prismatic distortion in the as-worn orientation for each of the left lens and the right lens;

identifying a vertical position on one of the lens blanks, relative to the optical centerline, at which the lens shape will exhibit the defined degree of rake while minimizing prismatic distortion in the as-worn orientation for each of the left lens and the right lens; and

cutting the lens from the identified horizontal and vertical position for each of the left lens and the right lens.

28. A method of constructing a dual lens eyeglass having wrap and rake in an as worn orientation, comprising:

determining a degree of wrap and a degree of rake for the as worn orientation for each of a left lens and a right lens, said degrees of wrap and rake such that an angle of incidence at which the normal line of sight passes through a posterior surface of the lens is greater than about 95°;

providing an eyeglass frame to support the left and right lenses with the selected degrees of lens wrap and lens rake in an as-worn orientation;

providing a first lens blank with a thickness asymmetrically tapered in a vertical dimension and asymmetrically tapered in a horizontal dimension;

cutting a left lens from a position on the first lens blank which is selected to cooperate with the selected degrees of wrap and rake in the as warn orientation;

providing a second lens blank with a thickness asymmetrically tapered in the vertical dimension and asymmetrically tapered in the horizontal dimension;

cutting a right lens from a position on the second lens blank which is selected to cooperate with the selected degrees of wrap and rake in the as warn orientation; and

mounting the left and right lenses to the frame with the selected degrees of wrap and rake in the as worn orientations whereby the asymmetric tapered thickness cooperates with the selected degrees of wrap and rake to reduce prismatic shift compared to a non tapered lens and compared to a vertically and horizontally symmetrically tapered lens mounted with said rake and wrap.

29. A method as in claim **28**, wherein the angle of incidence is between about 100 degrees and about 135 degrees.

30. A method as in claim **28**, wherein the front surface of each of the right lens and the left lens has a base curve of greater than about base **6**.

31. A method as in claim **30**, wherein each of the front right surface and the front left surface has a base curve of greater than about base **8**.

32. A method as in claim **30**, wherein each of the front right surface and the front left surface has a base curve within the range of from about 7.5 to about 10.5.

33. A method as in claim **28**, wherein each of the right and left lenses comprises polycarbonate.

34. A method as in claim **28**, wherein each of the right and left lenses has a maximum horizontal arc length within the range of from about 1½ inches to about 3½ inches.

35. A method as in claim **34**, wherein each of the right and left lenses has a maximum horizontal arc length within the range of from about 2 inches to about 3 inches.

36. A method as in claim **28**, wherein a medial edge of each of the right and left lenses has a thickness within the range of from about 1 mm to about 2.5 mm.

37. A method as in claim **36**, wherein the medial edge of each of the right and left lenses has a thickness within the range of from about 1.5 mm to about 1.8 mm.

38. A method as in claim **28**, wherein each of the right and left lens has a front surface and a rear surface, defining a lens thickness therebetween for each of the right and left lenses;

each of the front surface and rear surface of the right lens conforming substantially to portions of the surfaces of a front right sphere having a first center and a rear right sphere having a second center, respectively, such that the thickness of the right lens is tapered in both horizontal and vertical planes;

each of the front surface and rear surface of the left lens conforming substantially to portions of the surfaces of a front left sphere having a third center and a rear left sphere having a fourth center, respectively, such that the thickness of the left lens is tapered in both horizontal and vertical planes;

wherein each of said first, second, third and fourth centers are offset from one another following the mounting step, the eyeglass further characterized by:

a right optical centerline extending through the first and second centers of the right lens;

a left optical centerline extending through the third and fourth centers of the left lens;

wherein a right mechanical center of the right lens is offset both horizontally and vertically from the right side optical centerline, by a vertical distance which corresponds to the amount of rake exhibited by the right lens in the as worn orientation and by a horizontal distance which corresponds to the amount of wrap exhibited by the right lens in the as worn orientation, and a left mechanical center is offset both horizontally and vertically from the left optical centerline, by a vertical distance which corresponds to the amount of rake exhibited by the left lens in the as worn orientation, and by a horizontal distance which corresponds to the amount of wrap exhibited by the left lens in the as worn orientation to produce eyewear which exhibits a desired reduction in prismatic error.

39. The method of claim **38**, wherein each of said front right sphere and said front left sphere has a base curve of greater than about base **6**.

40. The method of claim **39**, wherein a vertical component of the wearer's normal line of sight from each eye deviates in the as worn orientation by no more than about 10 degrees from parallel with a horizontal component of the corresponding optical centerline.

41. The method of claim **38**, wherein each of said front right sphere and said front left sphere has a base curve of greater than about base **8**.

42. The method of claim **41**, wherein each of said front right sphere and said front left sphere has a base curve within the range of from about 7.5 to about 10.5.

43. A method of manufacturing optically corrected, non-prescription dual lens eyewear, comprising:

providing an eyeglass frame configured to maintain a left lens in a first predetermined relationship with respect to a wearer's left reference line of sight and a right lens in a second predetermined relationship with respect to the wearer's right reference line of sight, when the eyewear is worn on the head of the wearer, each predetermined relationship including an amount of wrap and an amount of rake;

choosing a vertically and horizontally tapered left lens thickness with an associated left optical centerline vertically and horizontally aligned with respect to the wearer's left reference line of sight in the first predetermined relationship, to compensate for prismatic distortion relative to a uniformly thick lens having the first predetermined relationship;

cutting a left lens with the chosen tapered left lens thickness from a location on a first lens blank;

choosing a vertically and horizontally tapered right lens thickness with an associated right optical centerline vertically and horizontally aligned with respect to the wearer's right reference line of sight in the second predetermined relationship, to compensate for prismatic distortion relative to a uniformly thick lens having the second predetermined relationship; and a cutting a right lens with the chosen tapered right lens thickness from a location on a second lens blank.

44. The method of claim 43, wherein providing the corrected left lens comprises cutting the left lens from a vertically and horizontally tapered lens blank having the left optical centerline, and providing the corrected right lens comprises cutting the right lens from a similar lens blank having the right optical centerline.

45. The method of claim 44, wherein choosing the vertically and horizontally tapered left lens thickness comprises selecting a position on the lens blank such that cutting the lens from that position and mounting the lens on the eyeglass frame in the first predetermined relationship results in the left optical centerline being within about 10° of parallel to the wearer's left reference line of sight in each of a vertical and a horizontal plane.

46. A method of manufacturing nonprescription, dual lens eyewear exhibiting wrap and downward rake, the method comprising the steps of:

selecting a desired as worn lens orientation relative to a wearer's reference line of sight;

obtaining a lens which has been cut from a preselected non centered location on a lens blank, which location relates to the desired as worn lens orientation to achieve a desired optical result, the lens blank comprising an inner surface conforming to a first sphere having a first center, and an outer surface conforming to a second sphere having a second center offset from the first center, a vertically and horizontally tapered lens thickness defined between the inner and outer surfaces, and an optical centerline passing through the first and second centers; and

mounting the lens in a frame with rake and wrap such that the optical centerline is oriented with respect to the wearer's reference line of sight to achieve the desired optical result.

47. The method of claim 46, wherein the wearer's reference line of sight is the wearer's straight ahead normal line of sight.

48. The method of claim 47, wherein the lens is mounted such that the optical centerline is horizontally and vertically spaced from the wearer's normal line of sight.

49. The method of claim 48, wherein the optical centerline is substantially parallel with the normal line of sight.

50. The method of claim 49, wherein the optical centerline deviates within a vertical plane by no more than about 10 degrees from parallel with the normal line of sight and deviates within a horizontal plane by no more than about 10 degrees from parallel with the normal line of sight.

51. The method of claim 46, wherein the obtaining step comprises obtaining a lens cut from a position on the lens blank such that the geometric center of the lens is displaced from the geometric center of the lens blank in both a vertical and a horizontal plane by an amount corresponding to the desired as worn lens orientation to achieve the desired optical result.

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UNITED STATES DISTRICT COURT
CENTRAL DISTRICT OF CALIFORNIA

NOTICE OF ASSIGNMENT TO UNITED STATES MAGISTRATE JUDGE FOR DISCOVERY

This case has been assigned to District Judge James V. Selna and the assigned discovery Magistrate Judge is Arthur Nakazato.

The case number on all documents filed with the Court should read as follows:

SACV10- 708 JVS (ANx)

Pursuant to General Order 05-07 of the United States District Court for the Central District of California, the Magistrate Judge has been designated to hear discovery related motions.

All discovery related motions should be noticed on the calendar of the Magistrate Judge

NOTICE TO COUNSEL

A copy of this notice must be served with the summons and complaint on all defendants (if a removal action is filed, a copy of this notice must be served on all plaintiffs).

Subsequent documents must be filed at the following location:

[ ] **Western Division**
312 N. Spring St., Rm. G-8
Los Angeles, CA 90012

[X] **Southern Division**
411 West Fourth St., Rm. 1-053
Santa Ana, CA 92701-4516

[ ] **Eastern Division**
3470 Twelfth St., Rm. 134
Riverside, CA 92501

Failure to file at the proper location will result in your documents being returned to you.

Name & Address: Chandler G. Weeks, Esq.
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Solana Beach, CA 92075
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UNITED STATES DISTRICT COURT
CENTRAL DISTRICT OF CALIFORNIA

OAKLEY, INC., a Washington corporation PLAINTIFF(S) v. SWITCH VISION SYSTEMS, LLC, a New Jersey limited liability company DEFENDANT(S).	CASE NUMBER **SACV10-708 JVS (ANx)** **SUMMONS**

TO: DEFENDANT(S): ______________________________

A lawsuit has been filed against you.

Within 21 days after service of this summons on you (not counting the day you received it), you must serve on the plaintiff an answer to the attached ☑ complaint ☐ ______________ amended complaint ☐ counterclaim ☐ cross-claim or a motion under Rule 12 of the Federal Rules of Civil Procedure. The answer or motion must be served on the plaintiff's attorney, Chandler G. Weeks, whose address is 462 Stevens Avenue, Suite 310, Solana Beach, CA 92075. If you fail to do so, judgment by default will be entered against you for the relief demanded in the complaint. You also must file your answer or motion with the court.

Clerk, U.S. District Court

Dated: JUN - 3 2010

By: [signature]
Deputy Clerk

(Seal of the Court)

[Use 60 days if the defendant is the United States or a United States agency, or is an officer or employee of the United States. Allowed 60 days by Rule 12(a)(3)].

UNITED STATES DISTRICT COURT, CENTRAL DISTRICT OF CALIFORNIA
CIVIL COVER SHEET

I (a) PLAINTIFFS (Check box if you are representing yourself ☐)
OAKLEY, INC., a Washington corporation

DEFENDANTS
SWITCH VISION SYSTEMS, LLC, a New Jersey limited liability company

(b) Attorneys (Firm Name, Address and Telephone Number. If you are representing yourself, provide same.)
WEEKS, KAUFMAN, NELSON & JOHNSON
462 Stevens Avenue, Suite 310
Solana Beach, CA 92075

Attorneys (If Known)

II. BASIS OF JURISDICTION (Place an X in one box only.)

☐ 1 U.S. Government Plaintiff
☑ 3 Federal Question (U.S. Government Not a Party)
☐ 2 U.S. Government Defendant
☐ 4 Diversity (Indicate Citizenship of Parties in Item III)

III. CITIZENSHIP OF PRINCIPAL PARTIES - For Diversity Cases Only
(Place an X in one box for plaintiff and one for defendant.)

	PTF	DEF		PTF	DEF
Citizen of This State	☐ 1	☐ 1	Incorporated or Principal Place of Business in this State	☐ 4	☐ 4
Citizen of Another State	☐ 2	☐ 2	Incorporated and Principal Place of Business in Another State	☐ 5	☐ 5
Citizen or Subject of a Foreign Country	☐ 3	☐ 3	Foreign Nation	☐ 6	☐ 6

IV. ORIGIN (Place an X in one box only.)

☑ 1 Original Proceeding ☐ 2 Removed from State Court ☐ 3 Remanded from Appellate Court ☐ 4 Reinstated or Reopened ☐ 5 Transferred from another district (specify): ☐ 6 Multi-District Litigation ☐ 7 Appeal to District Judge from Magistrate Judge

V. REQUESTED IN COMPLAINT: JURY DEMAND: ☑ Yes ☐ No (Check 'Yes' only if demanded in complaint.)

CLASS ACTION under F.R.C.P. 23: ☐ Yes ☑ No ☐ **MONEY DEMANDED IN COMPLAINT: $**________________

VI. CAUSE OF ACTION (Cite the U.S. Civil Statute under which you are filing and write a brief statement of cause. Do not cite jurisdictional statutes unless diversity.)
This is a claim for patent infringement under 35 USC Sections 271 and 281

VII. NATURE OF SUIT (Place an X in one box only.)

OTHER STATUTES
☐ 400 State Reapportionment
☐ 410 Antitrust
☐ 430 Banks and Banking
☐ 450 Commerce/ICC Rates/etc.
☐ 460 Deportation
☐ 470 Racketeer Influenced and Corrupt Organizations
☐ 480 Consumer Credit
☐ 490 Cable/Sat TV
☐ 810 Selective Service
☐ 850 Securities/Commodities/ Exchange
☐ 875 Customer Challenge 12 USC 3410
☐ 890 Other Statutory Actions
☐ 891 Agricultural Act
☐ 892 Economic Stabilization Act
☐ 893 Environmental Matters
☐ 894 Energy Allocation Act
☐ 895 Freedom of Info. Act
☐ 900 Appeal of Fee Determination Under Equal Access to Justice
☐ 950 Constitutionality of State Statutes

CONTRACT
☐ 110 Insurance
☐ 120 Marine
☐ 130 Miller Act
☐ 140 Negotiable Instrument
☐ 150 Recovery of Overpayment & Enforcement of Judgment
☐ 151 Medicare Act
☐ 152 Recovery of Defaulted Student Loan (Excl. Veterans)
☐ 153 Recovery of Overpayment of Veteran's Benefits
☐ 160 Stockholders' Suits
☐ 190 Other Contract
☐ 195 Contract Product Liability
☐ 196 Franchise

REAL PROPERTY
☐ 210 Land Condemnation
☐ 220 Foreclosure
☐ 230 Rent Lease & Ejectment
☐ 240 Torts to Land
☐ 245 Tort Product Liability
☐ 290 All Other Real Property

TORTS
PERSONAL INJURY
☐ 310 Airplane
☐ 315 Airplane Product Liability
☐ 320 Assault, Libel & Slander
☐ 330 Fed. Employers' Liability
☐ 340 Marine
☐ 345 Marine Product Liability
☐ 350 Motor Vehicle
☐ 355 Motor Vehicle Product Liability
☐ 360 Other Personal Injury
☐ 362 Personal Injury-Med Malpractice
☐ 365 Personal Injury-Product Liability
☐ 368 Asbestos Personal Injury Product Liability

IMMIGRATION
☐ 462 Naturalization Application
☐ 463 Habeas Corpus-Alien Detainee
☐ 465 Other Immigration Actions

TORTS
PERSONAL PROPERTY
☐ 370 Other Fraud
☐ 371 Truth in Lending
☐ 380 Other Personal Property Damage
☐ 385 Property Damage Product Liability

BANKRUPTCY
☐ 422 Appeal 28 USC 158
☐ 423 Withdrawal 28 USC 157

CIVIL RIGHTS
☐ 441 Voting
☐ 442 Employment
☐ 443 Housing/Accommodations
☐ 444 Welfare
☐ 445 American with Disabilities - Employment
☐ 446 American with Disabilities - Other
☐ 440 Other Civil Rights

PRISONER PETITIONS
☐ 510 Motions to Vacate Sentence Habeas Corpus
☐ 530 General
☐ 535 Death Penalty
☐ 540 Mandamus/ Other
☐ 550 Civil Rights
☐ 555 Prison Condition

FORFEITURE / PENALTY
☐ 610 Agriculture
☐ 620 Other Food & Drug
☐ 625 Drug Related Seizure of Property 21 USC 881
☐ 630 Liquor Laws
☐ 640 R.R. & Truck
☐ 650 Airline Regs
☐ 660 Occupational Safety /Health
☐ 690 Other

LABOR
☐ 710 Fair Labor Standards Act
☐ 720 Labor/Mgmt. Relations
☐ 730 Labor/Mgmt. Reporting & Disclosure Act
☐ 740 Railway Labor Act
☐ 790 Other Labor Litigation
☐ 791 Empl. Ret. Inc. Security Act

PROPERTY RIGHTS
☐ 820 Copyrights
☑ 830 Patent
☐ 840 Trademark

SOCIAL SECURITY
☐ 861 HIA (1395ff)
☐ 862 Black Lung (923)
☐ 863 DIWC/DIWW (405(g))
☐ 864 SSID Title XVI
☐ 865 RSI (405(g))

FEDERAL TAX SUITS
☐ 870 Taxes (U.S. Plaintiff or Defendant)
☐ 871 IRS-Third Party 26 USC 7609

FOR OFFICE USE ONLY: Case Number: SACV10-708 JVS (ANx)

AFTER COMPLETING THE FRONT SIDE OF FORM CV-71, COMPLETE THE INFORMATION REQUESTED BELOW.

UNITED STATES DISTRICT COURT, CENTRAL DISTRICT OF CALIFORNIA
CIVIL COVER SHEET

VIII(a). IDENTICAL CASES: Has this action been previously filed in this court and dismissed, remanded or closed? ☑ No ☐ Yes
If yes, list case number(s):

VIII(b). RELATED CASES: Have any cases been previously filed in this court that are related to the present case? ☐ No ☑ Yes
If yes, list case number(s): see attached list

Civil cases are deemed related if a previously filed case and the present case:
(Check all boxes that apply)
☐ A. Arise from the same or closely related transactions, happenings, or events; or
☐ B. Call for determination of the same or substantially related or similar questions of law and fact; or
☐ C. For other reasons would entail substantial duplication of labor if heard by different judges; or
☑ D. Involve the same patent, trademark or copyright, and one of the factors identified above in a, b or c also is present.

IX. VENUE: (When completing the following information, use an additional sheet if necessary.)

(a) List the County in this District; California County outside of this District; State if other than California; or Foreign Country, in which **EACH** named plaintiff resides.
☐ Check here if the government, its agencies or employees is a named plaintiff. If this box is checked, go to item (b).

County in this District:*	California County outside of this District; State, if other than California; or Foreign Country
Orange County	

(b) List the County in this District; California County outside of this District; State if other than California; or Foreign Country, in which **EACH** named defendant resides.
☐ Check here if the government, its agencies or employees is a named defendant. If this box is checked, go to item (c).

County in this District:*	California County outside of this District; State, if other than California; or Foreign Country
	Essex County, New Jersey

(c) List the County in this District; California County outside of this District; State if other than California; or Foreign Country, in which **EACH** claim arose.
Note: In land condemnation cases, use the location of the tract of land involved.

County in this District:*	California County outside of this District; State, if other than California; or Foreign Country
Orange County	

*** Los Angeles, Orange, San Bernardino, Riverside, Ventura, Santa Barbara, or San Luis Obispo Counties**
Note: In land condemnation cases, use the location of the tract of land involved

X. SIGNATURE OF ATTORNEY (OR PRO PER): [signature] **Date** June 2, 2010

Notice to Counsel/Parties: The CV-71 (JS-44) Civil Cover Sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law. This form, approved by the Judicial Conference of the United States in September 1974, is required pursuant to Local Rule 3-1 is not filed but is used by the Clerk of the Court for the purpose of statistics, venue and initiating the civil docket sheet. (For more detailed instructions, see separate instructions sheet.)

Key to Statistical codes relating to Social Security Cases:

Nature of Suit Code	Abbreviation	Substantive Statement of Cause of Action
861	HIA	All claims for health insurance benefits (Medicare) under Title 18, Part A, of the Social Security Act, as amended. Also, include claims by hospitals, skilled nursing facilities, etc., for certification as providers of services under the program. (42 U.S.C. 1935FF(b))
862	BL	All claims for "Black Lung" benefits under Title 4, Part B, of the Federal Coal Mine Health and Safety Act of 1969. (30 U.S.C. 923)
863	DIWC	All claims filed by insured workers for disability insurance benefits under Title 2 of the Social Security Act, as amended; plus all claims filed for child's insurance benefits based on disability. (42 U.S.C. 405(g))
863	DIWW	All claims filed for widows or widowers insurance benefits based on disability under Title 2 of the Social Security Act, as amended. (42 U.S.C. 405(g))
864	SSID	All claims for supplemental security income payments based upon disability filed under Title 16 of the Social Security Act, as amended.
865	RSI	All claims for retirement (old age) and survivors benefits under Title 2 of the Social Security Act, as amended. (42 U.S.C. (g))