ONE-PIECE BIFOCAL INTRAOCULAR LENS CONSTRUCTION

This application is a continuation application of Ser. No. 07/561,256, filed Jul. 30, 1990, now abandoned, which is a continuation of Ser. No. 07/297,966, filed Jan. 17, 1989, now abandoned, which is a continuation-in-part of Ser. No. 07/182,253, filed Apr. 15, 1988, now abandoned, which is a continuation-in-part of Ser. No. 07/015,878, filed Feb. 18, 1987, now abandoned, which is a continuation-in-part of Ser. No. 06/871,077, filed Jun. 5, 1986, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to intraocular lenses to be used as artificial lens implants in eyes from which the cataractous natural lens has been removed, and more particularly to an improved rigid lens having multiple lenses.

2. Description of the Prior Art

The implantation of an intraocular lens for restoring vision after cataract surgery is well-known in the art. In general, two forms of surgery are used to remove cataracts. These are extracapsular cataract extraction and intracapsular extraction. (Discussed in Hoffer U.S. Pat. Re. 31,626.) Following extraction of a cataractous lens, an intraocular lens is normally implanted in either the anterior or the posterior chamber of the eye. In an anterior chamber implant, the lens is generally situated forward of, or mounted to, the iris. In the case of posterior chamber implants, the lens is situated behind the iris and may be mounted within the cleft or fornix of the capsule which remains in place after extracapsular surgery. Posterior chamber implants are generally preferred, in part because this is the location from which the natural lens is removed.

In both anterior or posterior chamber implants, the lens is usually centered and fixed in position by one or more supporting strands or haptic members. While available intraocular lenses incorporate haptic member(s) having various geometric shapes and configurations, the typical haptic member is a flexible strand of nonbiodegradable material which is fixed to the lens body, and exhibits specific spring-like memory qualities so that the haptic member can be compressed or off-set from the normal rest position and thereafter returned to the fully extended condition when pressure is removed.

The intraocular implant is an artificial lens which has one given focal length. Since the intraocular implant is made of a rigid material it cannot change the focal length by deformation as the natural lens does (called accommodation). As a result of this, if the focal length is selected to provide a sharp image for a distant object, then an object which is closer (i.e. at reading distance) will not be imaged sharply on the retina. Alternately, one could image closer objects sharp by selecting a different focal length, but then, of course, distant objects would appear out of focus.

Contact lenses have been made having multi-focal lengths and also having variable light absorption. R. N. Camp U.S. Pat. No. 3,270,099 issue Aug. 30, 1966 discloses a method for making a multi-focal length contact lens. The Camp patent deals with a contact lens which is not used for the same function or manner as an intraocular lens. Further, the Camp patent teaches that the eye uses the inner part of the cornea for near vision while the outer part is used for distant vision. For this reason, the Camp contact lens covers the cornea with a contact lens which has one power in the inner part and another power in the outer part. As a basis for such a lens, the Camp patent teaches that the divergent rays which enter the peripheral portion are not focused on the retina and hence are unseen. This is, of course, a violation of the laws of physics as light is detected by the retina regardless of whether it is focused or unfocused.

Neefe U.S. Pat. No. 3,034,403 was issued May 15, 1962 and discloses a contact lens of apparent variable light absorption. The center portion of the contact lens is tinted while the outer portion is clear.

Bifocal intraocular lenses are known, see for example Nielson et al U.S. Pat. No. 4,636,211. The Nielson reference discloses a concentrically bifocal (or target) lens, i.e. a lens implant having an outer annular portion of one power, in an inner circular portion of another power. The add on power difference between the far and near vision portions of Nielson et al '211 is indicated as being +2.50 diopters. The inner lens of Nielson et al '211 is indicated as being, on the average, about 2.12 mm in diameter.

The features that are possible in a bifocal intraocular lens are, to a great extent, dependent upon the method of manufacture used and/or the material from which the lens is made. A conventional method of making an intraocular lens, is through the compression molding technique. For this technique, a mold is made by machining a cavity out of a piece of tool steel. The radius of curvature of the cavity is made equal to the radius of curvature of the convex side of the lens. The cavity is then polished. Material for the lens, which typically has a consistency analogous to plexiglass, is generally manufactured in the form of rods preferably having an outside diameter equal to that of an intraocular lens be produced in the mold. The material of the rod is cut into small discs, which are heated and pressed in the polished mold. After cooling, the formed lens is released from the mold. Generally, the obtained product is ready for implantation, without any further manipulations, except typically for sterilization. In many instances haptics will also have been added.

Bifocal intraocular lenses can be formed as a gradient index lenses. That is, they are constructed to have a refractive index gradient through the optical region, with the gradient providing for different powers. There are basically two conventional ways of achieving this. A first is to produce the implant as a conventional implant, as previously described. The finished product, as a unifocal IOL, is then provided with a hole drilled in the center. With a second compression mold, a cylinder with one planar end and one spherical end, whereby the spherical end has a radius of curvature equal to the radius of the curvature of the IOL having a hole drilled therein, is formed. The obtained cylinder is inserted into the bore hole of the first lens, producing a lens with a smooth outer surface. The materials chosen for the first lens (with a hole in the center) in the second cylinder (the inner lens) are typically sufficiently different, so that the refractive indices of the two differ enough to cause a desired bifocal arrangement.

Another conventional way to produce a gradient index IOL is to start with lens material in rod form. The rod then is heated from the outside, preferably with infrared radiation, to heat the material unevenly. In particular, the outside is heated more than the inside.