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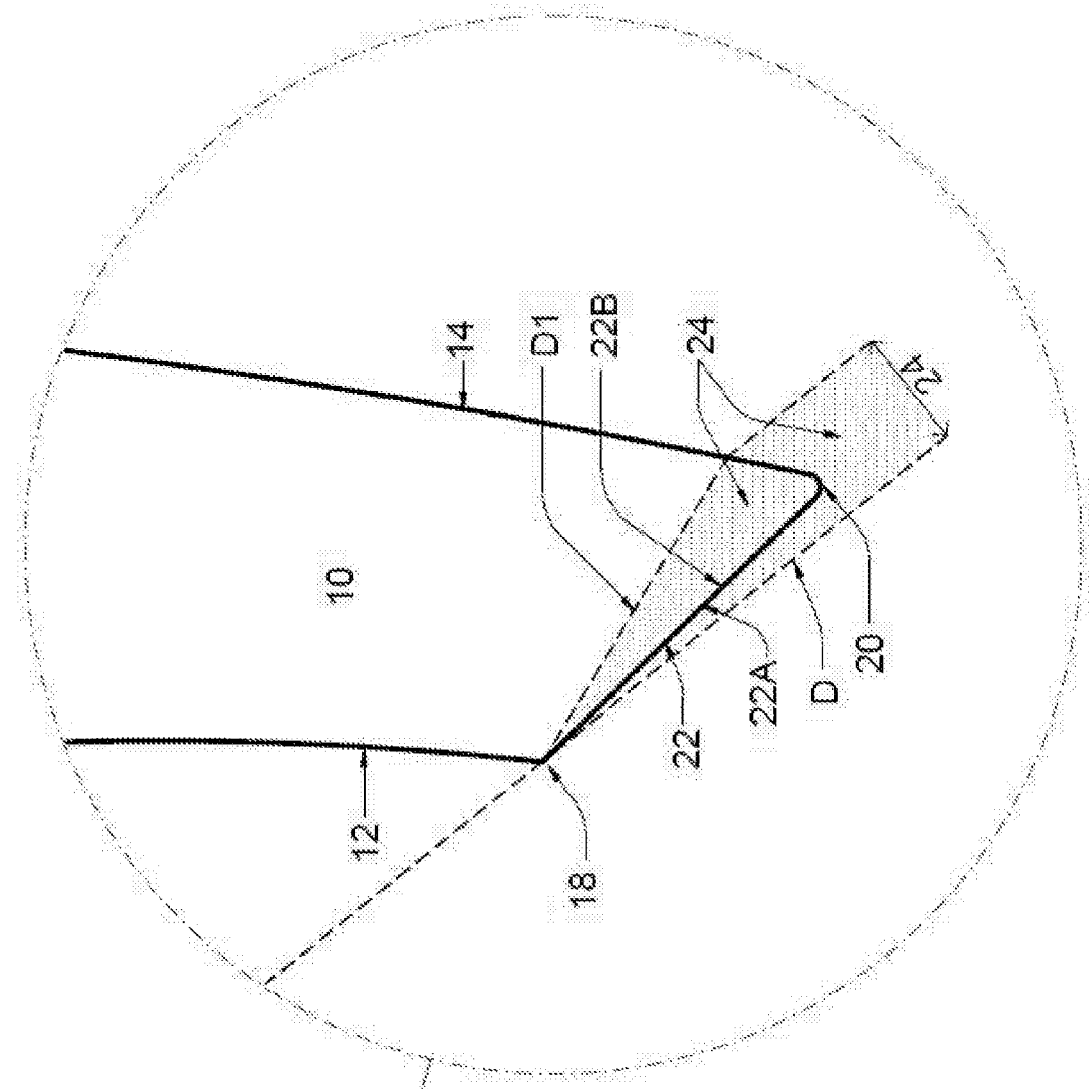


Fig 3

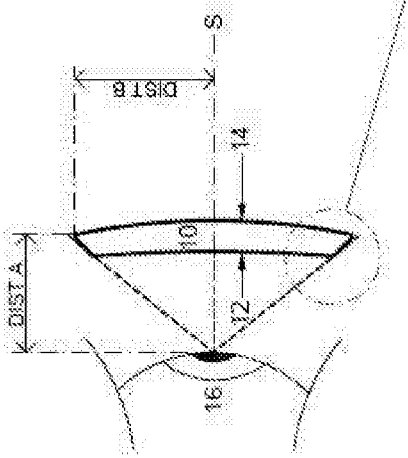
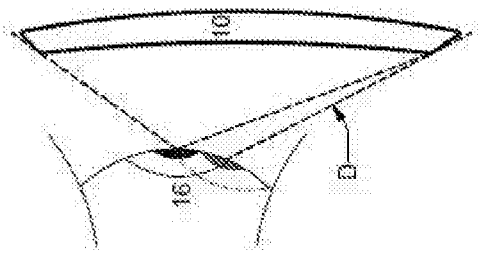


Fig 1



Plan

Fig 2

The following terms are registered trade marks and should be read as such wherever they occur in this document:

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Invisible edge lens

Technical field

The present invention relates to eyeglass lenses used to modify vision.

Background

It is estimated that about 75% of people will require some form of vision correction in their lifetime. A commonly used form of vision modification is a pair of spectacles or glasses worn in front of the eyes, supported by a frame resting on the ears and nose. Some glasses have frames covering the entire periphery of the lenses. These frames add weight and are visible to the wearer and onlookers.

Alternatively, glasses can have a frame partially covering the edge of the lens, which may be supported by a nylon filament attached to the frame for a more discrete look. Some persons prefer to wear 'frame-less' or 'rimless' glasses, with the lens not bounded by any frame, to minimise the appearance of wearing spectacles. However, these frame-less glasses still present the wearer with the distraction of a visible lens edge. This appears as a dark or grey partial ring in their peripheral vision or a ring of reflected light, both of which vary continuously according to lighting conditions. This effect interrupts the continuity of the scene being viewed, in contrast to the view experienced by the person without glasses. The edge visibility continually reminds the wearer that they are wearing glasses. In the case of playing sports or other activity requiring an uninterrupted field of view, this distraction is especially annoying.

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Accordingly, there exists a need for a lens for use in frame-less glasses or spectacles that in embodiments improves the user experience.

Summary of invention

According to a first aspect of the present invention, there is provided a method of manufacturing a lens for use in frame-less spectacles as set out in independent claim 1. Preferred/optional features are set out in claims 2 to 7. The method provides a lens for use in frame-less spectacles for a user

having an eye with a line of sight along an axis S [S being straight ahead] which is about 0 degrees when the user is looking directly ahead, and lines of sight D [D being deviated from straight ahead] in any direction from axis S due to natural eye movement,

the lens comprising;

an inner lens surface (usually concave) that is closest to the eye, having an inner peripheral rim; an outer lens surface (usually convex) bounded by an outer peripheral rim; and an essentially flat, angled peripheral edge joining the inner peripheral rim and the outer peripheral rim;

wherein a junction between the angled peripheral edge and the inner lens surface forms a cleanly machined vertex at the inner peripheral rim, while the junction of the angled peripheral edge and the outer lens surface forms a radiused vertex at the outer peripheral rim;

characterised that in use the angled peripheral edge angle is less than any lines of sight D, such that said lines of sight may strike the inside peripheral rim but not an external surface of the angled peripheral edge nor the outer peripheral rim, thus concealing the angled peripheral edge and the outer peripheral rim; and

said lines of sight are refracted, at the point of the inner peripheral rim, away from an internal surface of the angled peripheral edge, creating an invisible zone which conceals said internal surface of the angled peripheral edge and said outer peripheral rim, such that the internal surface and external surface of the angled peripheral edge and outer peripheral rim are not visible to the user in use.

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Thus, there is provided in a pair of frame-less spectacles, a lens design having an inner lens surface closest to the eye with an inner peripheral rim, and an outer opposing lens surface with an outer peripheral rim, which is the boundary of the lens material. The two rims are formed by the respective intersections of the lens' inner and outer surfaces with a machined edge (angled lens edge) at the extremity of the lens' perimeter.

The machined edge is ground at an angle that is calculated to keep the angled peripheral lens edge concealed from the user's direct and peripheral vision at all angles of natural eye movement in use. This angle is always less than that of the user's line of sight.

The angled peripheral lens edge can be around the entire periphery of the lens. Any transparent material has an internal and external surface at it's boundary, both

of which are reflective and thus visible in various light conditions. The said angled peripheral lens edge has an internal surface that is bounded by the lens material on the inside and an external surface bounded by the atmosphere on the outside. In

frame-less lenses machined in the conventional way, the lens edge is visible to both onlookers and to the wearer, whether it is polished to a clear finish or not. The current invention makes the lens edge boundary invisible to a wearer in use.

An aim of the present invention is to combine characteristics of the human eye with a new lens design to improve the user experience by eliminating lens edge visibility and reflections in even the most extreme lighting conditions, e.g. direct sunlight or viewing bright and moving lights when the wearer is in a dark environment, such as when driving at night. In these conditions, in embodiments, zero reflections or stray light are noticeable to the user.

Also featured is a lightweight design and a frame attachment system which in embodiments is barely noticeable to the wearer, which in combination with the invisible lens edges creates, in embodiments, a user experience as close as possible to that of not wearing spectacles.

The angled peripheral lens edge has an internal and external surface. Light and images can be reflected from both surfaces, making them visible. It is taught that when the lens edge is ground at the disclosed angle, the external surface of the angled peripheral edge (and the outer peripheral rim) is concealed from the wearers vision by the inner peripheral rim. At the disclosed edge angle, the internal surface of the angled peripheral edge (and the outer peripheral rim) is also concealed from the wearer by the phenomenon of refraction, as their line of sight is 'bent' or refracted away from said internal surface. The included angle between the actual line of sight and the refracted line of sight creates a 'sector' or 'zone' invisible to the wearer. Thus, the concealment of both the internal and external edge surfaces occurs at the vertex that is the inner peripheral rim.

The sector of invisibility is defined as the area of view missing, between the direct line of sight passing outside the inner peripheral rim, and the refracted line of sight within the lens, and beyond. In a two-dimensional view, as in Figure 3 this may be described as an 'area' but in use in 3 dimensions, using, for example a circular lens, the sector is described as the volume of a partial cone shaped void of image reaching the eye, bounded by the periphery of the inner peripheral rim on the outside, and on the inside by a radial line following the refracted line of sight as it moves around and passes through the outer surface of the lens. The invisible zone extends beyond the lens.

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If the line of sight occurs at an incidental angle of 45 degrees to the inner surface, the deviation of that angle by refraction is approximately 18 degrees. Thus, the width of the invisible zone within the lens material, measured at the outer surface, is quite small, typically less than 1mm, depending on the thickness of the lens.

Light entering the lens from an outside source, but near the edge, i.e. within the sector of invisibility is refracted towards the internal surface of the angled peripheral lens edge and is reflected away from the wearer's line of sight. This effect causes images viewed through the lens at its edge to seem to disappear, 'jump' or shift as the user's view transitions from through the lens to outside the lens' influence. This is the property of any lens, with an angled edge or not, whether framed or not. If the scene being viewed is of a relatively uniform nature, such as a wall, ceiling, sky, sea, field of grass or forest the effect of the 'shift' of image is unnoticeable. In normal use this 'shifting' of an image at the edge of a lens occurs in the peripheral vision and is naturally minimised by the following characteristics of human vision.

The eye/brain interface tends to ignore images in the peripheral vision and apportions nearly all emphasis to the direct, focussed vision. Only sudden changes, large objects, lights, shadows and movement in peripheral areas attract the attention of the brain, as they may constitute danger. In contrast direct vision provides vital information all the time. The dominant eye accurately establishes when the head, and thus the rest of the body, are oriented straight ahead, necessary information for co-ordinated and safe movement. The focussed vision of both eyes works to calculate distance via binocular vision. Because these factors are so important the brain prioritises what is in the direct and focussed vision, while peripheral images lack detail and are comparatively ignored.

Accordingly, in embodiments, the angled edge design itself essentially eliminates distractions in the peripheral vision. It builds on, and co-operates with, the tendency of the eye/brain interface to ignore said distractions, improving the ability to concentrate attention on focussed vision. This makes the lens of embodiments of the present invention extremely relaxing in use. The result is that in many circumstances wearers can forget they are wearing spectacles as no edge or reflections are visible and the 'shift' of images at the lens edge is minimised.

If an object, light or shadow representing danger should suddenly appear in the peripheral vision it is still noticeable to the user, as it would be to a person with no

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spectacles. Thus, there is no safety hazard from wearing the present invisible edge lens.

Embodiments of the present invention can be applied to fashion, prescription, reading spectacles and sunglasses. Herein, the terms glasses and spectacles are used interchangeably. The lenses can be clear, or they can be tinted. The lenses can be any shape including round, oval, square, rectangular, hexagonal, octagonal. In the case of tinted lenses, the tint may be faded near the edge of the lens, so the transition from a tinted view to one of normal brightness is graduated, not cut off sharply, thus less noticeable.

It should be understood that while spectacles are referred to herein as a use for the angled edge design, it is also applicable to a magnifying glass lens (hand-held or supported by a flexible arm) such as used by a jeweller, craftsman or hobbyist.

To effectively manufacture an angled edge lens, the starting point may be a lens already made to a customer's prescription and cut to the desired shape and size, including a small radius on the outer rim, but without an angled edge.

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A cutter for producing the angled edge may then be applied to the lens edge, the cutter spindle pivoting at a point essentially representing the position of the user's pupil, relative to the lens being machined. The spindle may swivel at this point through 360 degrees.

The cutter may be mechanically guided by an integral 'feeler' or roller following the outer periphery of the otherwise finished lens, thus maintaining the desired angle around the entire lens edge according to the customer's actual optical requirements 'in situ'. The guide or feeler also controls when the cut is finished, i.e. when the angled peripheral edge meets the already radiused outer peripheral rim. The edge angle can be adjusted, or fine-tuned, by changing the relative position between the lens and the spindle pivot point.

Alternatively, distances A and B may be entered into a geometric program or algorithm to electronically calculate the desired grinding angle for edge invisibility at all points of the lens' periphery. To calculate the optimal angle of the angled lens edge, two measurements are used, distances A and B (See Figure 1). Distance A represents the longitudinal measurement from the eye's surface, adjacent to the centre of the pupil, to the outer peripheral rim of the lens. Distance B is the lateral measurement from the optical centre of the lens (where the gaze is straight ahead, depicted by axis S) to the

outer peripheral rim. The optical centre of the lens may also be the mounting point on a rotating spindle when the angled lens edge is being machined. Both the machining cutter and the lens mounting spindle may adjust their positions in operation to achieve the desired lens shape and edge angle. The distance between the eye surface and the lens inner surface, measured along axis S may also be used to calculate the desired edge angle.

The angled edge must be ground essentially flat in relation to a radial line in all directions from the pupil to the lens edge. A slightly concave or convex shape may be desirable to minimise reflections on the edge's external surface. Of course, the edge may be continuously curved in a peripheral direction.

The outer peripheral rim is by manufacture a sharp edge and, in embodiments will have a radiused finish for cosmetic, tactile and safety reasons. A small radius can be provided by machining and/or polishing.

By contrast the inner peripheral rim must be a clean machined edge i.e. with no chamfer or radius (refer Figure 3). The inner peripheral rim can be said to be a vertex which is the point at which the inner lens surface and peripheral edge surface meet. This angular junction being cleanly machined and non-radiused is crucial to the lens design as any radius or blemish here allows reflections to be seen by a user.

The rendering invisible of the lens edge all occurs at the inner peripheral rim.

Polishing of the lens edge, if desired, must be by way of a relatively hard surface, such as a hard rubber roller with a fine polishing surface to avoid any rounding of the inner rim as would occur with a soft polishing medium. The polishing roller may follow the same contour as that of the lens edge cutter, following the same program as, and being interchangeable in fitting, with the machining cutter.

The wearer may move their eyes around while wearing eyeglasses. When this happens the angle from the pupil to the lens edge changes, which could bring the outer surface of the edge into view. In practice it is difficult to maintain an extreme angle of flex in the eyes as this exercise is tiring and disorienting. However, it is desirable that the lens edge should be invisible at even these angles of view. To prevent the edge from coming into view an adjustment of up to approximately 5 degrees is entered into the edge shaping algorithm, as a factor of distance B. (See Figure 3). As distance B becomes greater, the adjustment required is greater. Even if the wearer looks for the edge in their direct vision it is thus not visible.

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The angled edge lens creates a cosmetic problem in that when in use the modified edge appears to others as a ring of reflected light, though this is not seen by the wearer. When looking at the user there is a halo of light around the outside edge of the glasses more exaggerated than that of frame-less lenses of conventional design. This effect can be addressed by polishing the edge to make it more transparent. Alternatively, it can be coloured with a neutral hue such as grey or skin tone. Preferably, the edge can be painted with a clear or solid colour to complement the colour of the frame. For example, a transparent colour may be used to complement a frame with an anodised finish, a solid colour to complement a painted frame. The colour can be precision applied by a roller configured with same program as the grinding and/or polishing process. Paint may be specifically formulated to be compatible with or bond to a given lens material, for a durable finish. It may also be a dye. The colour may give the end-product an attractive and unique appearance and does not affect the users view as the lens edge is always within the invisible zone, whether painted or not. Since lenses of this design have not previously been seen, a new market segment can be created; the design also appealing to customers comprising existing markets for conventional rimless or thinly rimmed spectacles. In addition, pre-worn rimless spectacles may be retro modified to incorporate the angled peripheral edge design.

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The lens can be made from any material that lenses are typically made from including glass, plastic [CR39], polycarbonate or Trivex (RTM). Polycarbonate is by far the preferred material for frame-less lenses because of its combination of durability, light weight, good optics and cost. The art of manufacturing lenses is well developed, and the skilled person will appreciate that lenses are typically ground and polished or moulded to a desired shape prior to use. The shape/profile of the lens can be modified according to a user's prescription. The prescription can be obtained from an Optometrist who tests the user's eyes using a variety of eye testing techniques. Measurements A and B for calculating an angled edge may be obtained during a user's examination. Measurement can also be made of the vertical and horizontal angles of a lens on a user's face relative to a right-angled plane of axis S, to be replicated in lens modifying equipment.

The user can move their eyes around while wearing lenses supported by frames. The movement of the eye can be to change the location of focus. When the user is looking straight ahead, the user can be said to be looking along an axis S (straight ahead). The user can be relaxed with the pupil of the eye pointed forward along axis S. Typically, when the user is looking directly or straight ahead, their line of sight along

axis S falls substantially in the optical centre of the lens. The angle of the line of sight along axis S is for the purposes of this discussion is equal to 0 degrees. As the user moves their eye, the line of sight can vary from axis S. The user can look to the left side. The user can look to the right side. The user can look up. The user can look down. As the user looks in any of these directions, the line of sight can pass through the lens along axis D (deviated). If the user looks slightly away from straightforward, the line of sight might vary by 1 to 5 degrees from axis S. If the user looks further away from straightforward (in any direction), the light of sight can vary by 5 to 10 degrees, and so on. It is thought that the maximum range of normal eye movement allows the user to vary the angle of the line of sight relative to axis S by a maximum of about 30 degrees in any direction. Thus, lines of light along axes D are many and various but within the bounds of comfortable physical movement.

The peripheral angled edge of the lens approximately corresponds with some of the lines of sight D of the user in use. The user can move their eye around the peripheral edge of the lens to vary the lines of sight D. The peripheral edge of the lens is angled at less than any one of said user's lines of sight D. This means that not one of the user's lines of sight can strike both the inner peripheral rim and outer peripheral rim at the same time (see Figure 3). The peripheral edge of the lens can be configured to be up to 1, 2, 3, 4 or 5 degrees less than lines of sight D so as to appear invisible to the user in use. By invisible, it is meant that the peripheral edge of the lens is not visible to the user in use.

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In a pair of frame-less glasses or spectacles, a lens may have a modified edge configured to be inclined at an angle that is slightly offset from the user's line of sight, such that the edge of the lens is not visible at all angles of natural eye movement of the user when in use, wherein the modified edge is around the entire periphery of the lens, and optionally further wherein the modified edge is coloured with a coloured material that is visible to a person looking at the user but that is not visible to the user themselves in use.

Brief Description of the Figures

Embodiments of the invention will now be described with reference to the accompanying drawings which are only approximately drawn to scale and which are exemplary only and in which:

Figure 1 is an elevation view of the lens showing its relative position to the user's eye.

Figure 2 is a plan view showing the [usually] wider angle to the horizontal extremities of the lens. Also depicted is the change in angle from the pupil to the lens edge when the eye is flexed sideways.

Figure 3 is an enlarged view of a part of the lens of Figure 1 showing details of various aspects.

Detailed Description of Embodiments of the Invention

The lens 10 has an inner surface 12 that would be closest to the eye 16 in use. The inner surface 12 has an inner peripheral rim 18. As discussed, the inner peripheral rim 18 is a clean edge, not chamfered, rounded, radiused or otherwise modified. Accordingly, the inner peripheral rim 18 is defined by a vertex formed between the inner lens surface 12 and the angled peripheral edge surface 22.

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As shown in Figure 1, a distance can be measured from the outer peripheral rim 20 to the surface of the cornea of the eye 16 adjacent to the pupil (distance A). Note, this is not a distance of the lens surface 12 from the surface of the eye 16, but a distance of the outer peripheral rim 20 to the surface of the eye 16, measured in a longitudinal orientation.

The lens has an outer surface 14 opposing the inner surface 12. The outer surface 14 is exposed to the surrounding environment of the user. All surfaces can be modified with surface treatments such as anti-glare, non-reflective, scratch resistance, UV filters, other. The outer surface 14 has an outer peripheral rim 20. The outer peripheral rim 20 is the boundary of the lens material. The outer peripheral rim 20 is slightly rounded or radiused.

A distance can be measured from the outer peripheral rim 20 to axis S (distance B) (refer Figure 1). Distance B can vary according to the size of the lens with larger lenses having a larger distance B. The size of the lens may be varied according to the chosen style of lens.

The edge of the lens 22 is machined at an angle to correspond to a line drawn from a point on the eye surface corresponding to the centre of the pupil, looking straight ahead (axis S), to the machined edge of the lens. This angle is calculated by factoring distances A and B into a geometric equation. The angle required to attain total

invisibility is continuously variable due to distances A and B not being constant and is not likely to be the same at any two points on the lens edge periphery. The equipment used to manufacture the lens can be programmed to machine the lens at the continuously variable angle based on distances A and B.

Alternatively, the aforementioned angle may be attained by a mechanical connection between the cutter of the equipment and a 'feeler' or guide following the outer peripheral rim 20.

The peripheral angled edge 22 of the lens 10 approximately corresponds with lines of sight D of the user in use. The user can move their eye 16 around the peripheral edge 22 of the lens 10 to vary the lines of sight D. The peripheral edge 22 of the lens 10 is configured to be up to 1, 2, 3, 4 or 5 degrees less than any one of said lines of sight D so as to appear invisible to the user in use. By invisible, it is meant that the peripheral edge of the lens is not visible to the user in use.

In Figure 3, the angle of the peripheral edge 22 of the lens 10 is about 5 degrees less than the aforementioned line of sight D. In embodiments, this is to prevent the external surface 22A of the lens edge 22 becoming visible when the eyeball rotates in its socket (see Figure 2), not normally more than about 30 degrees from straight ahead. This movement of the eye 16 in the socket slightly changes the angle of the line of sight from the pupil to the lens edge 22. The internal surface 22B of the lens edge 22 is rendered invisible by the phenomenon of refraction, which is harnessed at the inner rim to create a 'sector of invisibility', or invisible zone 24. The sector of invisibility 24 is described as the angle between the refracted line of sight and the actual line of sight.

The peripheral edge of the lens 22 is bounded by the inner peripheral rim 18 and outer peripheral rim 20. The peripheral edge 22 is an essentially flat surface between the two rims 18, 20.

It will of course be realised that while the foregoing has been given by way of illustrative example of this invention, all such and other modifications and variations thereto as would be apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of this invention as is herein set forth. It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

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Where there is any conflict with content found in any document incorporated herein, the present specification takes precedence.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

Any promises made in the present description should be understood to relate to some embodiments of the invention and are not intended to be promises made about the invention as a whole. Where there are promises that are deemed to apply to all embodiments of the invention, the applicant/patentee reserves the right to later delete them from the description and does not rely on these promises for the acceptance or subsequent grant of a patent in any country.

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CLAIMS

1. A method of manufacturing a lens for use in frame-less spectacles for a user having an eye with a line of sight along an axis S (S being straight ahead) which is about 0 degrees when the user is looking directly ahead, and lines of sight D (D being deviated from straight ahead) in any direction from axis S resulting from peripheral vision and natural eye movement, the method comprising the steps of:

measuring a distance A being a longitudinal measurement from the user's eye surface, adjacent to the center of the pupil, to an outer peripheral rim of the lens; and

measuring a distance B being a lateral measurement from an optical center of the lens (axis S) to the outer peripheral rim;

placing into lens making equipment a lens modified to a user's prescription and cut to a desired shape and having an inner concave lens surface bounded by an inner peripheral rim, and an outer convex lens surface bounded by an outer peripheral rim, and a conventional lens edge configured at about 90 degrees to said outer lens surface joining the inner and outer peripheral rims;

modifying the conventional lens edge to be an essentially flat angled peripheral edge joining the inner peripheral rim and outer peripheral rim using an algorithm based on distance A and distance B to result in a manufactured lens in which the angled peripheral edge lies between any lines of sight D that pass the inner peripheral rim, and any lines of sight D1 refracted at the inner peripheral rim through the lens,

allowing or causing the junction between the angled peripheral edge and the inner lens surface to be a cleanly machined vertex at the inner peripheral rim; and

rounding the vertex at the outer peripheral rim to remove a cleanly machined vertex.

2. The method of claim 1 wherein the entire periphery of the angled peripheral edge of the lens is modified by the method to be invisible to the user.

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3. The method according to claim 1 or 2, wherein the method further includes the step of modifying the external surface of the angled peripheral edge with a coloured material.

4. The method according to any one of the preceding claims, wherein the manufactured lens is selected from a shape in the group comprising but not limited to circular, oval, square, rectangular, pentagonal, hexagonal and octagonal.

5. The method according to any one of the preceding claims wherein the method further includes the step of modifying any surface with a treatment selected from anti-glare, non-reflective, scratch-resistant, UV filter or other.

6. The method of manufacturing a lens according to any one of the preceding claims comprising programming lens making equipment with an algorithm based on the distances A and B, with adjustments factored in to allow for variations of deviated lines of sight D due to natural eye movement, to produce a lens with a continuously variable angled edge, machined around its entire periphery, that is always between any lines of sight D that pass the inner peripheral rim, and any lines of sight D1 refracted at the inner peripheral rim through the lens.

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