LENS WITH VARIABLE OPTICAL PROPERTIES

BACKGROUND OF THE INVENTION

The present invention relates to intraocular lenses, and, more particularly, to intraocular lenses having variable optical properties.

The crystalline lens of the eye is susceptible to, among other impairments, the growth of cataracts. In this condition, the light that would normally pass through the lens to the retina is blocked by the clouded lens.

Various ailments including cataractous tissue growth in the lens can necessitate or desirably be treated by the removal of the crystalline lens of the eye. The natural lens thereafter is replaced with an artificial lens referred to as an intraocular lens ("IOL"). Although the development of IOL's provided significant relief for some patients, the known IOL's only imperfectly mimic the functioning of the natural lens. For example, artificial lenses are generally not elastic like the crystalline lens of the eye and cannot alter their focusing power like the normal crystalline lens of the eye. As a result, the known IOL's generally do not permit continuous adjustment of the focal power of the lens.

Some attempts have been made to provide an intraocular lens that has a variable accommodation. One approach is to provide an IOL with multiple lens surface each with a different radius of curvature. These multifocal lenses utilizes the same principles as multi-focal eye glasses which enable the user to look through different portions of the lens to achieve different levels of diopter power. However, the levels of diopter power are fixed with the different radii of curvature of the lens surfaces and do not provide for variable levels of focusing power.

Another common approach to varying the focus of an IOL is to form a conventional hard intraocular lens with a flexible outer surface made from a material such as silicone. Water is then injected in between the conventional hard portion of the lens and the flexible outer surface of the lens. The water will stretch the outer flexible layer to change the radius of curvature of the intraocular lens and thereby change the accommodation of the lens. One disadvantage of this approach is that a fluid source, a fluid pump and a flow control valve all must be provided within close proximity to the lens. As the area around the crystalline lens of the eye is quite confined, most of the fluid injection components have to be provided on the lens itself. Further, an energy source must be provided to pump the fluid. As there is no mechanical force generated in the eye that is strong enough to pump the fluid, an external power supply is required to run the pump. Such an external power supply is usually implemented using a battery which has a limited life cycle.

A further approach that has been used to vary the accommodation of an IOL is the coating of a conventional IOL with a liquid crystal material. A voltage source is applied to the crystal material to polarize the crystals. Once the crystals are polarized the refractive index of the crystalline material changes thereby changing the accommodation of the IOL. One principal disadvantage of this type of system is the relatively large amount of energy that is required to polarize the liquid crystal material, on the order of 25 volts. As there is no known manner of generating that level of voltage within the body, an external power source, such as a battery, is therefore necessary.

The above described and other prior attempts to provide an intraocular lens with variable accommodation are generally complex systems. These complex systems are costly to manufacture and often times impractical to implement in the eye of a human. In addition, the above systems require external power sources, such as batteries, which have a limited life cycle and may require surgery to replace. Therefore, a need exists for a simple IOL with variable accommodation that only relies on the forces provided by the human body for operation.

SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, there is provided a variable focus intraocular lens which comprises an intraocular lens which varies the presence of a medium between two lens surfaces of the intraocular lens system to alter the accommodation of the lens system.

A preferred embodiment of the intraocular lens system of the present invention comprises a first optical component with at least a first lens surface, a second optical component with at least a second lens surface, a fluid reservoir between the first and second lens surfaces, and at least one continuous flow loop. The continuous flow loops connect the fluid reservoir between the two lens surfaces to a channel in a first portion of the intraocular lens. Preferably, the continuous flow loop comprise a piece of narrow tubing which contains the fluid in the flow path. In addition, the continuous flow loops are used to position and hold, the intraocular lens system in the eye. The continuous flow loops, the fluid channel and the fluid reservoir together define a continuous fluid flow path in the intraocular lens system.

The fluid path of the preferred embodiment contains multiple discrete segments of fluid which move through the fluid path of the lens system. The fluid segments include a segment of a positively charged fluid, negatively charged fluid, air, and at least one segment of oil, water or another fluid. There are no physical dividers in the narrow tubing to separate these fluid segments. The fluids themselves must be carefully chosen to ensure that a meniscus of sufficient strength will be formed at the fluid junction to keep two abutting segments of fluid separate and distinct. Additional segments of fluid may be added as long as positively charged fluids do not abut negatively charged fluids at any fluid juncture.

The ciliary body is the portion of the eye that is in charge of accommodation. When the ciliary body fires, an electrical action potential is created. When the ciliary body relaxes a potential of reverse charge is released. The continuous flow loops of the intraocular lens of the present invention are formed in the shape of conventional haptics and are anchored in the ciliary sulcus, a grove located between the ciliary body and the iris. When positive and negative charges are generated in the ciliary body they impact the charged fluid within the continuous flow loops. When a positive charge is generated in the ciliary body, the negatively charged fluid segment is attracted towards the ciliary body, and the positively charged fluid segment is repelled from the ciliary body, and visa versa. The applied charge thereby controls the position of the fluid segments within the continuous flow path. Preferably, the fluid segments are positioned such that when the ciliary body contracts, the segment of appropriately charged fluid