INTRAOCULAR LENS PROVIDING ACCOMODATION

BACKGROUND OF THE INVENTION

This invention relates generally to artificial intraocular lens for replacing the natural lens of the eye, and more particularly to a novel intraocular lens which is capable of emulating the natural process of accommodation in direct response to contraction and relaxation of the ciliary body of the host eye.

Accommodation is the natural process by which the lens of the eye can sharpen the curvature of its front and back surfaces and thereby change its refractive power in order to adjust from distance vision to near vision. This occurs in response to contraction of the ciliary body which results in an approximate one-half millimeter decrease in the equatorial diameter of the lens capsule. A recent article, "How the Human Eye Focuses" appearing in the July, 1988 issue of the magazine *Scientific American,* describes very well the structure of the eye and the accommodation process.

Most conventional intraocular lenses have a predetermined fixed refractive power with no accommodation capability. Prior proposals intended to provide the accommodation function are illustrated in U.S. Pat. Nos. 4,373,218, 4,409,691, and 4,731,078, but these are rather complicated in construction and operation.

In addition, conventional intraocular lenses exhibit positioning instability in the eye, called decentration. These lenses decenter because the haptic fingers which support the lens from the ciliary body or lens capsule have very small surface areas in contact with these tissues. Small surface areas greatly increase pressure of the fingers against these tissues, thus making it difficult to maintain the lens in its centered position.

Another problem associated with conventional intraocular lenses is the introduction of significant amounts of glare or halo effects around images, especially in dim lighting situations when the pupillary aperture is large.

SUMMARY OF THE INVENTION

Accordingly, a primary object of this invention is to provide a novel simplified intraocular lens capable of emulating the natural process of accommodation.

Another object of the invention is to provide the novel intraocular lens, wherein accommodation occurs over a substantial variable range of refractive power change.

Still another object of this invention is to provide the above novel intraocular lens which includes a first optical component having a fixed refractive power and a second optical component having a variable refractive power, the components being relatively movable towards each other in response to contraction of the ciliary body to increase the refractive power of the lens.

Another object of the invention is to provide the above novel intraocular lens which functions as a mechanical optical transducer capable of converting small dimensional changes of the ciliary body of the eye into large refractive power changes.

A further object of the invention is to provide the above novel intraocular lens wherein the first optical component has a surface of predetermined configuration for engagement by a flexible membrane of the second component, the refractive power of the second component gradually increasing as the membrane conforms to the shape of that surface.

Another object of the invention is to provide the above novel lens wherein the first and second optical components are connected together by haptic arms or fingers of substantial width and surface area to stabilize the lens as mounted within the ciliary body and eliminate decentration.

A further object of the invention is to provide the above novel intraocular lens wherein the haptic arms are shaped so as to create an outer optical zone around a primary central optical zone, the outer zone diverging light away from the principal axis and thereby reducing glare and halo around images.

Another object of the invention is to provide the above novel intraocular lens wherein the first optical component will continue to function should the second optical component fail or be destroyed, the lens thereby affording a special safety feature.

Other objects and advantages will become apparent as the description proceeds in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal fragmentary section through a human eye;

FIG. **2** is a fragmentary sectional view illustrating the novel intraocular lens of the invention magnified about nine times actual size, the fixed and variable optical components being positioned for far vision in response to relaxation of the ciliary body;

FIG. **3** is a view taken generally along line **3—3** of FIG. **2**;

FIG. **4** is a fragmentary sectional view taken along line **4—4** of FIG. **2**;

FIG. **5** is a fragmentary view taken along line **5—5** of FIG. **2**; and

FIG. **6** is a view similar to FIG. **2**, but illustrating the maximum refractive power position of the fixed and variable optical components for near vision in respense to contraction of the ciliary body.

DETAILED DESCRIPTION OF THE INVENTION

As shown in FIG. **1**, the human eye **10** includes cornea **12**, limbus **14**, sclera **16**, conjunctive **18**, iris **20**, anterior chamber **22**, posterior chamber **24**, natural lens **26**, ciliary muscle or body **28**, zonules **30**, and vitreous body **32**. Chambers **22** and **24** are filled with a fluid known as the aqueous humor.

When the eye is focused at a distance, the ciliary muscle or body **28** relaxes and expands, and its diameter is at a maximum. As muscle **28** expands it pulls zonules **30** taut, causing them in turn to pull on lens **26**. The pulling flattens the front and back of the lens and increases the diameter of its equator. In this condition - called the unaccommodated state - the ability of the lens to bend light is at a minimum.

When the eye attempts to focus on a point closer than e.g. 20 feet away, the ciliary muscle contracts, reducing the diameter of its opening and also causing the muscle to move slightly forward. Both changes reduce the stress on the zonules and thereby lessen the stress exerted by the zonules on the lens. The lens thereupon undergoes elastic recovery and the lens rebounds to a more relaxed state. As the lens focuses on progressively closer objects, it becomes thicker from front to back, its surface become more sharply curved and the diameter