VARIABLE POWER LENS SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a lens system, and more particularly, to a variable or adjustable power lens device.

2. Prior Art

Variable focus lenses of various types are disclosed. For example, U.S. Pat. Nos. 4,373,218 and 4,190,330 disclose liquid crystal devices. In these prior art systems, the liquid crystal element is a relatively thick film, and thus requires relatively high activation power. U.S. Pat. No. 4,373,218 discloses a variable power intraocular lens formed of an expandable sack for implantation into the anterior chamber of a human eye. The lens may be a liquid crystal device controlled by a separate microprocessor. The liquid crystal material is contained within the expandable sock. U.S. Pat. No. 4,190,330 discloses the use of liquid crystal material in a complex dual lens configuration in which the focal length is varied by application of an electromagnetic field such as a magnetic field produced by an induction coil surrounding the entire lens structure. In U.S. Pat. Nos. 4,222,641; 4,016,094; and 3,499,112 various liquid crystal matrix devices are disclosed for color and light control. However, there is no system providing variable cylinder power and axis, prism power and axis, light and color in addition to sphere.

Other prior art of some relevance is disclosed in the following U.S. Pat. Nos.: 29,684, Gordon; 3,673,616, Fedorov et al; 3,974,331, Pepin; 3,976,874, Lange et al; 3,980,880, D'Agostino; 3,982,239, Sherr; 4,019,807, Boswell et al; 4,044,546, Koike; 4,050,814, McFadden; 4,143,265, Krappatsch; 4,239,345, Berreman et al; 4,241,339, Ushiyama; 4,272,910, Danz; 4,279,474, Belgorod; 4,300,818, Schachar; 4,332,039, LaFuente; 4,362,933, Kroener et al; 4,368,386, Huignard et al; 4,374,325, Howorth.

SUMMARY OF THE INVENTION

In one form, the present invention comprises a variable power lens having a thin film of optically active molecular material on a substrate, and means in operative relation to the material for producing a variable gradient index of refraction therein. In another embodiment, the invention comprises a multi-element, self-powered, variable lens. The present invention may be constructed so that the power requirement is small. Suitable power supplies for the invention include for example, a solar cell, a thermionic device, a low level nuclear power source, and a biological fuel cell. In miniaturized form, the invention is used as an intra-ocular or contact lens system in a human. The invention includes a lens in which the index of refraction is graded across the face and thereafter fixed at the value so established. In yet another embodiment, the lens is a flat structure of virtually any size, wherein a refractive index gradient creates a substantial change in lens power.

OBJECTS OF THE INVENTION

It is therefore a principal object of the present invention to provide an adjustable power lens system of thin film construction utilizing an optically active molecular material such as liquid crystals.

Is is another object of the invention to provide an adjustable power lens system having an optically active molecular material on a substrate and means in operative relation to the material for producing a variable gradient index of refraction.

It is still another object of the invention to provide a multi-element variable lens using optically active molecular material.

It is still another object of the invention to provide a variable power lens comprising an optically active lens element responsive to an eletric potential for changing the lens power, means for controlling the electrical potential applied to the lens element and a source of electrical potential, wherein at least the lens element and control means are contained on a common substrate.

It is still another object of the invention to provide a variable power lens comprising an optically active lens element responsive to a plurality of applied electrical potentials configured in the form of addressable matrix locations for providing a gradient in the refractive index of the lens element.

It is still an additional object of the invention to provide a variable power, multi-element lens such as a Fresnel lens in which each element thereof comprises a controlled liquid optical element that is adapted for addressable control by a respective electrode of a plurality of electrodes to which selectable electrical voltages are applied.

It is still an additional object of the present invention to provide a contact lens to be placed upon the cornea of the human eye, the ophthalmic correction provided by such a lens being established by the application of selectable voltages to liquid crystal material contained in the lens.

It is still an additional object of the present invention to provide a moldable variable power lens in which an optically active, curable material is subjected to a selected electromagnetic field for selection of lens parameters before being cured into a permanent lens configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

The aforementioned objects and advantages of the present invention, as well as additional objects and advantages thereof will be more fully understood hereinafter as a result of detailed descriptions of various embodiments, when taken in conjunction with the accompanying drawings in which:

FIG. **1** is a schematic block diagram of one embodiment of the present invention and control therefor;

FIG. **2** is a schematic representation of the embodiment described in FIG. **1** as an integral device;

FIG. **3** is a side sectional representation of the device shown in FIG. **2** taken along lines **3—3** thereof;

FIG. **4** is a schematic representation of a device similar to that shown in FIGS. **2** and **3** with multiple elements;

FIGS. **5***a*–**5***d* are schematic representations of various electrode arrangements of the present invention;

FIGS. **6***a*–**6***c* show embodiments of the present invention in the form of an intraocular lens;

FIGS. **7***a*–**7***d* are schematic representations of fresnel lens elements which may be utilized in the present invention; and

FIG. **8** is a schematic representation of a method and apparatus for fabricating a fixed value gradient index lens.