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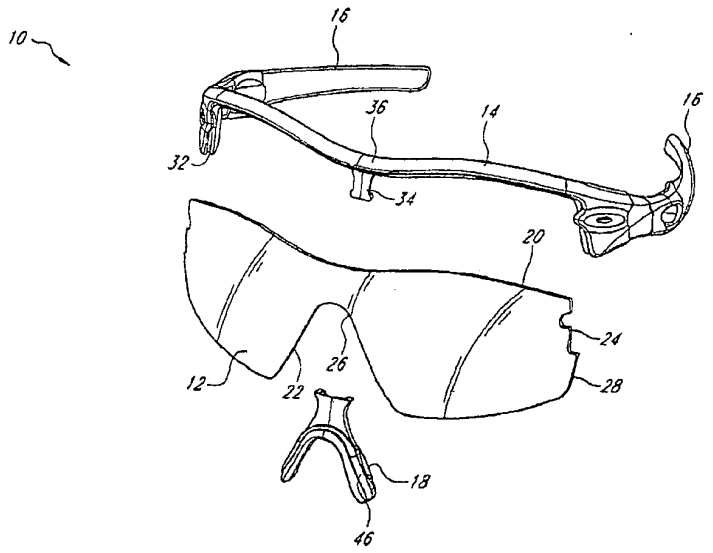

(57) Abstract: An eyeglass (10) is provided for component weight without reducing the overall structural integrity of the eyeglass (10), and for allowing adjustability of the eyeglass (10) to optimize optical and protective qualities during activities having differing head angles and primary lines of sight. The eyeglass (10) can comprise a lens (12), a frame (14), and a nosepiece (18). The frame 14 can have opposing terminals (30) and an upper groove (32) extending at least partially along the frame (14) and a downwardly extending post (34). The nosepiece (18) can have a mounting component (42) extending upwardly to engage the post (34), and the lens (12) can be cooperatively retained between the frame 14 and the nosepiece (18). Sets of corresponding nose pieces and lenses are provided, to optimize the eyeglasses for different primary viewing axes in the vertical plane.

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SPORTS-SPECIFIC SHIELD

BACKGROUND

[0001] The present invention relates generally to eyeglasses, and more particularly to a uniquely configured eyeglass shield that permits a wearer to adjust a frame thereof to provide a variety of vertical viewing angles for specific sporting applications. As discussed in greater detail below, embodiments of the present invention provide a sports-specific shield which can be selectively adjusted by the wearer in order to customize the configuration and fit of the eyeglass shield for beneficial use in specific activities, without requiring the use of tools. The resulting eyeglass shield can therefore be utilized in demanding sporting situations that require either a heads-up or heads-down posture of the wearer, such as competitive running, driving, skiing, or bicycle racing.

[0002] Eyeglasses, and sunglasses in particular, have long been designed with the general objective of blocking the sun or other sources of bright light from one's eyes. Over time, various features and advancements in this technology have been developed. The evolution of numerous designs of dual and unitary lens glasses initially differed essentially only in aesthetic features. However, eyeglass and lens designs have further developed in response to various optical considerations such as optical clarity, resolution, field of vision, refraction, and other such qualities. Typically, the optical qualities of the lens are best when the wearer's line of sight (LOS) extends in parallel to the optical center line (OCL) the lens.

[0003] Although these advancements in eyeglass technology have provided substantial benefits for eyeglass wearers participating in a broad range of activities, several sporting activities often require the wearer to assume body postures that displace the wearer's LOS particularly in the vertical plane from consistently being aligned with the OCL of particular lens. In addition, unique facial structures and geometries can result in different fits that similarly prevent different wearers from commonly enjoying the superior optical characteristics of a given eyeglass.

[0004] Many sporting activities may be characterized as requiring the user to assume either a heads-up or a heads-down posture. In the heads-up posture, which is illustrated in accompanying Figure 6A, a wearer's head is in a generally upright vertical

position directly above the shoulders. Thus, the OCL of the eyeglass lenses and the wearer's LOS tend to be aligned parallel and point more or less straight ahead. Activities such as running, driving, and the like, tend to encourage a heads-up posture of the wearer.

[0005] In the heads-down posture, a wearer assumes a generally forward-leaning posture with the head extending forwardly of the torso, shown generally in Figure 6B. In the heads-down posture, the head is tucked in an aerodynamic position with the OCL of the eyeglass lens typically being directed at the ground in front of the wearer; while the LOS is angularaly displaced upwardly with respect to the long. Thus, in order to optimize forward vision the wearer must lift their head upwardly from the racing posture, in order to bring their LOS into parallel with the OCL. The racing posture also brings the LOS high enough on conventional lenses that the upper frame can limit the field of view in the vertical plane. Activities such as bicycle racing and others commonly require the wearer to assume a heads-down posture for long periods of time.

[0007] Finally, unique facial geometries can prevent some wearers from enjoying superior optical characteristics of a given frame and lens system. A given pair of eyeglasses often fits differently on different wearers due to differences in facial structure. As a result, some wearer's straight-ahead LOS may not pass through the lens in parallel with the OCL. For example, an eyeglass that has been designed to fit a majority of wearers may nevertheless sit too high or too low on certain wearers depending on the structure and geometry of their nose and face. Therefore, the facial structure, as well as the particular activity in which the wearer is engaged, can cause the eyeglass have a particular fit on the wearer that prevents optimal vertical alignment of the OCL of the lens with the desired LOS of the wearer.

SUMMARY

[0008] In light of the above-mentioned deficiencies of eyeglass design, there is a need in the art for an improved eyeglass that allows a wearer to adjust the fit and/or optical orientation of the eyeglass depending on the activity in which the wearer is involved. Further, there is a need in the art for an eyeglass that can be adjusted to provide superior optical qualities that in a variety of eyeglass configurations. There is a need in the art for an adjustable eyeglass that allows the wearer to align their desired LOS with respect to the OCL of the lens and that can be used in both heads-up and heads-down activities. Furthermore,

there is a need in the art for an eyeglass that can be adjusted by the wearer without tools and provides superior frontal impact resistance. Finally, there is a need in the art for an adjustable eyeglass that can be easily modified by the wearer for specific activities that is lightweight, structurally durable, and that provides easy and quick assembly and disassembly, and sufficient protection of the eyes, even in a bicycle racing posture.

[0009] Accordingly, in an embodiment, an eyeglass is provided for minimizing component structural integrity and component weight without reducing the overall structural integrity of the eyeglass. The eyeglass can comprise a unitary lens, a frame, and a nosepiece. The lens can have an upper edge and a lower edge. The upper edge can have lateral indents formed at opposing ends thereof, and the lower edge can have a nosepiece opening formed therein.

[0010] The frame can have opposing terminals and an upper groove extending at least partially along the frame. The upper groove can be sized and configured to receive the upper edge of the lens with the lateral indents of the lens being receivable into the opposing terminals of the frame. Further, the upper groove can have a cross-sectional area defined by a depth and width of the upper groove. Additionally, the frame can further have a post extending downwardly from a central portion of the frame.

[0011] The nosepiece can have a bridge and a mounting component extending upwardly from the bridge. The nosepiece can have a lower groove extending at least partially across the bridge, and the lower groove can be sized and configured such that the lower edge of the lens is receivable therein. The mounting component can be attachable to the post for attaching the nosepiece to the frame. In such an embodiment, the cooperative engagement of the frame to the nosepiece can retain the lens therebetween for minimizing the cross-section of the upper groove without compromising overall lens retention and the overall structural integrity of the eyeglass. For example, the transverse cross-sectional area of the upper groove can be less than approximately 0.05 square inches and in some embodiments no greater than about 0.02 square inches. Further, a maximum thickness of the frame can be less than 90% of a thickness of the lens along the upper edge thereof. Thus, eyeglass weight and structural integrity of individual components can decrease while maintaining the overall structural integrity of the eyeglass.

[0012] In another embodiment, the post can comprises a connecting portion at a distal end thereof. Additionally, the mounting component can comprise a recess being sized and configured to receive at least the connecting portion of the post for attaching the nosepiece to the frame. The recess of the mounting component can be formed into a posterior side of the mounting component. The post can also be formed to connect to the frame posteriorly to the groove. In some embodiments, the post can be integrally formed with the frame. Further, the lens can be configured to be mounted anterior to the post and the mounting component of the nosepiece. Finally, an as-molded configuration of the lens can corresponds to the upper groove of the frame and the lower groove of the nosepiece.

[0013] In accordance with yet another embodiment, the eyeglass can be configured to be adjustable in order to minimize a vertical deviation angle of a wearer in heads-down activities. The vertical deviation angle can be defined as the angular displacement between an optical centerline of the eyeglass and an intended line of sight of the wearer. The lens of the eyeglass can define the optical centerline. In such an embodiment, the mounting component can have a vertical height that is customizable for minimizing a desired vertical deviation angle of the wearer.

[0014] In another embodiment, the eyeglass can be adjustable for optimizing the protective function of the eyeglass throughout a range of vertical viewing angles, while preserving optical quality. In such an embodiment, adjustment of the mounting component's vertical height from a first vertical height to a second vertical height can raise the height of the lens to provide protection while viewing out of the top of the eyeglass, while maintaining a desired relationship between the LOS and OCL.

[0015] The nosepiece of the adjustable eyeglass can be selected from a plurality of nosepieces having different vertical heights. A corresponding plurality of lenses having matched vertical heights is also provided; each with an OCL in the vertical which is selected to correspond to the desired LOS for each lens-nose piece combination.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The abovementioned and other features of the inventions disclosed herein are described below with reference to the drawings of the preferred embodiments. The

illustrated embodiments are intended to illustrate, but not to limit the inventions. The drawings contain the following figures:

[0017] Figure 1 is a perspective exploded front view of an adjustable eyeglass having a frame, lens, and a nose piece, according to an embodiment.

[0018] Figure 2 is a rear view of the frame and nose piece illustrated in Figure 1.

[0019] Figure 3A is a rear view of the eyeglass wherein the frame, lens, and nose piece are in an assembled state.

[0020] Figure 3B is a front view of the eyeglass of Figure 3A.

[0021] Figures 4A-4C illustrate exemplary embodiments of nosepieces wherein a post of the nosepiece has a given vertical height.

[0022] Figure 5A is a front view of the eyeglass wherein the frame and nose piece are assembled prior to installation of the lens, according to another embodiment.

[0023] Figure 5B is a front view of the eyeglass of Figure 5A in an assembled state.

[0024] Figure 6A is a side view of the eyeglass as worn on a wearer in a heads-up posture.

[0025] Figure 6B is a side view of the eyeglass as worn on a wearer in a heads-down posture illustrating a vertical viewing angle defined by a line of sight of the wearer and an optical centerline of the eyeglass.

[0026] Figure 7A is a front view of a prior art eyeglass.

[0027] Figure 7B is a side cross-sectional view of the prior art eyeglass of Figure 7A illustrating depth of a groove within a frame of the eyeglass wherein a lens is retained.

[0028] Figure 8 is a side cross-sectional view of the eyeglass of Figure 3B, illustrating an upper groove within the frame and the interconnection of the lens with the frame.

DETAILED DESCRIPTION

[0029] While the present description sets forth specific details of various embodiments, it will be appreciated that the description is illustrative only and should not be construed in any way as limiting. Furthermore, various applications of such embodiments

and modifications thereto, which may occur to those who are skilled in the art, are also encompassed by the general concepts described herein.

[0030] With reference to Figure 1, an embodiment of a uniquely configured eyeglass 10 is provided that can reduce the overall weight of the eyeglass 10 and improve the optical qualities enjoyed by a wearer during various heads-up and heads-down activities. The eyeglass 10 can be manufactured from a variety of materials and methods. However, according to one of the unique aspects of the present invention, the eyeglass 10 can be assembled using lighter-weight components that may not otherwise be used due to structural strength requirements.

[0031] For example, in previous eyeglass designs, thicker, bulkier, and heavier designs have been used to provide sufficient durability and structural integrity for the eyeglass 10. However, as described further herein, the eyeglass 10 can be formed using lighter-weight components (which consequently may have lesser structural integrity than otherwise comparable heavier-weight components) without reducing the overall structural integrity of the eyeglass. Further, embodiments also provide substantial resistance to torsional and/or bending stresses.

[0032] In addition, an embodiment of the eyeglass 10 can also provide optimal optical characteristics to a wearer at a plurality of vertical viewing angles. As mentioned above, many sporting activities may be characterized as requiring the user to assume either a heads-up or a heads-down posture. In the heads-down posture, the wearer typically directs their desired line of sight (LOS) through an upper area of the eyeglass that may not provide the wearer of prior art glasses with the intended optimal optical qualities of the eyeglass as available when viewing in parallel to through an optical centerline (OCL) of the eyeglass.

[0033] As shown in Figures 6A-6B, the angular divergence in the LOS 80 of the wearer with respect to the OCL 90 of the eyeglass 10 can be referred to as a vertical deviation angle 92. The vertical viewing angle 92 can also be defined as the angular displacement between the OCL 90 of the eyeglass 10 and the LOS 80 of the wearer. By reducing the vertical deviation angle 92, it is contemplated that the wearer can substantially benefit from improved optical qualities of the eyeglass 10 otherwise unavailable during typical heads-down activities and due to non-normal facial structures.

[0034] In Figure 1, the eyeglass 10 is illustrated as including a lens 12, a frame 14, a pair of opposing earpieces 16, and a nosepiece 18. These components of the eyeglass 10 can be configured as snap fit components that allow the wearer to quickly assembly or disassemble the eyeglass 10 without the use of tools. The lens 12 can be formed in a variety of configurations and geometries. Preferably, the lens 12 is configured to be lightweight and to provide superior optical qualities throughout the field of view of the wearer. It is contemplated that the lens 12 can be formed utilizing a dual or unitary design. As shown in Figure 1, the lens 12 has an upper edge 20 and a lower edge 22. As shown in Figures 6A-6B, the lens 12 can also define the optical centerline (OCL) 90. *See e.g.* U.S. Patent No. 6,010,218 to Houston, et al., entitled Decentered Corrected Lens for Eyewear, the disclosure of which is incorporated in its entirety by reference herein, particularly with respect to lens construction, design and optics.

[0035] The upper and lower edges 20, 22 can be formed according to a variety of shapes and contours, as described further below. The lens 12 can also include a pair of opposing lateral indents 24 formed in opposing side edges 28 thereof. The lateral indents 24 can be voids in the lens, and shaped in a variety of designs, as also described further below. Finally, the lens 12 can also include a nosepiece opening 26 whereinto the nosepiece 18 can be at least partially received.

[0036] As shown in Figures 1-2, the frame 14 can be configured to comprise opposing terminals 30 and an upper groove 32, which can collectively form an upper lens receiving portion. In an embodiment, the opposing terminals 30 are sized and configured to mate with at least a portion of the respective ones of the side edges 28 of the lens 12. Preferably, the terminals 30 are formed to removably receive the respective ones of the opposing lateral indents 24 of the lens 12.

[0037] The upper groove 32 can extend at least partially along the frame 14, and preferable extends intermediate the opposing lateral indents 30. The upper groove 32 is preferably sized and configured to receive the upper edge 20 of the lens 12. As shown in the embodiment illustrated in Figure 8, the upper groove 32 can define a lengthwise slot having a width 110 and a depth 112. The upper groove 32 can be formed having internal faces that are of differing or equal dimensions. For example, as shown in Figure 8, a rear face 114 can be

of a greater cross-sectional length than a forward face 116, and can further differ from that of the upper face 118 of the upper groove 32. The rear, forward, and upper faces 114, 116, 118 of the upper groove 32 can be modified to provide varying degrees of retention of the upper edge 20 of the lens 12 within the upper groove 32.

[0038] The opposing terminals 30 can be formed with the upper groove 32 extending at least partially therealong. In this regard, the eyeglass 10 can be at least partially assembled with the lateral indents 24 of the lens 12 being received into the opposing terminals 30 of the frame 12 and the upper edge 20 of the lens 12 being at least partially received within the upper groove 32. As mentioned above, the lateral indents 24 of the lens 12 can be variously configured, and can include distinctive geometric patterns that tend to interlock with a corresponding geometric pattern of the terminals 30. Such a feature can tend to ensure that the lens 12 is urged to within the upper groove 32 and properly fits with the frame 14. Such a feature may also be utilized to help the wear ensure that the lens 12 is in an engaged position with the frame 14 during assembly. As such, the lens 12 can be configured to be received within the upper groove 32 for vertically securing the upper edge 20 of the lens 12, and the opposing lateral indents 24 can be received within the respective ones of the opposing terminals 30 of the frame 14 for horizontally securing the lens 12 to the frame 14.

[0039] In accordance with an embodiment, the frame 14 can further comprise a post 34 extending downwardly from a central portion 36 of the frame 14. The post 34 can be formed in a variety of geometric shapes, as described herein. Preferably, the post 34 can be substantially rectangular in shape and of sufficient width and thickness to provide firm engagement with the nosepiece 18, as discussed further below. The post 34 is preferably integrally formed with the frame 14, such as being formed of a single, continuous piece of material as in injection molding. Alternatively, the post 34 can be formed of separate a material and can be joined to the frame 14 using an adhesive, mechanical interlock, interference fit or other fastener. Finally, as shown in Figure 2, the post 34 can also comprise a connecting portion 38 which may be formed at a distal end 39 of the post 34.

[0040] Figures 1-2 also illustrate an exemplary configuration of the nosepiece 18 wherein the nosepiece 18 has a bridge 40 and a mounting component 42 which may extend upwardly from the bridge 40 and having a vertical height 44. The bridge 40 and the

mounting component 42 are preferably integrally formed, as by injection molding, but can also be formed from separate, joinable materials.

[0041] The nosepiece 18 can further comprise a lower groove 46 that is formed along at least a portion of the bridge 40. For example, the lower groove 46 can extend at least partially along the bridge 40, as shown in Figure 1. The lower groove 46 of the bridge 40 is preferably sized and configured to removably receive the lower edge 22 of the lens 12. In particular, the lower groove 46 can be shaped to conform to the shape and size of the nosepiece opening 26 of the lens 12.

[0042] The mounting component 42 can be sized and configured to be attachable to the post 34 of the frame 14. The attachment of the post 34 to the mounting component 42 can be accomplished in a variety of configurations, such as with male and female-type interlocking connections and other first and second complementary surface structures. For example, one of the post 34 or the mounting component 42 can be formed as a male-type connector that can be removably connected to a corresponding female-type connector of the other one of the post 34 and the mounting component 42.

[0043] As illustrated in Figure 2, a posterior side 50 of the mounting component 42 can be formed to include a recess 54 into which the post 34 can be received. In such an embodiment, the connector portion 38 of the post 34 can be formed to mate with the recess 54 of the mounting component 42. Alternatively, an anterior side 52 of the nosepiece 18 can be configured to include the recess 54. Furthermore, it is also possible that the post 34 could include a recess and the mounting component 42 can be receivable therein. Such alternative embodiments and modifications are considered to be within the scope of the present disclosure and teachings.

[0044] Figures 3A-3B illustrate the cooperative engagement of the lens 12, frame 14, and nosepiece 18. In such an embodiment, the post 34 can be connected to the frame 14 posterior to the upper lens groove 32. In addition, the lens 12 can be configured to be mounted anterior to the post 34 and the mounting component 42 of the nosepiece 18. An as-molded configuration of the lens 12 can correspond to the upper groove 32 of the frame 14 and the lower groove 46 of the nosepiece 18.

[0045] The cooperative engagement provided by such an embodiment can provide significant advantages that can allow for the reduction in weight of such components without reducing the overall durability and structural integrity of the eyeglass 10. Further, in some embodiments, due to the engagement of the side edges 28 and/or lateral indents 24 of the lens 12 with the opposing terminals 30 of the frame 14, the eyeglass 10 can withstand torsional and/or bending stresses. In this regard, it is contemplated that the engagement of the side edges 28 and/or lateral indents 24 of the lens 12 with the opposing terminals 30 of the frame 14 can further stabilize and mitigate against such torsional and bending forces commonly encountered during use of the eyeglass 10. As a result, the lens 12 can be more surely retained by the frame 14 and nosepiece 18.

[0046] Figure 3A is a rear view of the eyeglass 10 in an assembled state, and Figure 3B is a front view thereof. As shown in Figure 3A, the mounting component 42 of the nosepiece 18 is attached to the post 34 of the frame 14 to fix the vertical relative positioning of the nosepiece 18 to the frame 14. Further, with the lens 12 installed, the mounting component 42 is also illustrated as being disposed intermediate the lens 12 and the post 34 of the frame 14 to fix the horizontal relative positioning of the nosepiece 18 relative to the frame 14, as shown in Figures 3A-3B.

[0047] During assembly, the lens 12 can be installed after the assembly of the frame 14 and nosepiece 18, although this is not required. Once assembled, the lens 12 can therefore be cooperatively engaged by the frame 14 and the nosepiece 18, which can be held in fixed relation to each other when the lens 12 is installed. Due to the fixed relationship of the frame 14 and the nosepiece 18, the upper and lower grooves 32, 46 can also be in substantially fixed relation relative to each other, thereby ensuring that the lens 12 is properly retained therein. Thus, such an embodiment can ensure maximum overall retention of the lens 12 and structural integrity of the eyeglass 10.

[0048] As mentioned above, another of the significant advantages provided by embodiments disclosed herein is the reduction, minimization, and/or elimination of the vertical deviation angle that otherwise would have been induced by positioning the upper frame at different vertical heights relative to the wearer's nose. Thus, during activities, such as bicycle racing and others that encourage a heads-down posture, the wearer can adjust the

eyeglass 10 by selectively interchanging the nosepiece 18 and mounting a corresponding lens to change the primary LOS while still allowing the wearer to enjoy the superior optical qualities of the lens 12.

[0049] Referring now to Figures 4A-4C, rear views of various embodiments of the nosepiece 18 are illustrated. As shown therein, the mounting component 42 of a first nosepiece 18' can be of a first vertical height 44', a second nosepiece 18" can correspond to a second vertical height 44", and a third nosepiece 18"' can correspond to a third vertical height 44"'. The vertical height 44 can generally be measured from a nasal apex 48 to a top end 62 of the nosepiece 18. Figures 4A-4C illustrate an exemplary group of nosepieces 18 that can be interchangeably used in some embodiments. These illustrations are provided for illustrative purposes only, and it is contemplated that various other sizes and/or configurations of the nosepiece 18 can be provided. As discussed above, the mounting component 42 can be interconnectable with the post 34 of the frame 14. It is contemplated that the wearer can select a nosepiece 18 having a specific vertical height 44 according to their needs and/or preferences. When fitted onto the eyeglass 10, the selected nosepiece 18 could thus provide a customized fit of the eyeglass 10 on the wearer. Each nosepiece is matched to a corresponding lens which has an OCL positioned in the vertical to remain substantially parallel to a wearer's intended LOS through that lens-nosepiece combination.

[0050] The vertical heights 44 of nosepieces 18 within a group of available nosepieces 18 can lie within a given range. For example, the vertical height 44 of a given one of the nosepieces can be within a preferred range of about one inch, such as +0.75 / -0.250 inches. Height 44 may be, for example, about 0.25", 0.5", 0.75" and 1.0 inch, or two or more nosepieces may be provided with ⅛ inch increments. The range can be broadened or modified depending on the geometries of the eyeglass 10 and in light of other considerations, such as the target activity, target consumer, etc.

[0051] It is contemplated that by interchanging the nosepiece 18 with one having a different vertical height 44, the wearer could modify upper edge of the lens 12 relative to the wearer's nose or straight ahead LOS 80. There can be provided a progression of nosepiece sizes. Thus, the wearer can selectively customize the eyeglass 10 (and also use the eyeglass 10 for various activities) such that the vertical height of the lens and the viewing

angle through the lens are optimized for a particular use, and the wearer's LOS 80 can still pass through the lens 12 more closely to parallel to the OCL, as explained further below with reference to Figure 6A-6B.

[0052] According to another aspect illustrated in Figures 4A-4C, the nosepiece 18 can further comprise a collar portion 56 and nose pad 58. The nose pad 58 can comprise single or dual nose pads that are attached to or formed integrally with the nosepiece 18. The nose pad 58 can be attached to a bottom portion 60 of the nosepiece 18. The collar portion 56 can generally extends intermediate the nose pad 58 and the lower groove 46. In this regard, the collar portion 56 can vary in size and configuration depending on the vertical height of the mounting component 42, as illustrated in Figures 4A-4C.

[0053] Additionally, it is contemplated that the lower groove 46 of the nosepieces 18', 18", and 18"' can be maintained in fixed relation relative to the top end 62 of the nosepieces 18', 18", and 18"'. In the embodiment illustrated in Figure 4A, the nose pad 58 and the lower groove 46 can be positioned generally contiguously to the nosepiece opening 26 of the lens 12 when assembled thereto. However, when the vertical viewing angle 92 is adjusted by increasing the vertical height 44, such as to the vertical height 44" or 44"' of Figures 4B or 4C, respectively, a vertical gap can result between the vertical position of the lower groove 46 and the nose pad 58. Accordingly, the collar portion 56 can help compensate for any such gap by filling the gap therebetween. The collar portion 56 can be solid, perforated, or otherwise configured. Therefore, the face and eyes of the wearer can be protected from air or other matter that could otherwise flow through such a gap.

[0054] Figure 5A illustrates an exploded view of an embodiment of the eyeglass 10 wherein the lens 12 can be installed/engaged onto the frame 14 and the nosepiece 18. Further, when disassembling the eyeglass 10 for adjustment or repair, the lens 12 can be disengaged from the frame 14 and the nosepiece 18 without requiring that other components of the eyeglass 10 be disassembled or removed prior to the disengagement of the lens 14. The engagement and disengagement of the lens is accomplished as described herein (forward and reverse order, respectively), by inserting the upper edge 20 of the lens 12 into the upper groove 32 and the opposing terminals 30, and then inserting the lower edge 22 of the lens 12 into the lower groove 46 of the nosepiece 18. This process can be accomplished by gently

bending the lens 12. The lens 12 can snap into place when properly engaged. In this manner, the wearer can selectively adjust the eyeglass 10 to fit using interchangeable nosepieces 18.

[0055] Figure 5B is a front view of the eyeglass 10 illustrating the installation and fit of a plurality of nosepieces 18', 18", and 18"'. As discussed above, the different vertical heights 44', 44", and 44"' (see Figures 4A-4C) can allow the wearer to adjust the fit of the eyeglass 10 to a corresponding elevation, thereby providing for the adjustment of the vertical viewing angle 92. The configuration of the nosepiece 18 can be modified to include any variety of sizes, shapes, nose pads, materials, collar portion configurations, and other features, and can correspond to an elevation of the eyeglass 10 on the face of the wearer, measured for example, with respect to the wearer's eyebrow.

[0056] Referring now to Figures 6A-6B, side views are shown of a wearer's head having the eyeglass 10 thereon. In Figure 6A, the wearer's head and the eyeglass 10 is in a generally heads-up position, and the OCL 90 of the lens 12 is generally horizontal (straight ahead). Further, the LOS 80 of the wearer is also generally horizontal, and substantially parallel with the OCL 90 of the lens 12.

[0057] However, in Figure 6B, an eyeglass 82 is illustrated in hidden lines wherein the eyeglass 82 is not adjusted to compensate for the vertically elevated (with respect to the lens) LOS 80. Thus, the LOS 80 of the wearer would pass through an upper portion of the lens of the eyeglass 82, closer to the upper frame. Such as result provides poor optical results and also inferior protection from wind, light and debris. In addition, the wearers LOS 80 could be obstructed by the frame of the eyeglass 82. In any event, with the frame of the eyeglass being so close to the LOS 80, the wearer's field of view could certainly be reduced.

[0058] In contrast, Figure 6B also shows an eyeglass 84 wherein the vertical height of the nosepiece has been increased and a lens with a corresponding configuration has been inserted to reduce the vertical deviation angle 92 and provide superior eye protection. As shown in Figure 6B, the LOS 80 of the wearer tends to pass more closely through a central portion of the lens, and is more aligned with the OCL 90 of the lens. Such an implementation can tend to improve the overall optical qualities enjoyed by the wearer. Further, such an embodiment tends to ensure that the wearer's LOS 80 is not obstructed by the frame of the eyeglass 84 when the wearer assumes a head-down posture.

[0059] Figures 7A-7B illustrate front and cross-section views, respectively, of an exemplary prior art sunglass 100. The sunglass 100 includes a frame 101, a lens 102, and a nosepiece 104. The frame 101 includes a groove 106 and the lens 102 has an upper edge 108 that is received into the groove 106 of the frame 101. As shown in the cross-sectional view of Figure 7B, the groove 106 is used to entirely support the lens 102 and the nosepiece 104. Thus, the groove 106 of such a sunglass 100 must be particularly deep, thick, and generally more robust. In some prior art sunglasses, the lens groove can be as deep as 0.10 inches. As a result, the overall weight and appearance of the sunglass 100 may be heavier and more bulky.

[0060] In contrast, a side view of the embodiment illustrated in Figure 5B is shown in Figure 8, which further illustrates the above-mentioned features of lightweight configuration and cooperative engagement of the eyeglass 10. As shown therein, the upper groove 32 be generally defined by the width 110 and the depth 112. In further contrast to the prior art sunglass of Figures 7A-B, the depth 112 of the eyeglass 10 can be within the range of about 0.030-0.080 inches. Preferably, the depth 112 is less than or equal to about 0.050 inches. The much smaller depth 112 consequently allows more material to be removed from the frame 14, thereby allowing the weight of the frame to be reduced, due to the structural contribution of the nose-piece and lens.

[0061] In some embodiments of the frame 14, the maximum thickness 120 of the frame 14 in the vertical dimension is preferably less than 90% of the thickness of the lens 12, for example, along the upper edge 20 of the lens 12. In other embodiments, the thickness of the lens 12 can also be greater than the thickness 120 of the frame 14 in the vertical direction. The maximum width 122 of the frame 14 in the horizontal dimension is preferably less than 350% of the thickness of the lens 12. As illustrated in Figure 8, the contour and cross-sectional configuration of the frame 14 can be variously designed. Therefore, the dimensions and shape of the frame 14 can be modified. However, it is contemplated that the cross-section of the frame 14 can be substantially minimized by employing the teachings herein.

[0062] As mentioned above, the upper groove 32 can be formed having internal faces that are of differing or equal dimensions. The upper groove 32 can have a cross-sectional area defined by the width 110 and the depth 112, and perhaps by the rear face 114,

forward face 116, and the upper face 118. Preferably, the cross-sectional area of the upper groove 32 is approximately equal to or less than 0.02 square inches. In this regard, the cross-sectional area of the lens 12 that is engaged within the upper groove 32 can preferably be less than approximately 0.02 square inches. The rear face 114 can be of a greater cross-sectional length than a forward face 116, and can further differ from that of the upper face 118 of the upper groove 32. The rear, forward, and upper faces 114, 116, 118 of the upper groove 32 can be modified to provide varying degrees of retention of the upper edge 20 of the lens 12 within the upper groove 32.

[0063] Although these inventions have been disclosed in the context of certain preferred embodiments and examples, it will be understood by those skilled in the art that the present inventions extend beyond the specifically disclosed embodiments to other alternative embodiments and/or uses of the inventions and obvious modifications and equivalents thereof. In addition, while several variations of the inventions have been shown and described in detail, other modifications, which are within the scope of these inventions, will be readily apparent to those of skill in the art based upon this disclosure. It is also contemplated that various combination or sub-combinations of the specific features and aspects of the embodiments may be made and still fall within the scope of the inventions. It should be understood that various features and aspects of the disclosed embodiments can be combined with or substituted for one another in order to form varying modes of the disclosed inventions. Thus, it is intended that the scope of at least some of the present inventions herein disclosed should not be limited by the particular disclosed embodiments described above.

WHAT IS CLAIMED IS:

1. An eyeglass for minimizing component weight without reducing the overall structural integrity of the eyeglass, the eyeglass comprising:

a unitary lens having an upper edge and a lower edge, the upper edge having lateral connectors formed at opposing ends thereof, the lower edge having a nosepiece opening formed therein;

a frame having opposing terminals and an upper groove extending at least partially along the frame, the upper groove being sized and configured to receive the upper edge of the lens with the lateral connectors of the lens being receivable into the opposing terminals of the frame, the upper groove having a cross-sectional area defined by a depth and width of the upper groove, the frame further having a post extending downwardly from a central portion of the frame; and

a nosepiece having a bridge and a mounting component extending upwardly from the bridge, the nosepiece having a lower groove extending at least partially across the bridge, the lower groove being sized and configured with the lower edge of the lens being receivable therein, the mounting component being attachable to the post for attaching the nosepiece to the frame;

wherein cooperative engagement of the frame to the nosepiece is operative to retain the lens therebetween for minimizing the cross-section of the upper groove without compromising overall lens retention and the overall structural integrity of the eyeglass.

2. The eyeglass of Claim 1 wherein the cross-sectional area of the upper groove is approximately less than 0.02 square inches.

3. The eyeglass of Claim 1 wherein a maximum thickness of the frame is less than 90% of a thickness of the lens along the upper edge thereof.

4. The eyeglass of Claim 1 wherein the post comprises a connecting portion at a distal end thereof, and the mounting component comprises a recess being sized and configured to receive at least the connecting portion of the post for attaching the nosepiece to the frame.

5. The eyeglass of Claim 1 wherein the post connects to the frame posteriorly to the groove.

6. The eyeglass of Claim 1 wherein the post is integrally formed with the frame.

7. The eyeglass of Claim 1 wherein the recess of the mounting component is formed into a posterior side of the mounting component.

8. The eyeglass of Claim 1 wherein an as-molded configuration of the lens corresponds to the upper groove of the frame and the lower groove of the nosepiece.

9. The eyeglass of Claim 1 wherein the lens is configured to be mounted anterior to the post and the mounting component of the nosepiece.

10. An adjustable eyeglass for optimizing a vertical viewing angle of a wearer during a heads-down activity, comprising:

a unitary lens having an upper edge and a lower edge and defining the optical centerline;

a frame having an upper lens receiving portion and a post, the upper lens receiving portion extending at least partially along the frame, the post extending downwardly from a central portion of the frame, the post being integrally formed with the frame; and

a nosepiece having a bridge and a mounting component extending upwardly from the bridge, the nosepiece having a lower groove extending at least partially across the bridge, the lower groove being sized and configured with the lower edge of the lens being receivable therein, the mounting component being attachable to the post for attaching the nosepiece to the frame and for supporting the lens between the nosepiece and the frame, the mounting component having a vertical height, the vertical height of the nosepiece being customizable for optimizing the vertical viewing angle of the wearer.

11. The eyeglass of Claim 10 wherein the nosepiece is selected from a plurality of nosepieces having different vertical heights.

12. The eyeglass of Claim 11 wherein a selected nosepiece is interchangeable with another selected nosepiece.

13. The eyeglass of Claim 10 wherein the nosepiece further comprises a nose pad and a collar portion, the nose pad being formed along a bottom portion of the bridge, the collar portion being formed along the bridge and extending intermediate the lower groove of the bridge and the nose pad.

14. The eyeglass of Claim 13 wherein the collar portion varies in size relative to the vertical height of the mounting component.

15. The eyeglass of Claim 10 wherein the post comprises a connecting portion at a distal end thereof, and the mounting component comprises a recess being sized and configured to receive at least the connecting portion of the post for attaching the nosepiece to the frame.

16. The eyeglass of Claim 15 wherein the recess of the mounting component is formed into a posterior side of the mounting component.

17. The eyeglass of Claim 10 wherein the post extends downwardly from a central portion of the frame posterior to the lens receiving portion of the frame.

18. An adjustable eyeglass system for optimizing optical characteristics of the eyeglass along a line of sight of a wearer, the eyeglass comprising:

at least a first and a second unitary lenses having an upper edge and a lower edge, each lens defining an optical centerline;

a frame having an upper groove and a post, the upper groove extending at least partially along the frame, the post extending downwardly from a central portion of the frame, the post being integrally formed with the frame; and

at leas a first and a second nosepiece having a bridge and a mounting component extending upwardly from the bridge, the mounting component being attachable to the post for attaching the nosepiece to the frame and for cooperatively retaining the lens between the nosepiece and the frame, the mounting components having a first and a second vertical height;

wherein removing the first nose piece and first lens and mounting the second nose piece and second lens to the frame moves the optical centerline from a first angle to a second angle with respect to a straight ahead line of sight, and changes the height of the lens in the vertical relative to the wearer's straight ahead line of sight.

19. The eyeglass of Claim 18 wherein the second lens has a greater vertical height above the nose piece opening than the first lens.

20. The eyeglass of Claim 18 wherein the nosepieces are selected from a plurality of nosepieces having different vertical heights, the selected nosepiece being interchangeable with another selected nosepiece.

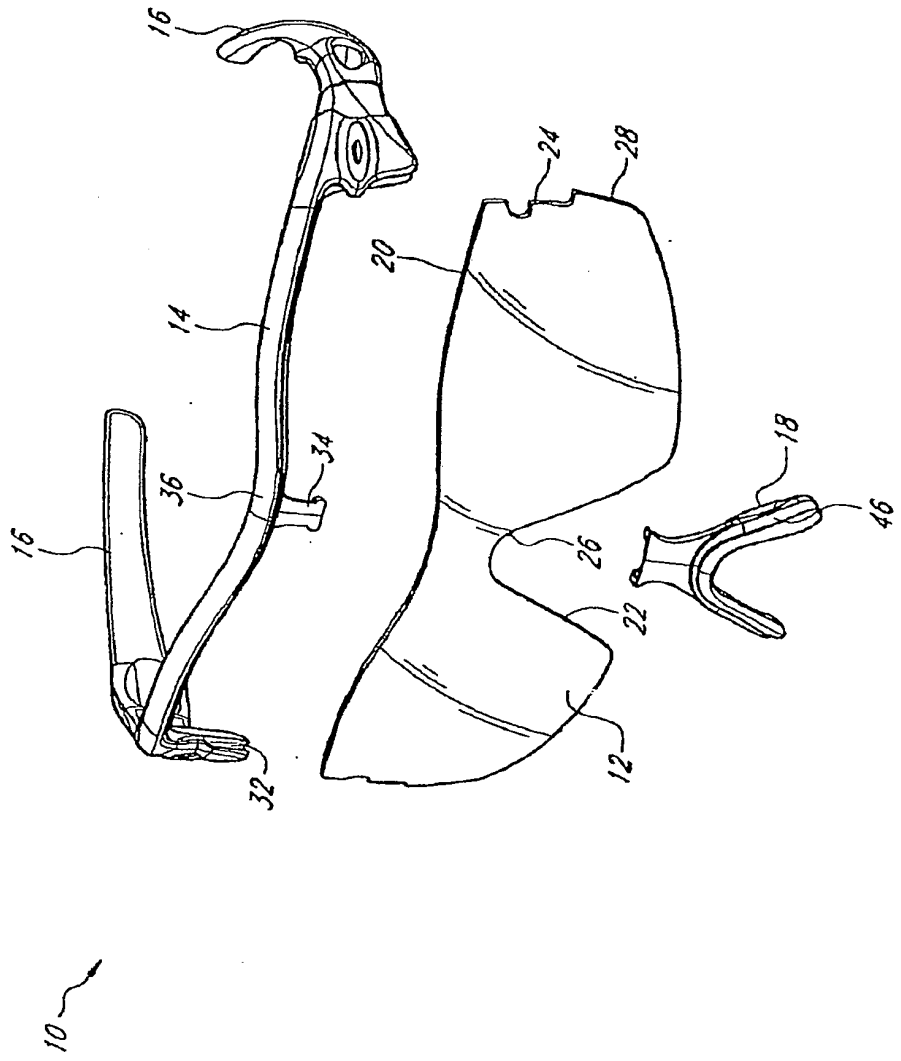

FIG. 1

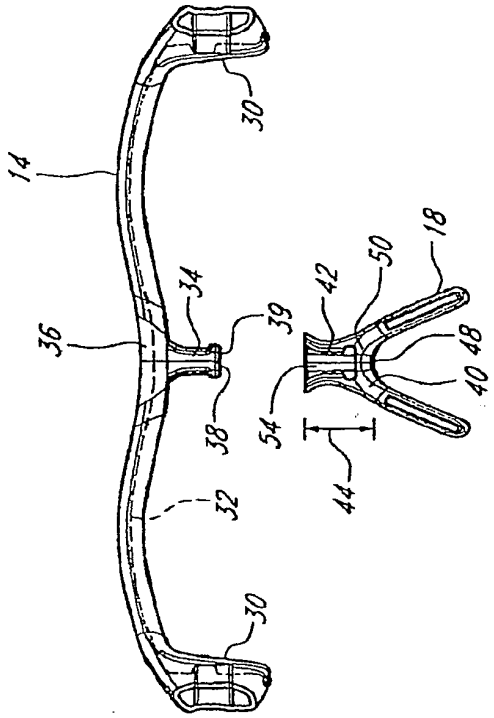

FIG. 2

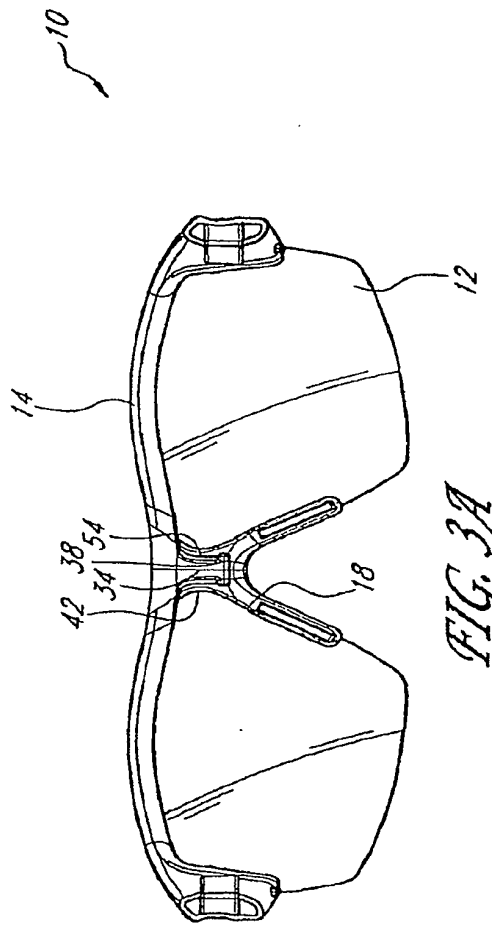

FIG. 3A

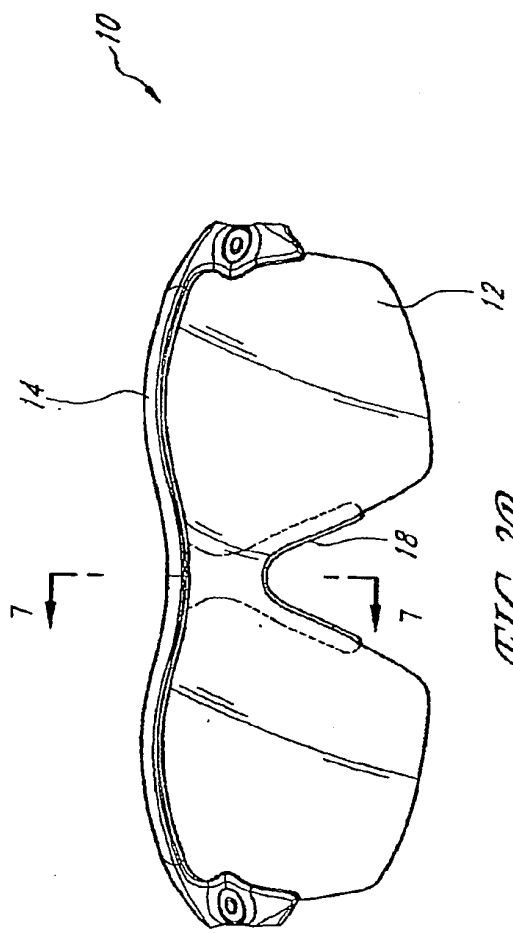

FIG. 3B

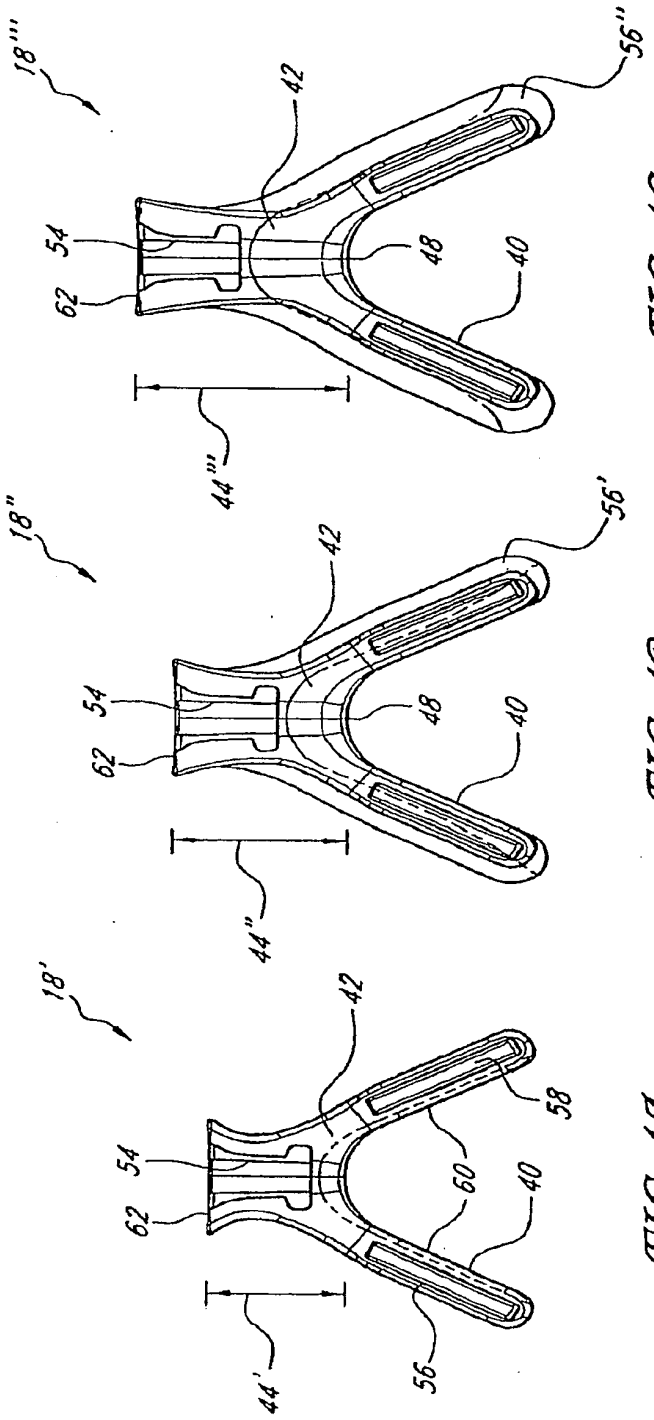

FIG. 4C

FIG. 4B

FIG. 4A

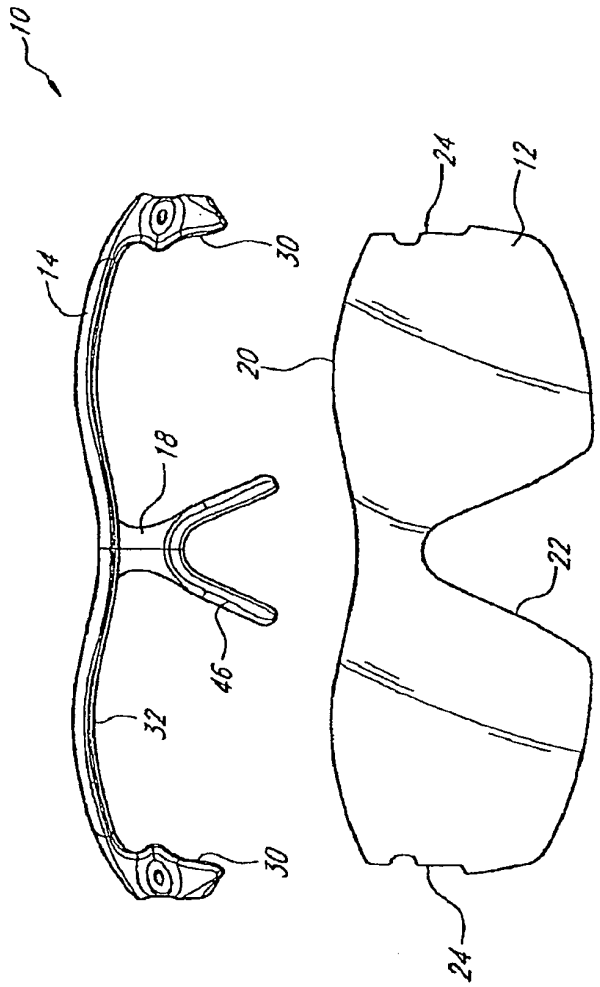

FIG. 5A

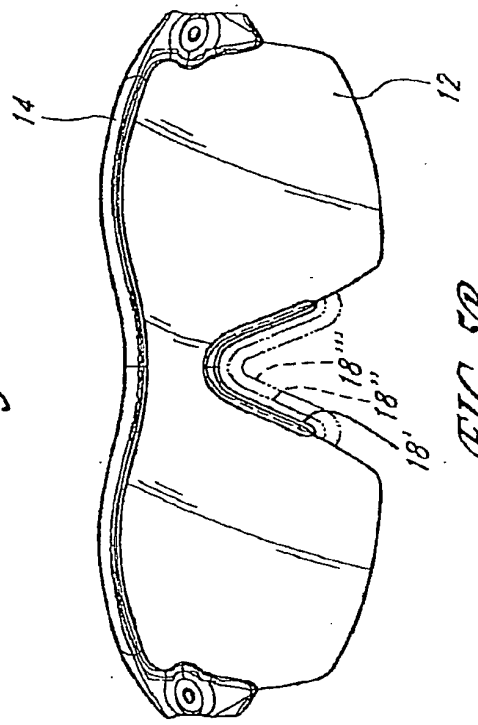

FIG. 5B

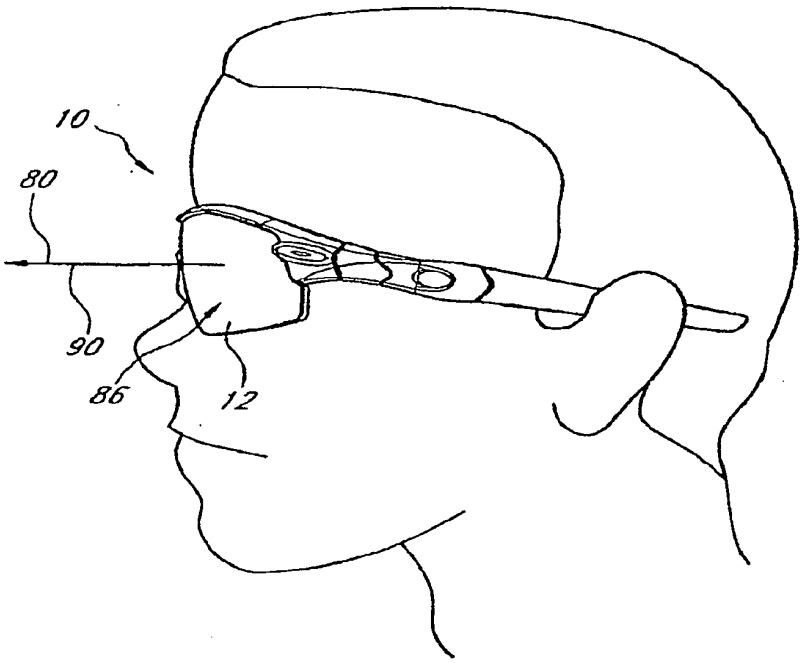

FIG. 6A

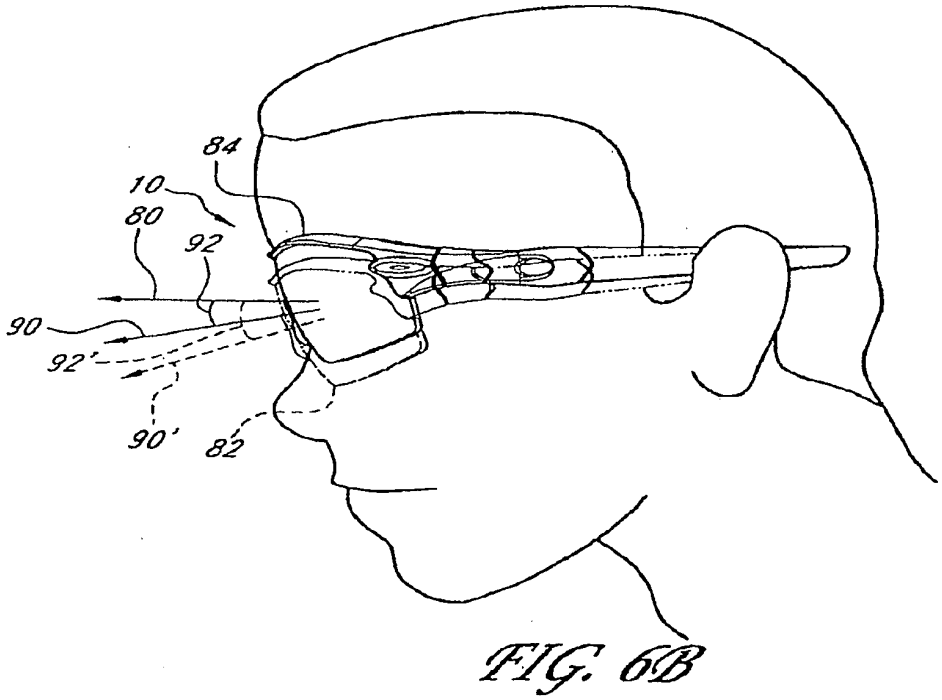

FIG. 6B

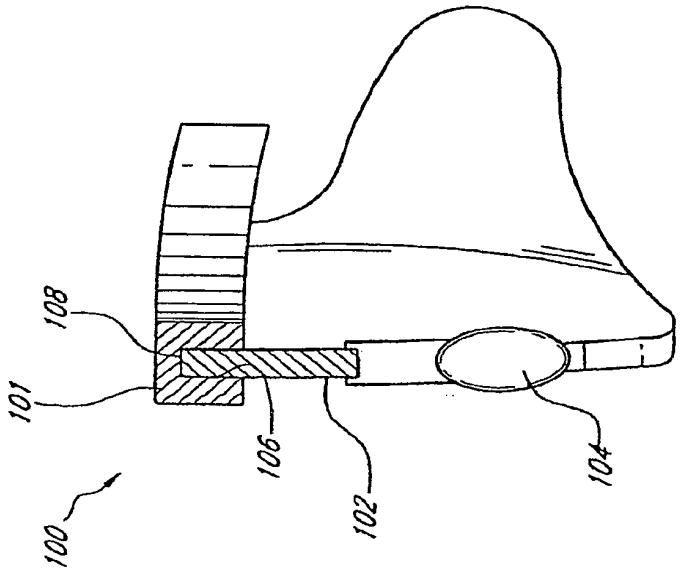

FIG. 7B
(PRIOR ART)

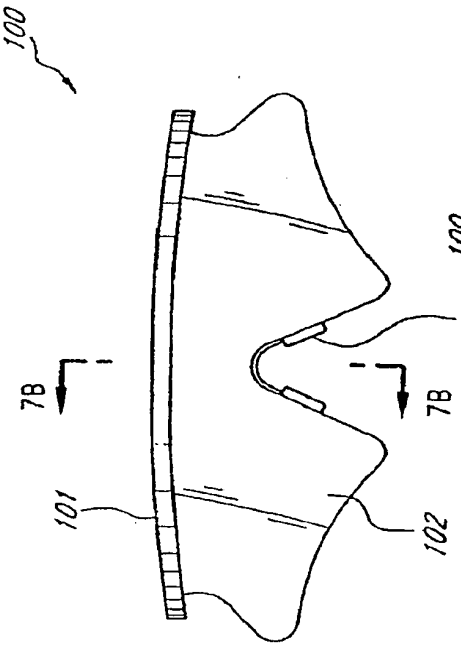

FIG. 7A
(PRIOR ART)

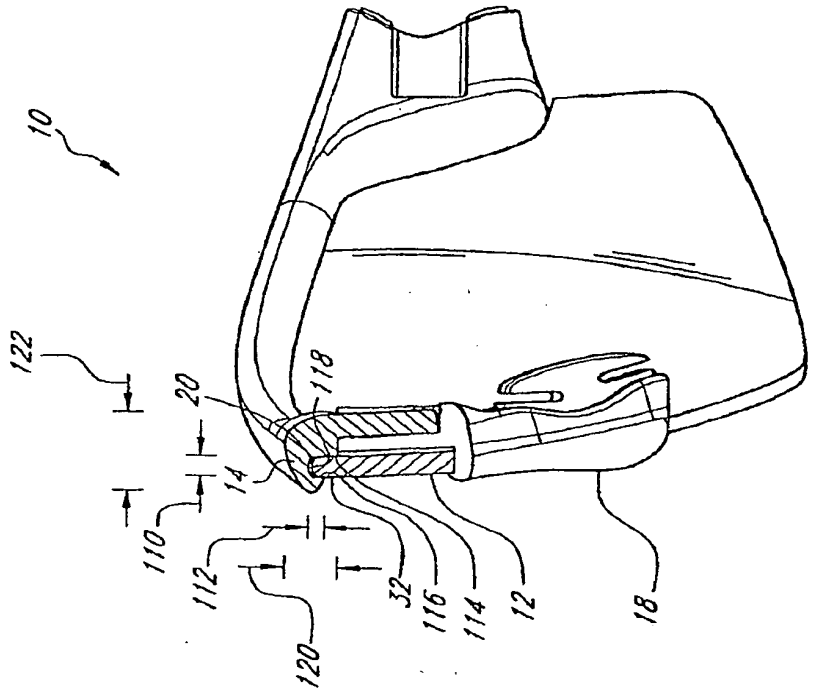

FIG. 8

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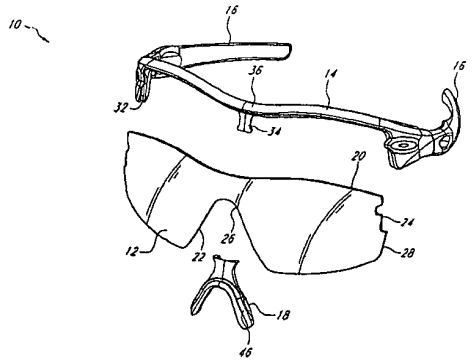
权利要求书 4 页 说明书 13 页 附图 8 页

[54] 发明名称

体育专项防护

[57] 摘要

提供了一种眼镜(10)，用于在不降低眼镜(10)的整体结构完整性的情况下的部件重量，并用于允许眼镜(10)的可调节性以在具有不同头部角度和主要视线的活动中优化光学和保护质量。眼镜(10)可包括镜片(12)、框架(14)和鼻梁架(18)。框架(14)可具有相对的端部(30)、至少部分地沿着框架(14)延伸的上部沟槽(32)以及向下延伸的柱部(34)。鼻梁架(18)可具有向上延伸以接合柱部(34)的安装件(42)和可共同地被保持在框架(14)与鼻梁架(18)之间的镜片(12)。提供了成套的对应的鼻梁架和镜片，以便为垂直面内的不同的主要视线对眼镜进行优化。



1. 一种眼镜，用于在不降低所述眼镜的整体结构完整性的情况下使部件重量最小化，所述眼镜包括：

单一的镜片，具有上边缘和下边缘，所述上边缘具有在其相对端处形成的侧连接器，所述下边缘具有形成于其内部的鼻梁架开口；

框架，具有相对的端部和至少部分地沿着所述框架延伸的上部沟槽，所述上部沟槽的大小和构造被确定成接纳所述镜片的所述上边缘，并且所述镜片的所述侧连接器可被接纳在所述框架的所述相对的端部中，所述上部沟槽具有由所述上部沟槽的深度和宽度限定的横截面积，所述框架进一步具有从所述框架的中央部向下延伸的柱部；以及

鼻梁架，具有中梁和从所述中梁向上延伸的安装件，所述鼻梁架具有至少部分地横过所述中梁延伸的下部沟槽，所述下部沟槽的大小和构造被确定成在所述下部沟槽中可接纳所述镜片的所述下边缘，所述安装件可被附接至所述柱部以便将所述鼻梁架附接至所述框架；

其中，所述框架与所述鼻梁架的共同接合所起的作用是将所述镜片保持在所述框架与所述鼻梁架之间，以在不损害所述眼镜的整体镜片保持力和整体结构完整性的情况下使所述上部沟槽的横截面最小化。

2. 如权利要求 1 所述的眼镜，其中，所述上槽的所述横截面积大约小于 0.02 平方英寸。

3. 如权利要求 1 所述的眼镜，其中，所述框架的最大厚度小于沿着所述镜片的所述上边缘的所述镜片的厚度的 90%。

4. 如权利要求 1 所述的眼镜，其中，所述柱部包括位于其末端的连接部，所述安装件包括凹口，所述凹口的大小和构造被确定成至少接纳所述柱部的所述连接部以便将所述鼻梁架附接至所述框架。

5. 如权利要求 1 所述的眼镜，其中，所述柱部可在所述沟槽的后面连接至所述框架。

6. 如权利要求 1 所述的眼镜，其中，所述柱部与所述框架一体地形成。

7. 如权利要求 1 所述的眼镜，其中，所述安装件的所述凹口形成于所述安装件的后侧部中。

8. 如权利要求 1 所述的眼镜，其中，所述镜片的模制出的构造符合所述框架的所述上部沟槽和所述鼻梁架的所述下部沟槽。

9. 如权利要求 1 所述的眼镜，其中，所述镜片被构造成被安装在所述柱部和所述鼻梁架的所述安装件的前面。

10. 一种可调整的眼镜，用于在采取低头姿势的活动中优化佩戴者的垂直视角，包括：

单一的镜片，具有上边缘和下边缘，并且限定光学中心线；

框架，具有上部镜片接纳部和柱部，所述上部镜片接纳部至少部分地沿着所述框架延伸，所述柱部从所述框架的中央部向下延伸，所述柱部与所述框架一体地形成；以及

鼻梁架，具有中梁和从所述中梁向上延伸的安装件，所述鼻梁架具有至少部分地横过所述中梁延伸的下部沟槽，所述下部沟槽的大小和构造被确定成在所述下部沟槽中可接纳所述镜片的所述下边缘，所述安装件可被附接至所述柱部以便将所述鼻梁架附接至所述框架并在所述鼻梁架与所述框架之间支撑所述镜片，所述安装件具有垂直高度，所述鼻梁架的所述垂直高度可被定制以优化所述佩戴者的所述垂直视角。

11. 如权利要求 10 所述的眼镜，其中，所述鼻梁架选自具有不同

垂直高度的多个鼻梁架。

12. 如权利要求 11 所述的眼镜，其中，被选择的鼻梁架与另一被选择的鼻梁架可互换。

13. 如权利要求 10 所述的眼镜，其中，所述鼻梁架进一步包括鼻垫和轭部，所述鼻垫沿着所述中梁的底部形成，所述轭部沿着所述中梁形成并且在所述中梁的所述下部沟槽与所述鼻垫的中间延伸。

14. 如权利要求 13 所述的眼镜，其中，所述轭部的大小相对于所述安装件的所述垂直高度变化。

15. 如权利要求 10 所述的眼镜，其中，所述柱部包括位于其末端的连接部，所述安装件包括凹口，所述凹口的大小和构造被确定成至少接纳所述柱部的所述连接部以便将所述鼻梁架附接至所述框架。

16. 如权利要求 15 所述的眼镜，其中，所述安装件的所述凹口形成于所述安装组件的后侧部中。

17. 如权利要求 10 所述的眼镜，其中，所述柱部在所述框架的所述镜片接纳部的后面从所述框架的中央部向下延伸。

18. 一种可调整的眼镜系统，用于沿着佩戴者的视线优化所述眼镜的光学特性，所述眼镜包括：

至少第一和第二单一的镜片，具有上边缘和下边缘，每个镜片限定光学中心线；

框架，具有上部沟槽和柱部，所述上部沟槽至少部分地沿着所述框架延伸，所述柱部从所述框架的中央部向下延伸，所述柱部与所述框架一体地形成；以及

至少第一和第二鼻梁架，具有中梁和从所述中梁向上延伸的安装

件，所述安装件可被附接至所述柱部以便将所述鼻梁架附接至所述框架，从而共同将所述镜片保持在所述鼻梁架与所述框架之间，所述安装件具有第一和第二垂直高度；

其中，通过移除所述第一鼻梁架和第一镜片以及将第二鼻梁架和第二镜片安装至所述框架，将所述光学中心线从第一角度向与正前视线有关的第二角度移动，并且相对于所述佩戴者的正前视线改变所述镜片的在垂直方向上的高度。

19. 如权利要求 18 所述的眼镜，其中，所述第二镜片在所述鼻梁架的开口上方的垂直高度大于所述第一镜片。

20. 如权利要求 18 所述的眼镜，其中，所述鼻梁架选自具有不同垂直高度的多个鼻梁架，所述被选择的鼻梁架与另一被选择的鼻梁架可互换。

体育专项防护

背景技术

本发明大体上涉及眼镜，更具体地涉及特有构造的眼镜防护，允许佩戴者调节其框架以便为专项体育应用提供多种垂直视角。如下文所更详细地讨论，本发明的实施方式提供了一种体育专项防护（sports-specific shield），可由佩戴者在不使用工具的情况下进行选择性地调节，以便定制眼镜防护的构造和佩戴，从而获得在特定活动中的有益应用。因此，由此得到的眼镜防护可用于需要佩戴者采取抬头或低头姿势的苛求的运动场合比如，竞技性奔跑、驾驶、滑雪或自行车竞赛。

长期以来，设计眼镜、尤其是太阳镜的一般性目标是将人眼与太阳或其它亮光源阻隔。随着时间的过去，这种技术的各种特性和进步已得到了发展。大量的双镜片和单镜片眼镜的设计的演变最初基本上仅在美学特性上有所变化。然而，眼镜和镜片设计已经进一步发展以适应各种光学考虑因素，比如，光透明度（optical clarity）、分辨率、视野、折射及其它的这类特性。常规地，当佩戴者的视线（LOS）平行于镜片的光学中心线（OCL）延伸时，镜片的光学质量是最好的。

尽管眼镜技术的这些进步已经为参加广泛活动的眼镜佩戴者提供了基本的益处，但是某些体育活动常常需要佩戴者采取某种身体姿势，使得尤其位于垂直平面内的佩戴者的 LOS 从与特定镜片的 OCL 持续对准的状态移开。此外，独特的面部结构和形状可导致佩戴的不同，同样地使不同的佩戴者不能普遍地享受给定眼镜的较好的光学特征。

许多体育活动的特征在于要求使用者采取抬头或低头的姿势。在如图 6A 所示的抬头姿势中，佩戴者的头部位于完全在肩部上方的大体上竖直的位置。因而，眼镜镜片的 OCL 和佩戴者的 LOS 倾向于平行排列并且或多或少地指向正前。例如奔跑、驾驶等的活动倾向于促使佩戴者采取抬头姿势。

在大体上如图 6B 所示的低头姿势中，佩戴者采取大体上前倾的姿势，同时头部伸到躯干的前方。在低头姿势中，头部收低至空气动力学的位置，此时眼镜镜片的 OCL 常规地指向佩戴者前方的地面；同时 LOS 关于该线向上有角度地偏移。因而，为了优化前方视野，佩戴者必须将其头部从竞赛姿势向上抬起，以使其 LOS 与 OCL 平行。竞赛姿势还使 LOS 比传统的镜片高到足以使上框架可能在垂直平面内限制视野。比如自行车竞赛以及其它的活动通常要求佩戴者长时间采取低头姿势。

最后，独特的面部形状可能阻止某些佩戴者享受给定框架和镜片系统的较好的光学特征。由于面部结构的差异，一副给定的眼镜常常以不同的方式适合不同的佩戴者。因此，某些佩戴者的正前的 LOS 可能不会平行于 OCL 穿过镜片。例如，已经被设计为适合多数佩戴者的眼镜可能由于某些佩戴者的鼻子和脸部的结构和形状不同而架的太高或者太低。因此，面部结构和佩戴者所参与的具体活动可导致佩戴者佩戴眼镜的一种特定方式，这种方式阻止镜片的 OCL 与佩戴者期望的 LOS 光学垂直对准。

发明内容

根据眼镜设计的上述缺点，本领域需要一种改进的眼镜，这种眼镜允许佩戴者依据其所参加的活动调节眼镜的佩戴和/或光学方向。进一步地，本领域需要一种眼镜，这种眼镜可被调节以便在多种眼镜构造中提供较好的光学质量。本领域需要一种可调整的眼镜，这种眼镜允许佩戴者将其所期望的 LOS 关于镜片的 OCL 对准，并且可用于采取抬头姿势和低头姿势的活动中。而且，本领域需要一种眼镜，这种眼镜可由佩戴者不使用工具进行调节，并且提供较好的抗正面冲击性。最后，本领域需要一种可调整的眼镜，这种眼镜可由佩戴者容易地进行调节以用于专项活动，而且这种眼镜是轻质的、结构上经久耐用的，并且提供容易和快速的组装和拆卸，甚至在采取自行车竞赛姿势的情况下对眼睛提供充分的保护。

因此，在实施方式中提供了一种眼镜，用于在不降低所述眼镜的

整体结构完整性的情况下使部件结构完整性和部件重量最小化。所述眼镜可包括单一的镜片、框架和鼻梁架。所述镜片可具有上边缘和下边缘。所述上边缘可具有在其相对端处形成的侧凹口，所述下边缘具有形成于其内部的鼻梁架开口。

所述框架可具有相对的端部和至少部分地沿着所述框架延伸的上部沟槽。所述上部沟槽的大小和构造可被确定成接纳所述镜片的所述上边缘，并且所述镜片的所述侧凹口可被接纳在所述框架的所述相对的端部中。进一步地，所述上部沟槽可具有由所述上部沟槽的深度和宽度限定的横截面积。此外，所述框架可进一步具有从所述框架的中央部向下延伸的柱部。

所述鼻梁架可具有中梁和从所述中梁向上延伸的安装件。所述鼻梁架可具有至少部分地横过所述中梁延伸的下部沟槽，所述下部沟槽的大小和构造可被确定成在其中可接纳所述镜片的所述下边缘。所述安装件可被附接至所述柱部以将所述鼻梁架附接至所述框架。在该实施方式中，所述框架与所述鼻梁架的共同接合可将所述镜片保持在所述框架与所述鼻梁架之间，以便在不损害所述眼镜的整体镜片保持力和整体结构完整性的情况下使所述上部沟槽的横截面最小化。例如，所述上槽的所述横截面积可小于大约 0.05 平方英寸，而在某些实施方式中，所述横截面积可不大于大约 0.02 平方英寸。进一步地，所述框架的最大厚度小于沿着所述镜片的所述上边缘的所述镜片的厚度的 90%。因而，在保持所述眼镜的所述整体结构完整性的同时，可降低眼镜的重量和单个部件的结构完整性。

在另一实施方式中，所述柱部可包括位于其末端的连接部。另外，所述安装件可包括凹口，所述凹口的大小和构造被确定成至少接纳所述柱部的所述连接部以将所述鼻梁架附接至所述框架。所述安装部的所述凹口可形成于所述安装件的后侧部中。所述柱部可被形成为在所述沟槽的后面连接至所述框架。在某些实施方式中，所述柱部可与所述框架一体地形成。进一步地，所述镜片可被构造成被安装在所述柱部和所述鼻梁架的所述安装件的前面。最后，所述镜片的模制出的构造可符合所述框架的所述上部沟槽和所述鼻梁架的所述下部沟槽。

根据又一实施方式，所述眼镜可被构造成是可调整的，以便在采取低头姿势的活动中使佩戴者的垂直偏移角最小化。所述垂直偏移角可被定义为所述眼镜的光学中心线与佩戴者的所期望的视线之间的角偏移。所述眼镜的所述镜片可限定光学中心线。在该实施方式中，安装件可具有可定制的垂直高度，以使佩戴者的期望的垂直偏移角最小化。

在另一实施方式中，所述眼镜是可调整的，以在整个垂直视角范围内优化所述眼镜的保护功能，同时保持光学质量。在该实施方式中，将安装件的垂直高度从第一垂直高度调整至第二垂直高度可增加镜片的垂直高度，以便在观察到眼镜的顶部之外时提供保护，同时维持 LOS 与 OCL 之间的期望的关系。

可调整的眼镜的鼻梁架可选自具有不同垂直高度的多个鼻梁架。还提供了具有匹配的垂直高度的对应的多个镜片；每个镜片的位于垂直面内的OCL被选择成符合对于每个镜片-鼻梁架组合的期望的LOS。

附图说明

下面参照优选实施方式的附图对本文所公开的本发明的上述和其它特征进行描述。图示的实施方式旨在说明而非限制本发明。附图包括下列各图：

图 1 是根据实施方式的具有框架、镜片和鼻梁架的可调整的眼镜的前方分解立体图；

图 2 是图 1 所示的框架和鼻梁架的后视图；

图 3A 是眼镜的后视图，其中框架、镜片和鼻梁架处于组装状态；

图 3B 是图 3A 的眼镜的正视图；

图 4A-4C 图示了鼻梁架的示例性实施方式，其中鼻梁架的柱部具有给定的垂直高度。

图 5A 是根据另一实施方式的眼镜的正视图，其中框架和鼻梁架在安装镜片前被组装在一起；

图 5B 是处于组装状态的图 5A 的眼镜的正视图；

图 6A 是由处于抬头姿势的佩戴者佩戴眼镜的侧视图；

图 6B 是由处于低头姿势的佩戴者佩戴眼镜的侧视图，其中图示了由佩戴者的视线和眼镜的光学中心线所限定的垂直视角；

图 7A 是现有技术的眼镜的正视图；

图 7B 是图 7A 的现有技术的眼镜的侧视横截面图，其中图示了在其中保持有镜片的眼镜的框架内的沟槽的深度；

图 8 是图 3B 的眼镜的侧视横截面图，其中示出了框架内的上部沟槽以及镜片与框架的互相连接。

具体实施方式

虽然本发明说明书阐述了各种实施方式的具体细节，但是可以理解本说明书仅是示例性的，并且不应以任何方式解释为限制性的。而且，可由本领域技术人员想到的这些实施方式的各种应用及其修改也包含在本文所描述的一般概念内。

参照图 1，本发明提供了特有构造的眼镜 10 的实施方式，可减小眼镜 10 的整体重量，并可改善由佩戴者在各种采取抬头和低头姿势的活动中所享受的光学质量。眼镜 10 可由各种材料和方法制造。然而，根据本发明的特有方面中的一个，可使用轻质部件组装眼镜 10，或者因结构强度方面的要求也可以不使用这种部件。

例如，在过去的眼镜设计中，采用较厚、较大和较重的设计来为眼镜 10 提供充分的耐用性和结构完整性。然而，如本文进一步所述，在不不降低眼镜的整体结构完整性的情况下，可利用轻质部件（因而与较重部件相比其结构完整性可能较低）形成眼镜 10。进一步地，实施方式还对扭转和/或弯曲应力提供了基本的抵抗。

此外，眼镜 10 的实施方式还可向处于多个垂直视角的佩戴者提供最优的光学特性。如上所述，许多体育活动的特征在于要求使用者采取抬头或低头姿势。在低头姿势中，佩戴者一般将其期望的视线（LOS）指引穿过眼镜的上部区域，这样可能不会向现有技术的眼镜的佩戴者提供在平行于眼镜的光学中心线（OCL）观察时可获得的眼镜的预期最优光学质量。

如图 6A-6B 所示，可以将佩戴者的 LOS 80 关于眼镜 10 的 OCL 90

的角偏移表示为垂直偏移角 92。垂直视角 92 还可以被定义为眼镜 10 的 OCL 90 与佩戴者 LOS 80 之间的角偏移。通过减小垂直视角 92，可以预见佩戴者基本上可从眼镜 10 的改善的光学质量中获益，而在通常的采取低头姿势的活动中由于非标准的面部结构无法获得这种改善的光学质量。

在图 1 中，眼镜 10 被图示为包括镜片 12、框架 14、一对相对的眼镜脚 16 和鼻梁架 18。眼镜 10 的这些部件可被构造成允许佩戴者不使用工具而快速地组装和拆卸眼镜 10 的卡扣连接（snap fit）部件。镜片 12 可被形成为各种构造和几何形状。优选地，镜片 12 被构造成轻质且在佩戴者的整个视野中提供较好的光学质量。可以预见，可以利用双镜片或单镜片设计来形成镜片 12。如图 1 所示，镜片 12 具有上边缘 20 和下边缘 22。如图 6A-6B 所示，镜片 12 还可限定光学中心线（OCL）90。例如参见 Houston 等人的题为“用于眼镜的偏轴校正镜片（Decentered Corrected Lens for Eyewear）”的第 6,010,218 号美国专利，本文通过引用的方式并入该公开的全部内容，尤其是关于镜片的构造、设计和光学的内容。

如下文进一步描述，可按照各种形状和轮廓形成上边缘和下边缘 20、22。镜片 12 还可包括形成于其相对的侧边缘 28 的一对相对的侧凹口 24。还如下文进一步描述，侧凹口 24 可以是镜片中的空洞(void)，并且呈各种形状。最后，镜片 12 还可包括可至少部分地接纳鼻梁架 18 的鼻梁架开口 26。

如图 1-2 所示，框架 14 可被构造成包括可共同形成上部镜片接纳部的相对的端部 30 和上部沟槽 32。在实施方式中，相对的端部 30 的大小和构造被确定成与对应的镜片 12 的侧边缘 28 的至少一部分配装。优选地，端部 30 被形成为可拆卸地接纳对应的镜片 12 的侧凹口 24。

上部沟槽 32 可至少部分地沿着框架 14 延伸，并且优选地相对的侧凹口 30 的中间延伸。上部沟槽 32 的大小和构造优选地确定成接纳镜片 12 的上边缘 20。如图 8 所示的实施方式所示，上部沟槽 32 可限定出具有宽度 110 和深度 112 的纵向槽。上部沟槽 32 可被形成为具有不同或相同尺寸的内表面。例如，如图 8 所示，后表面 114 具有比前

表面 116 更大的横截面长度，并且可进一步不同于上部沟槽 32 的上表面 118 的横截面长度。上部沟槽 32 的后表面 114、前表面 116 和上表面 118 可被修改以便在上部沟槽 32 内提供不同程度的镜片 12 的上边缘 20 的保持力。

相对的端部 30 可被形成为使上部沟槽 32 沿着其至少部分地延伸。由此，通过框架 12 的相对的端部 30 在其中接纳镜片 12 的侧凹口 24，以及上部沟槽 32 至少部分地在其中接纳镜片 12 的上边缘 20，可至少部分地组装眼镜 10。如上所述，镜片 12 的侧凹口 24 可被不同地构造并可包括特别的几何样式，这些几何样式倾向于与对应的端部 30 的几何样式互锁。这个特征倾向于确保将镜片 12 推进上部沟槽 32 内并与框架 14 完全地配合。还可利用这个特征来帮助佩戴，以确保镜片 12 在组装过程中处于与框架 14 接合的位置。同样地，镜片 12 可被构造成被接纳在上部沟槽 32 中，以便将垂直地固定镜片 12 的上边缘 20，并且相对的侧凹口 24 可被接纳在各自的框架 14 的相对的端部 30 中，以便将镜片 12 水平地固定至框架 14。

根据实施方式，框架 14 可进一步包括从框架 14 的中央部 36 向下延伸的柱部 34。如本文所述，柱部 34 可被形成为各种几何形状。如下文进一步所述，优选地，柱部 34 可基本呈矩形，并且具有足够的宽度和厚度以提供与鼻梁架 18 的牢固接合。柱部 34 优选地与框架 14 一体地形成，比如由一片单一、连续的材料通过注模形成。可选地，柱部 34 可由分离的材料形成，并且可利用粘合剂、机械互锁、过盈配合或其它紧固件结合至框架 14。最后，如图 2 所示，柱部 34 还可包括可在柱部 34 的末端 39 处形成的连接部 38。

图 1-2 还图示了鼻梁架 18 的示例性构造，其中鼻梁架 18 具有中梁 40 和安装件 42，安装件 42 可从中梁 40 向上延伸并具有垂直高度 44。中梁 40 与安装件 42 优选地例如通过注模一体地形成，但是也可由分离的可结合的材料形成。

鼻梁架 18 可进一步包括沿着中梁 40 的至少一部分形成的下部沟槽 46。如图 1 所示，例如，下部沟槽 46 可至少部分地沿着中梁 40 延伸。中梁 40 的下部沟槽 46 的大小和构造优选地被确定成可拆卸地接

纳镜片 12 的下部边缘 22。具体地，下部沟槽 46 的形状可被确定成符合镜片 12 的鼻梁架开口 26 的形状和大小。

安装件 42 的大小和构造可被确定成可附接至框架 14 的柱部 34。可利用各种构造将柱部 34 附接至安装件 42，比如阳型和阴型互锁连接以及其它第一和第二互补表面结构。例如，柱部 34 或安装件 42 中的一个可形成为阳型连接器，该阳型连接器可拆卸地连接至柱部 34 和安装件 42 中剩余的另一个形成的对应的阴型连接器。

如图 2 所示，安装件 42 的后侧部 50 可被形成为包括可接纳柱部 34 的凹口 54。在该实施方式中，柱部 34 的连接器部 38 可被形成为与安装件 42 的凹口 54 配装。可选地，鼻梁架 18 的前侧部 52 可被构造成包括凹口 54。此外，柱部 34 还可包括可在其中接纳安装件 42 的凹口。该可选的实施方式和修改被认为是在本公开和教导的范围内。

图 3A-3B 图示了镜片 12、框架 14 和鼻梁架 18 的共同接合。在该实施方式中，柱部 34 可在上部镜片沟槽 32 的后面连接至框架 14。此外，镜片 12 可被构造成安装在柱部 34 和鼻梁架 18 的安装件 42 的前面。镜片 12 的模制出的构造可符合框架 14 的上部沟槽 32 和鼻梁架 18 的下部沟槽 46。

由该实施方式提供的共同接合可提供显著的优势，即可在不降低眼镜 10 的整体耐用性和结构完整性的情况下减小这些部件的重量。进一步地，在某些实施方式中，由于镜片 12 的侧边缘 28 和/或侧凹口 24 与框架 14 的相对的端部 30 接合，眼镜 10 可承受扭转和/或弯曲应力。由此，可以预见镜片 12 的侧边缘 28 和/或侧凹口 24 与框架 14 的相对的端部 30 的接合可进一步稳定和减轻通常在眼镜 10 的使用中遇到的扭转和弯曲力。因此，镜片 12 可由由框架 14 和鼻梁架 18 更牢固地保持。

图 3A 是处于组装状态的眼镜 10 的后视图，而图 3B 是该处于组装状态的眼镜 10 的正视图。如图 3A 所示，鼻梁架 18 的安装件 42 被附接至框架 14 的柱部 34，以便将鼻梁架 18 相对于框架 14 的垂直定位固定。如图 3A-3B 所示，进一步地，在镜片 12 被安装的情况下，安装件 42 还被图示为放置在镜片 12 与框架 14 的柱部 34 的中间，以

便将鼻梁架 18 相对于框架 14 的水平定位固定。

在组装过程中，可在组装框架 14 和鼻梁架 18 之后安装镜片 12，尽管这并非必要。镜片 12 一旦被组装后，可与框架 14 和鼻梁架 18 共同接合，并且当镜片 12 被安装时，框架 14 与鼻梁架 18 彼此之间可保持固定关系。由于框架 14 与鼻梁架 18 彼此之间的固定关系，上部沟槽 32 和下部沟槽 46 也可相对于彼此基本上处于固定关系，从而确保将镜片 12 完全地保持在其中。因此，该实施方式能够确保镜片 12 的最大的整体保持力和眼镜 10 的结构完整性。

如上所述，由本文所公开的实施方式所提供的显著的优点中的另一个是减小、最小化和/或消除可由将上框架定位在相对于佩戴者的鼻子的不同高度而引起的垂直偏移角。因此，在例如自行车竞赛和其它促使采用低头姿势的竞赛的活动中，佩戴者可通过选择性地互换鼻梁架 18 以及安装相应的镜片来改变主要的 LOS 来调节眼镜 10，同时仍然允许佩戴者享受镜片 12 的较好的光学质量。

现在参照图 4A-4C，其中图示了鼻梁架 18 的各种实施方式的后视图。如图所示，第一鼻梁架 18'的安装件 42 可具有第一垂直高度 44'，第二鼻梁架 18"则可对应于第二垂直高度 44"，而第三鼻梁架 18'"可对应于第三垂直高度 44'"。大体上可从鼻梁架 18 的鼻顶点 48 至顶端 62 来测得垂直高度 44。图 4A-4C 图示了可在某些实施方式中互换使用的一组示例性鼻梁架 18。提供这些图示仅出于说明性目的，而且提供各种其它大小和/或构造的鼻梁架 18 是可以预见的。如上所讨论，安装件 42 可与框架 14 的柱部 34 互相连接。可以预见佩戴者可根据其需要和/或偏好选择具有特定的垂直高度 44 的鼻梁架 18。当所选择的鼻梁架 18 被安装在眼镜 10 上时，可向佩戴者提供眼镜 10 的定制的佩戴方式。每个鼻梁架与具有位于垂直面内的 OCL 的相应的镜片匹配，而通过这种镜片-鼻梁架组合，该 OCL 与佩戴者所期望的 LOS 保持基本平行。

一组可选鼻梁架 18 中的鼻梁架 18 的垂直高度 44 可处于给定的范围内。例如，给定的一个鼻梁架的垂直高度 44 可处于大约一英寸的优选范围内，比如+0.75 / -0.250 英寸。高度 44 可以是例如大约 0.25"、

0.5"、0.75"和 1.0 英寸，或者两个或更多的鼻梁架可以被设置成具有1/8英寸的增量。可以根据眼镜10的几何形状，并依据比如目标活动、目标消费者等的其它考虑因素对范围进行加宽或修改。

可以预见通过将鼻梁架18与具有不同垂直高度44的鼻梁架互换，佩戴者可以相对于佩戴者的鼻子或正前LOS 80的修改镜片12的上边缘。可提供一系列的鼻梁架的大小。因而，佩戴者可选择性地定制眼镜10（并且还可为各种活动使用眼镜10），从而为特定的使用而优化镜片的垂直高度和穿过镜片的视角，而且佩戴者的LOS 80仍可与OCL更接近于平行地穿过镜片12，以下参照6A-6B对此进行进一步解释。

根据图 4A-4C 所示的另一方面，鼻梁架 18 可进一步包括轭部(collar portion)56和鼻垫58。鼻垫58可包括被附接至鼻梁架18或与鼻梁架18一体地形成的单鼻垫或双鼻垫。鼻垫58可被附接至鼻梁架18的底部60。轭部56大体上可在鼻垫58与下部沟槽46的中间延伸。由此，如图4A-4C所示，环部56的大小和构造可随安装件42的垂直高度的不同而改变。

此外，可以预见鼻梁架18'、18"和18'"的下部沟槽46可保持相对于鼻梁架18'、18"和18'"的顶端62的固定关系。在图4A所示的实施方式中，当组装镜片12时，当鼻垫58和下槽46被组装至镜片12的鼻梁架开口26时，可被定位成与镜片12的鼻梁架开口26大体上接触。然而，当通过将垂直高度44比如分别增加至图4B或图4C的垂直高度44"或44'"来调节垂直视角92时，下部沟槽46与鼻垫58的垂直位置之间会产生垂直间隙。因此，轭部56通过填充该垂直间隙可有助于补偿任何这种间隙。轭部56可以是实心的、穿孔的或者其它构造。因此，佩戴者的脸部和眼睛可得到保护而不受会穿过该间隙的空气或者其它物质的影响。

图 5A 图示了眼镜 10 的实施方式的分解图，其中镜片 12 可被安装/接合在框架 14 和鼻梁架 18 上。进一步地，当拆卸眼镜 10 以调整或修理时，可将镜片 12 从框架 14 和鼻梁架 18 分离，而无需在分离镜片 14 之前拆卸或移除眼镜 10 的其它部件。如本文所述，通过将镜片12的上边缘20插入上部沟槽32和相对的端部30，然后将镜片12的

下边缘 22 插入鼻梁架 18 的下部沟槽 46 来完成镜片的接合和分离(分别以正向和反向顺序)。可通过轻轻地弯曲镜片 12 来完成此过程。当镜片 12 被完全接合时，镜片 12 可卡扣入位。通过上述方式，佩戴者可利用可互换的鼻梁架 18 选择性地调节眼镜 10 以使其适合。

图 5B 是眼镜 10 的正视图，其中图示了多个鼻梁架 18'、18"和 18"'的安装和佩戴。如以上所讨论，不同的垂直高度 44'、44"和 44"'(见图 4A-4C)可允许佩戴者将眼镜 10 的佩戴调节到相应的高度，从而提供垂直视角 92 的调整。鼻梁架 18 的构造可被修改成包括任意各种大小、形状、鼻垫、材料、轭部构造及其它特征，并且可符合眼镜 10 在佩戴者脸部上的高度，例如，关于佩戴者的眉毛所测量的高度。

现在参照图 6A-6B，其中图示了佩戴着眼镜 10 的佩戴者的头部的侧视图。在图 6A 中，佩戴者的头部和眼镜 10 大体上处于抬头位置，并且镜片 12 的 OCL 90 大体上是水平的(正前)。进一步地，佩戴者的 LOS 80 大体上也是水平的，并且基本上平行于镜片 12 的 OCL 90。

然而，在图 6B 中，以虚线图示了眼镜 82，其中，眼镜 82 未被调节以便对(关于镜片)垂直升高的 LOS 80 进行补偿。因而，佩戴者的 LOS 80 可能从更接近上框架的、眼镜 82 的镜片的上部穿过。从而这样造成的后果是光学效果差，而且对风、光和碎屑的防护作用低略。此外，佩戴者 LOS 80 可能被眼镜 82 的框架遮挡。无论如何，由于眼镜的框架如此接近 LOS 80，佩戴者的视野必定会被减小。

对照之下，图 6B 还示出了眼镜 84，其中，鼻梁架的垂直高度已经被增加，并且具有相应构造的镜片已经被插入以减小垂直偏移角 92 并提供较好的眼睛保护。如图 6B 所示，佩戴者的 LOS 80 倾向于更接近镜片的中心部分穿过，并与镜片的 OCL 90 更加对准。这种实施会倾向于改善由佩戴者享受的整体光学质量。进一步地，该实施方式倾向于当佩戴者采取低头姿势时，确保佩戴者的 LOS 80 不被眼镜 84 的框架所遮挡。

图 7A-7B 分别图示了示例性的现有技术的太阳镜 100 的正视图和横截面图。太阳镜 100 包括框架 101、镜片 102 和鼻梁架 104。框架 101 包括沟槽 106，并且镜片 102 具有被接纳在框架 101 的沟槽 106

中的上边缘 108。如图 7B 的横截面图所示，沟槽 106 用于完全地支撑镜片 102 和鼻梁架 104。因而，这种太阳镜 100 的沟槽 106 必须特别地深和宽并且大体上更坚固。在某些现有技术的太阳镜中，镜片沟槽可深达 0.10 英寸。因此，太阳镜 100 的整体重量可能更大，外观可能更庞大。

对照之下，图 8 示出了如图 5B 所示的实施方式的侧视图，并进一步图示了眼镜 10 的轻质构造和共同接合的上述特征。如图所示，上部沟槽 32 大体上由宽度 110 和深度 112 限定。与图 7A-B 的现有技术的太阳镜进一步相对照，眼镜 10 的深度 112 可处于大约 0.030-0.080 英寸的范围内。优选地，深度 112 小于或等于大约 0.050 英寸。因此，由于鼻梁架和镜片的结构方面的贡献，小的多的深度 112 允许更多的材料得以从框架 14 移除，从而允许框架的重量得以减小。

在框架 14 的某些实施方式中，框架 14 的垂直方向上的最大厚度 120 优选地小于例如沿着镜片 12 的上边缘 20 的镜片 12 的厚度的 90%。在其它实施方式中，镜片 12 的厚度还可大于垂直方向上的框架 14 的厚度 120。水平方向上的框架 14 的最大厚度 122 优选地小于镜片 12 的厚度的 350%。如图 8 所示，可将框架 14 设计成各种轮廓和横截面构造。因此，可以修改框架 14 的尺寸和形状。然而，可以预见通过采用本文所教导的方案，可基本上将框架 14 的横截面最小化。

如上所述，上部沟槽 32 可被形成为具有不等或相等尺寸的内表面。上部沟槽 32 可具有由宽度 110 和深度 112 或者由后表面 114、前表面 116 和上表面 118 限定的横截面积。优选地，上部沟槽 32 的横截面积大约等于或小于 0.02 平方英寸。由此，接合在上部沟槽 32 中的镜片 12 的横截面积可优选地小于大约 0.02 平方英寸。上部沟槽 32 的后表面 114 的横截面长度可大于前表面 116 的横截面长度，并且可进一步不同于上表面 118 的横截面长度。上部沟槽 32 的后表面 114、前表面 116 和上表面 118 可被修改以便在上部沟槽 32 内提供镜片 12 的上边缘 20 的不同程度的保持力。

尽管在特定优选实施方式和实施例的背景下公开了本发明，本领域的技术人员会理解，本发明从具体公开的实施方式扩展开到其它的

可替换的实施方式和/或本发明的使用以及本发明的明显的修改和等同。此外，尽管已经示出并详细地描述了本发明的一些变形，但是基于本公开，落入本发明的范围内的其它修改对本领域的技术人员来说是显而易见的。还可以预见，可以对实施方式的特定特征和方面的进行各种组合或次组合，并且这些组合或次组合仍然落入本发明的范围内。应该理解，所公开的实施方式的各种特征和方面可以彼此组合或彼此替代，以便形成所公开的发明的变化模式。因而，意图是本文所公开的至少部分的发明的范围不应受限于上述具体公开的实施方式。

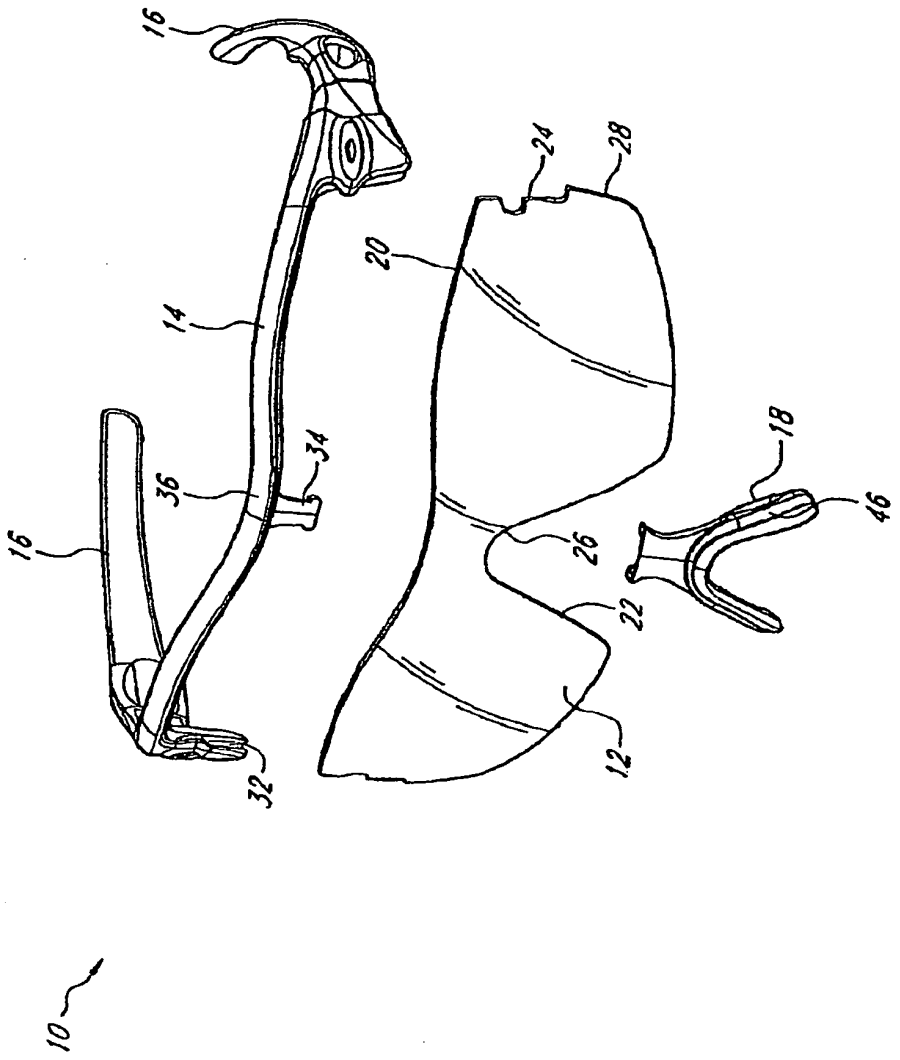


图 1

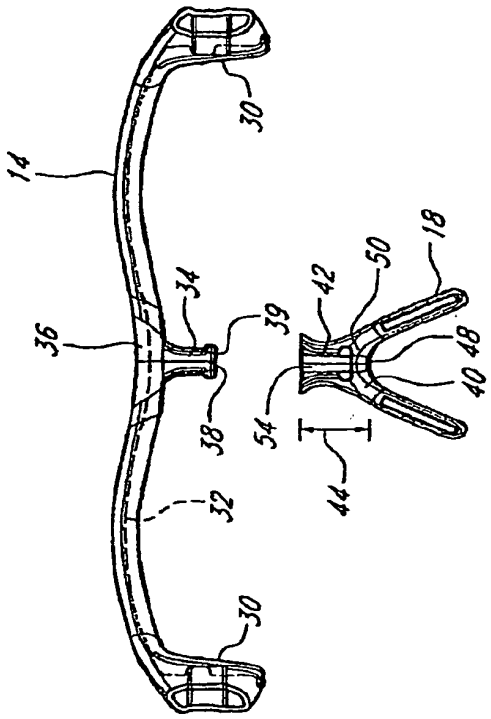


图 2

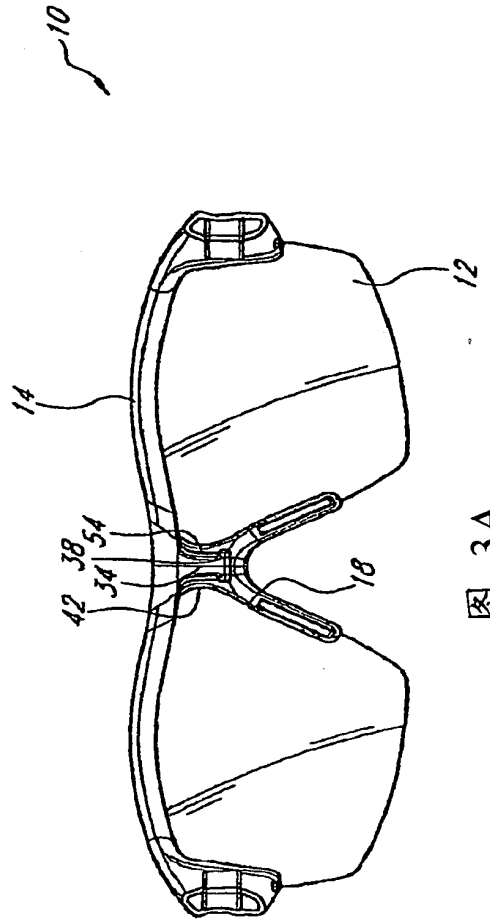


图 3A

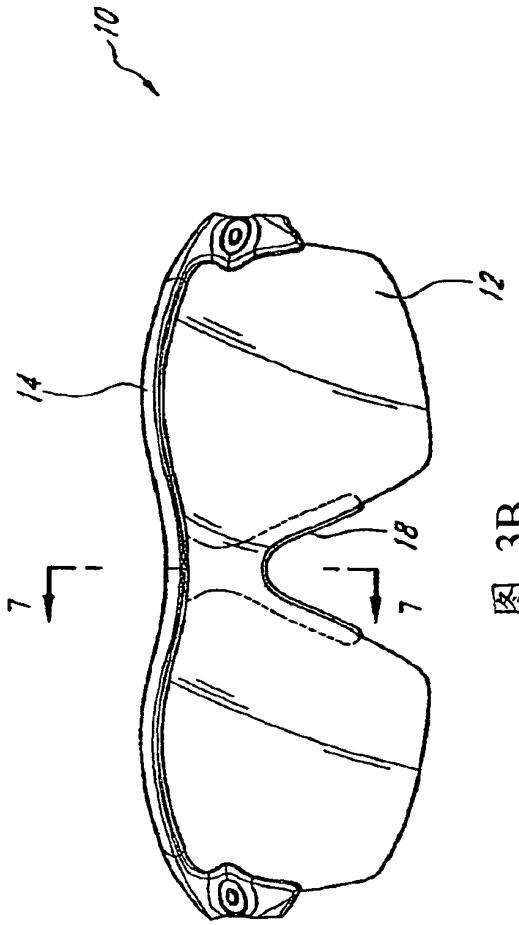


图 3B

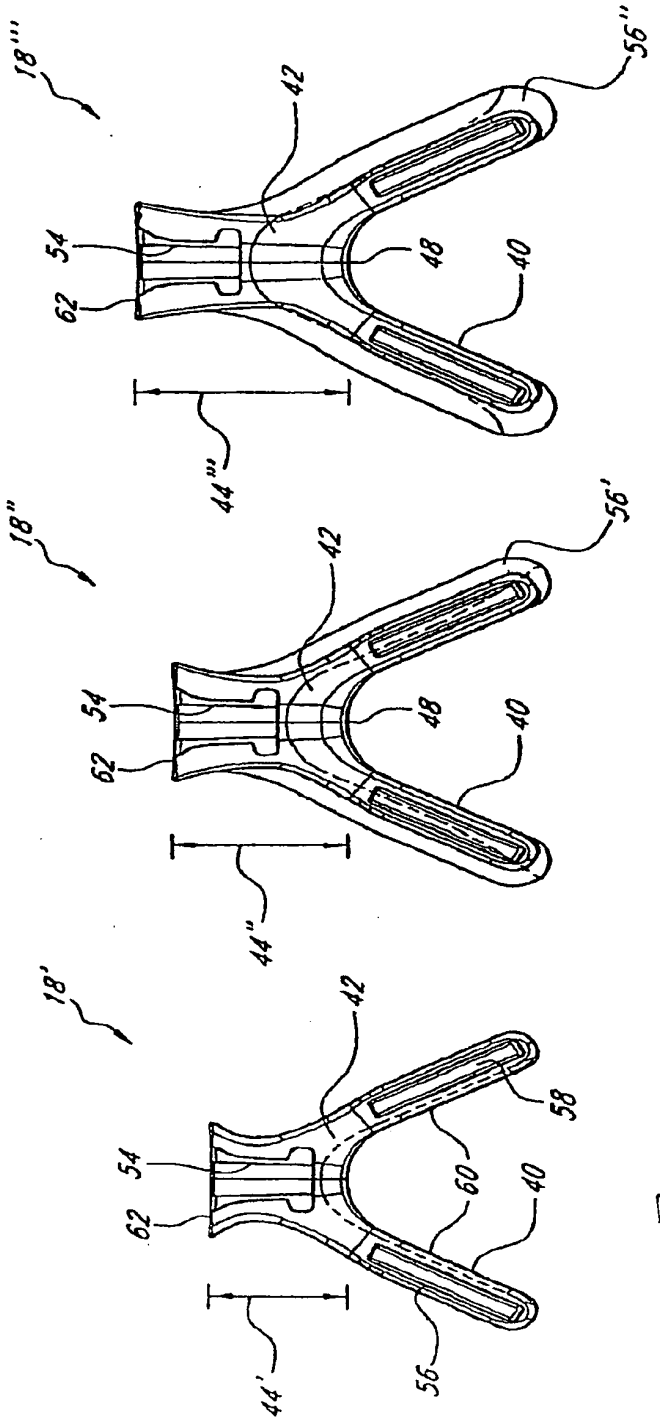

18'''
42
56''
54
48
62
40
44'''
18''
42
56'
54
48
62
40
44''
18'
42
58
54
60
62
40
44'
56

图 4C

图 4B

图 4A

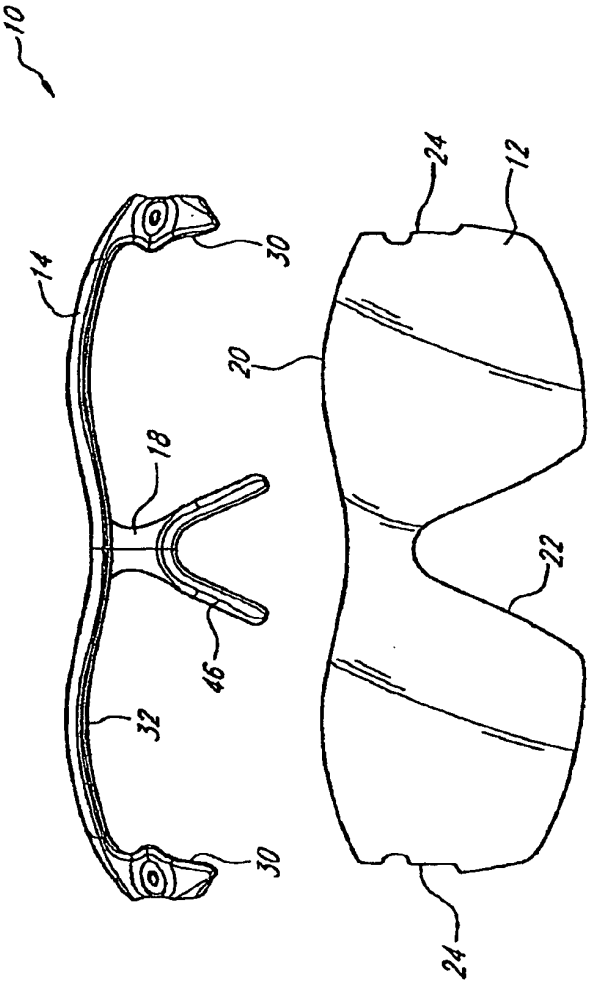


图 5A

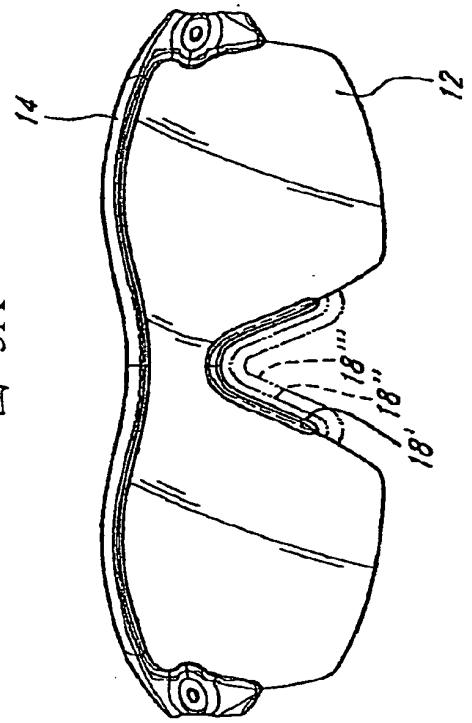


图 5B

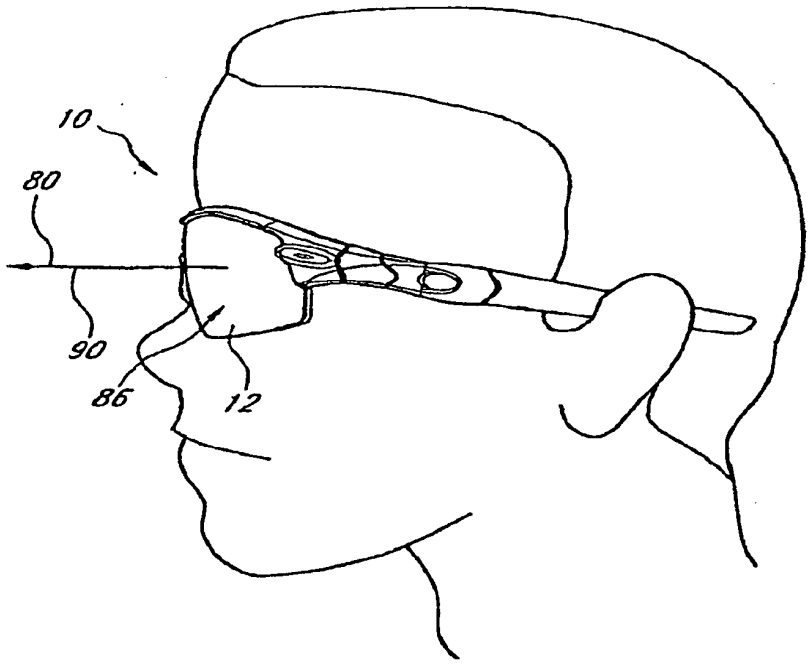


图 6A

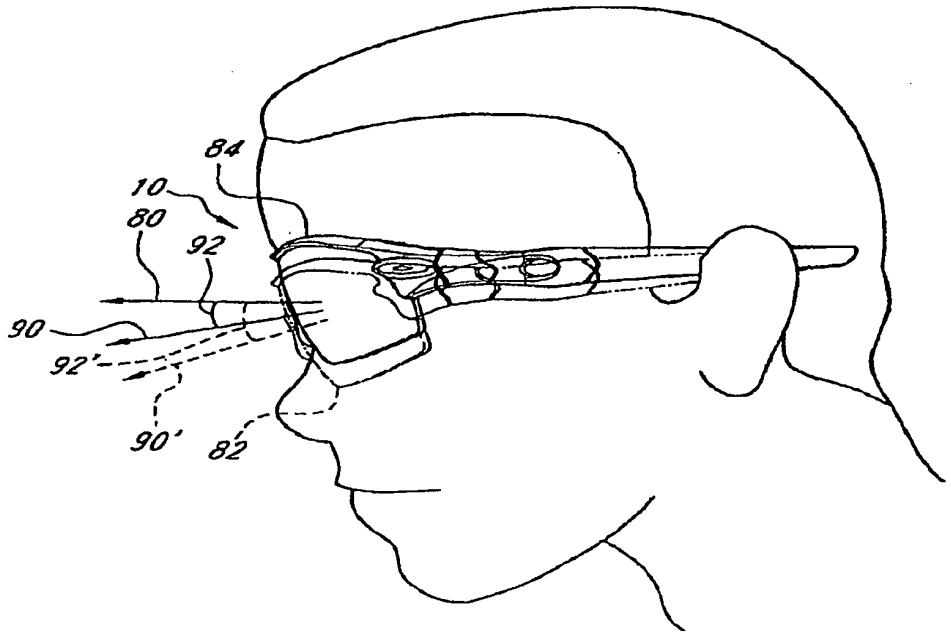


图 6B

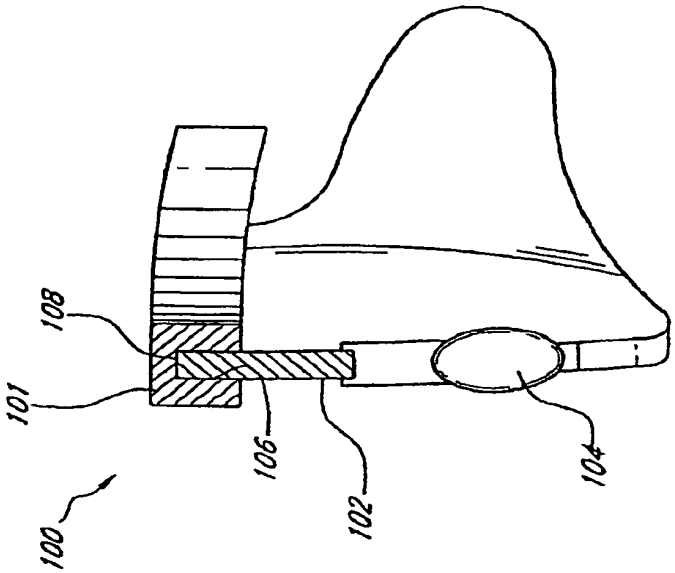


图 7B
(现有技术)

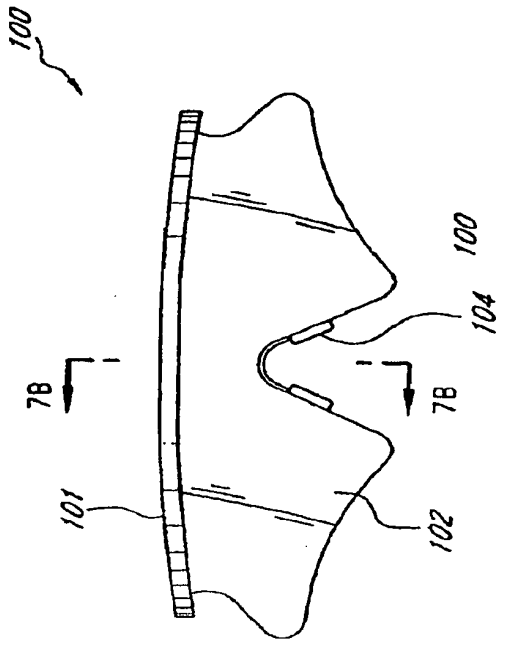


图 7A
(现有技术)

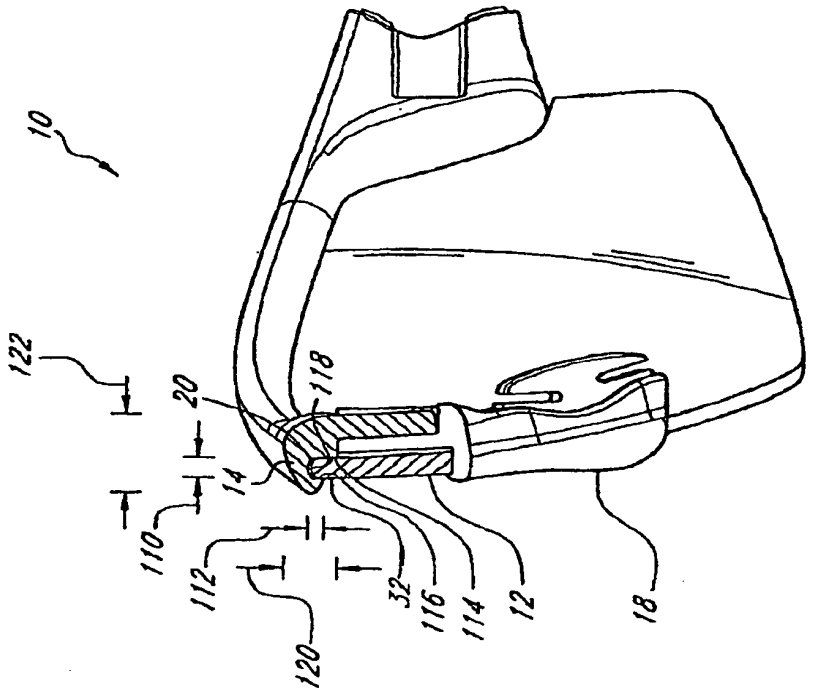


图 8

说明书摘要

发明名称：体育专项防护

提供了一种眼镜(10),用于在不降低眼镜(10)的整体结构完整性的情况下的部件重量,并用于允许眼镜(10)的可调节性以在具有不同头部角度和主要视线的活动中优化光学和保护质量。眼镜(10)可包括镜片(12)、框架(14)和鼻梁架(18)。框架(14)可具有相对的端部(30)、至少部分地沿着框架(14)延伸的上部沟槽(32)以及向下延伸的柱部(34)。鼻梁架(18)可具有向上延伸以接合柱部(34)的安装件(42)和可共同地被保持在框架(14)与鼻梁架(18)之间的镜片(12)。提供了成套的对应的鼻梁架和镜片,以便为垂直面内的不同的主要视线对眼镜进行优化。

ABSTRACT

TITLE: SPORTS-SPECIFIC SHIELD

An eyeglass (10) is provided for component weight without reducing the overall structural integrity of the eyeglass (10), and for allowing adjustability of the eyeglass (10) to optimize optical and protective qualities during activities having differing head angles and primary lines of sight. The eyeglass (10) can comprise a lens (12), a frame (14), and a nosepiece (18). The frame 14 can have opposing terminals (30) and an upper groove (32) extending at least partially along the frame (14) and a downwardly extending post (34). The nosepiece (18) can have a mounting component (42) extending upwardly to engage the post (34), and the lens (12) can be cooperatively retained between the frame 14 and the nosepiece (18). Sets of corresponding nose pieces and lenses are provided, to optimize the eyeglasses for different primary viewing axes in the vertical plane.