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A METHOD FOR MAKING MULTI-FOCAL LENGTH CONTACT LENSES

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This is a continuation-in-part of application Serial No. 125,485 filed July 20, 1961 and now abandoned.

This invention relates to contact lenses and more particularly to multi-focal length contact lenses and a method of making same.

Afocal and single focal contact lenses are well known and have been in extensive use for many years. Such lenses provide many desirable advantages over spectacles, but their use has been limited to individuals having visual defects correctable by single optical power lenses. There is and has been a long-standing need for multi-focal length contact lenses, especially bifocal, for use by individuals having visual defects correctable only by multi-power lenses. Notwithstanding this need, a practical multi-focal length contact lens has not heretofore been available. The present invention is directed toward producing multi-focal length contact lenses for correcting visual defects requiring such multi-power structures while retaining all of the advantages of conventional afocal and single focal contact lenses.

It is an object of the present invention to produce a multi-focal length contact lens that is adaptable to provide a corrected near and distant vision while retaining all of the advantages of afocal and single focal contact lenses and a novel method of making such lenses.

A further object is to produce such multi-focal contact lens where the optical system of the lens moves in unison with the eye, and the line of sight is always substantially coincident with the optical axis of the lens.

Another object is to produce a multi-focal length contact lens having a plurality of areas of different optical powers with a common optical axis but in which each area functions independently of the other in conjunction with the optical system of the eye.

Yet a further object is to produce a single or unitary multi-focal contact lens having more than two curved optical surfaces each of which functions as a refracting or optical surface.

Another further object is to produce a multi-focal length contact lens having a central area of a given optical power and a surrounding peripheral area of a different optical power so arranged that no line of demarcation is detectable by the eye.

Yet another object is to provide a novel method of producing the aforesaid multi-focal length contact lenses from conventional lens forming materials including artificial resinous materials.

A further object is to provide a method for producing a multi-focal contact lens having a plurality of areas of different predetermined indices of refraction.

These and other objects will become more apparent when read in conjunction with the following detailed description and the attached drawings wherein:

FIGURE 1 is a schematic illustration in axial section of a lens worn on an eye;

FIGURE 2 is a front elevation of a bifocal contact lens wherein the optical axes of its optical surfaces are divergent and the eye is positioned for distant vision;

FIGURE 3 is a view similar to FIGURE 2 but with the eye rotated downwardly relative to the lens to a position for near vision;

FIGURE 4 is an enlarged axial section of a lens embodying areas of different indices of refraction to produce more than two optical surfaces;

FIGURES 5 and 6 are enlarged axial sections of lenses in which the central portions of the lenses have optical surfaces with radii of curvature different than the remaining optical surfaces of the lenses;

FIGURES 7, 8 and 9 are views similar to FIGURE 4 showing other forms of lenses;

FIGURE 10 is a vertical cross-section showing in disassembly the general configuration of a block of a refractive material provided with a curved optical surface to serve as a junction curvature and superimposed thereabove a formable mass of a polymerizable refractive material that is to be integrally bonded to the block;

FIGURE 11 is a vertical cross-section showing the block and formable mass of FIGURE 10 pressed together by molds during the bonding process;

FIGURE 12 is a vertical cross-section of the monolithic refractive mass produced from the assemblage shown in FIGURES 10 and 11;

FIGURE 13 is an axial section of a lens similar to that shown in FIGURE 9 produced from the monolithic mass shown in FIGURE 12;

FIGURE 14 is an isometric view of a blank of material having formed therein a curved optical surface;

FIGURE 15 is a figure similar to FIGURE 14 in which the concave portion of the blank shown in FIGURE 14 has been filled with a resin material and has polymerized with the material shown in the blank of FIGURE 14;

FIGURE 16 is a section through the blank of FIGURE 15 showing the relationship of the original blank of material, the material filling the concave in the original blank, and in dotted lines the lens to be cut therefrom; and

FIGURE 17 is a sectional view through a lens cut from the blank of FIGURE 16 along the dotted lines shown in FIGURE 16.

Most of the objects of the present invention are achieved by the production of a lens of the present invention which has a central portion of one optical power and a peripheral portion of a different optical power surrounding the central portion. The central and peripheral portions are arranged so that their optical axes coincide and the central portion has a diameter substantially equal to the diameter of the center portion of the cornea of the eye that is not used in a primary sense in distant vision, that is, at distances greater than about 15 feet.

Referring to the drawings, a detailed description of a preferred illustrative embodiment of the present invention will now be given. As seen in FIGURE 1, a lens is generally indicated by the numeral **11** and is worn on the cornea **12** of the eye **13**. The lens **11** is in the form of a corneal lens of a small thin miniscus of preferably clear and transparent refractive materials. It is to be noted that the present invention is not limited to the production of corneal lens but may be utilized in other forms of contact lenses if so desired.

The lens **11** has a posterior optical surface **14** of approximately the same shape as the cornea **12** and an anterior optical surface **15** of the radius of curvature dependent upon the optical characteristics desired from the lens. The lens **11** is comprised of a unitary structure having a central portion **16** and a surrounding peripheral portion **17** of different optical powers. The term optical power is used in its definition as the reciprocal of focal length and depends not only upon the radii of curvature of the optical surfaces but also upon the relative index of refractions of the refractive materials of such portions. The optical axes of these portions coincide. The central portion **16** has a diameter substantially equal to the diameter of the portion in the center of the cornea **12** of the eye **13** that is primarily used for near vision.

That this area is of secondary importance in near vision can be readily appreciated when the optical system of the eye **13** is considered. Parallel or near parallel light rays **18** from a distant object enter the peripheral portion **17** of