LENS SYSTEM FOR VARIABLE REFRACTION

DESCRIPTION

1. Technical Field

The present invention relates generally to variable refraction means and, more particularly, to a lens system for correction of impaired accommodation.

2. Background Prior Art

Good visual acuity requires that an individual be able to focus upon objects in the visual field. The ability to focus is conferred by the part of the eye called the lens. Normally, light rays from an external object pass through the lens on their way to the retina at the back of the eye. As light rays pass through the lens, they are bent or refracted so as to project a clear image on the retina. The amount of bending is termed refractive power. The refractive power needed to focus upon an object depends upon how far away the object is; close objects require more refractive power than distant objects.

A healthy lens changes its refractive power by changing its shape. The lens may undergo this alteration in shape, termed accommodation, by virtue of its elastic properties. Should the lens become inelastic, as often occurs with aging, or be removed surgically because of cataract or other disease states, the ability to accommodate becomes suboptimal. Specialized types of spectacles and contact lenses have been used in an attempt to restore accommodative ability. Each suffers from either a severely contracted visual field, a limited number of refractive powers, a limited area on the optical surface available for refracting light rays from any particular distance or a combination of these.

For example, the most common type of aid utilized today for correction of impaired accommodation incorporates a bifocal spectacle lens. This system is extremely cumbersome for the wearer since the eye must be alternately aligned with two discreet areas of the lens in order to achieve two different refractive powers. In addition, the visual field is reduced relative to unifocal spectacles. A variety of bifocal hard contact lenses have also been tried, generally without satisfactory results.

More recently, it has been proposed that liquids be used to produce either a spectacle lens or a contact lens having more than a single refractive power, and examples of such proposals are disclosed in U.S. Pat. Nos. 2,241,415; 2,437,642; 3,598,479; 3,614,215; and, 4,174,156. French Pat. No. 1,279,252 also discloses the use of liquids to produce variable power lens systems. So far as is presently known, none of these systems have achieved any degree of clinical or commercial success. In short, there is a great need for an improved lens system for the correction of impaired accommodation.

SUMMARY OF THE INVENTION

The present invention is a lens system for variable refraction having both solid and liquid components. The system includes a part termed the optical zone that serves to refract light rays and that also has both solid and liquid components. The solid components of the system comprise a housing having an internal closed space or chamber. A portion of the chamber spans the entire optical zone, and the housing is transparent in this region. Two or more immiscible liquids completely occupy the chamber. At least two of the contained liquids are transparent, and only transparent liquids have access to the optical zone. Each of the transparent liquids has a different refractive index. The following two relationships between the transparent liquids and the optical zone relate to the two general categories into which the several preferred embodiments of the present invention fall:

1. Two transparent liquids simultaneously constitute the liquid component of the optical zone such that the interface between them is always disposed essentially perpendicular to the optical axis.
2. Only one transparent liquid at a time constitutes the liquid component of the primary portion of the optical zone.

Differences in density exist between certain of the contained liquids, and such differences are responsible for gravitationally-mediated redistribution of the liquids when the system is tilted relative to the earth. Redistribution of the liquids results in a change in the refractive power of the system. Specifically, if condition 1 obtains, the change in power is due to partial displacement from the optical zone of one transparent liquid by another leading to a change in the curvature of the interface between the liquids. As this change is continuous in character, embodiments of the present invention manifesting this type of refractive power change all provide a continuous spectrum of refractive power. Preferred embodiments providing this function include continuous spectrum spectacles and continuous spectrum contact lenses. If condition 2 obtains, the change in power results from total displacement from the primary portion of the optical zone of one transparent liquid by another. The preferred embodiment of the present invention manifesting this type of refractive power change is a bifocal contact lens incorporating singly or in combination any of three distinct modifications of a closed chamber defining a simple convergent or divergent liquid lens confined to the area over the cornea.

In the detailed description to follow, the continuous spectrum spectacles will be discussed first, followed by bifocal contact lenses. Because of numerous structural similarities between the bifocal contact lenses and the continuous spectrum contact lenses, discussion of the latter will immediately follow discussion of the bifocal contact lenses.

BRIEF DESCRIPTION OF ILLUSTRATIONS

FIG. **1** is a side cross-sectional view of the earpiece and frame of a pair of spectacles;

FIG. **2** is a fragmentary cross-sectional view similar to FIG. **1** showing the spectacles in a tilted position;

FIG. **3** is a fragmentary top projectional view of the earpiece and upper portion of the frame of a pair of spectacles;

FIG. **4** is a fragmentary front view of the spectacles;

FIG. **5** is a larger-than-scale side view of the curved cylinder and associated connecting channels;

FIG. **6** is a side cross-sectional view of the frame and lens of a pair of spectacles, as viewed along line **6**—**6** in FIG. **4**.

FIG. **7** is a side cross-sectional view of the frame and lens of a pair of spectacles, as viewed along line **7**—**7** in FIG. **4**.

FIG. **8** is a cross-sectional view similar to FIG. **7**, showing the spectacles tilted 45°.

FIG. **9** is a schematic representation of a side cross-sectional view of the frame and lens of a pair of spectacles, as viewed along line **7**—**7** in FIG. **4**.