MULTIFOCUS INTRAOCULAR LENS

BACKGROUND OF THE INVENTION

This invention relates to an intraocular lens, and more specifically to an intraocular lens that internally alters its focal length.

Lenses are optical devices that bend light. The angle at which the light is bent is determined by: (1) the angle of incidence of the light wave; (2) the specific wave length; and (3) the refractive indices (n) of all the mediums through which it passes. Using Schnell's law, the refracting power of a lens system can be obtained. The power is determined by the change in n of the refractive media at their interfaces and their surface shape characteristics. In a lens system, the power of the system is determined by all the refracting interfaces and all the differences in n. The power of the lens system can be changed by altering the curvature of the lenses or the index of refraction of one or more parts of the system or both. In conventional systems, the effective power of the system is changed by mechanically changing the separation of one or more solid lenses.

Single lenses generally are of a fixed focal length. Fused bifocal lenses and aspheric lenses have two or more optical focal planes that are engaged by changing the relationship of the light path or the observer to the lens. All such lenses require movement of either the lens, light path, or observer to engage a different focal plane. Without moving the lens in relationship to the light path, the focal length of fused bifocals and aspheric lenses can not be altered.

The natural lens of the eye is a single lens with a variable focal length. The focal length is changed by muscles in the eye that change the shape of the lens. Thus, this natural lens does not require a movement in the position of the lens, the light path, or the observer to achieve a change in focal length.

Removal of the natural lens by surgery necessitates its replacement with glasses, a contact lens, or an intraocular lens. The first intraocular lens was inserted in 1949 by Ridley in London. It consisted of a solid lenticle with one focal point. Since that time all intraocular lenses, including those currently being implanted, whether anterior chamber, posterior chamber, or iris supported, have had a solid plastic lenticle with a single focal point.

Recent developments have dealt primarily with (1) ultraviolet protection, (2) flexible support, (3) flexible lenticle and haptics, and (4) laser ridge for the posterior capsule. None of these address a major disadvantage of present intraocular lenses, which is the fact that they cannot change focal length on demand.

A recent U.S. patent to Schachar (U.S. Pat. No. 4,373,218) discloses the use of an extra-scleral fluid reservoir to inflate and deflate a flexible posterior chamber lens in order to vary the power of the lens. This lens has at least four major disadvantages: (1) a permanent communication exists between the intraocular structures and the extraocular reservoir, which, along with the lens' electronics, increases the risk of infection and inflammation; (2) it requires an electrical source and microprocessor, which are subject to electrical failure; (3) it is dependent on an electrical pump and valve system, which are subject to mechanical wear and failure; and (4) it is not self-contained.

U.S. Pat. No. 4,010,496 to Neefe is for a bifocal intraocular lens that is solid and depends on an intact pupil and iris support. The wearer of this lens will have bifocal vision when his pupil is dilated; the lower part of the lens will be available for near vision and the upper part will be available for far vision. The wearer will have far vision only, when his pupil is constricted and the lower part of the lens is closed off. This situation is nonphysiologic in at least two circumstances. First, under normal reading conditions, a person reads under bright light, causing the pupil to constrict. A person reading under these conditions would not be able to use the part of the Neefe lens designed for near vision. Second, under conditions of low light, the pupil is dilated. The wearer of the Neefe lens will have near vision instead of far vision under these circumstances, even when looking straight ahead. Finally, this lens could lead to visual confusion from having the bifocal plane split the field of vision by dividing the retina, which, in turn, could lead to diplopia and/or glare.

Intraocular lenses are now implanted after cataract surgery in over 70% of the cases. The lenses that currently are being implanted are all fixed focal length. They are made of solid plastic, and they do not adjust for near and far vision. Thus, the power of the eye must be altered by external lenses. Moreover, the removal of the natural lens leaves the eye with no means to focus at different distances. Thus, bifocal lenses are necessary for close work.

SUMMARY OF THE INVENTION

The invention described herein provides means for obviating the above-stated problems of current intraocular lenses. The present invention is a more physiologic intraocular lens that adjusts its optical zone for near and far vision without external modification such as glasses or contact lenses, or externally supplied power, such as from a battery.

The present invention is a multifocus intraocular lens comprising a body of transparent material suitable for permanent placement in the eye; a hollow lenticule in the body, the lenticule being positioned for encompassing the light path between the pupil of the eye and the retina; a pair of fluid reservoirs in the body, one above and one below the lenticule and in fluid communication therewith; channel means for interconnecting the reservoirs, bypassing the light path and the lenticule and forming a closed system within the body; and a transparent fluid means filling the closed system for changing the index of refraction of the lens upon predetermined changes in the inclination of the light path with respect to the horizontal.

The important advantage of this invention is that it provides maintenance free visual correction without external devices after the natural lens has been removed from the eye. It adjusts focal lengths between near and far vision when the wearer of the lens follows the natural inclination to look down for near vision, such as needed for reading, or to look to the distance for far vision. This method of adjustment is unlike that for bifocal or trifocal lenses where the wearer must learn to look through various areas of the lens to get the needed correction. The adjustment is accomplished by moving fluids of different n through the optical zone, whereby the effective power of the lens is altered without altering the light path through the lens, the curvature of the lens, the distance separating the lens elements, or the distance from the focal plane. As a result, the lens will focus on near objects when the eye is in the normal reading position (i.e., 45–90 degrees from horizontal)