MULTIFOCAL OPHTHALMIC LENS

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to a refractive ophthalmic lens for simultaneous multifocal vision, the lens having at least one of its surfaces formed with a number of concentric circular bands, each of which has a prescribed dioptric power, the bands having an elliptical cross-section.

2. DESCRIPTION OF THE PRIOR ART

One form of multifocal ophthalmic lens is proposed in U.S. Pat. Nos. 4,210,391; 4,340,283 and 4,338,005 (Allen L. Cohen) whereby a multifocal Fresnel lens is constructed by means of modifying the phase separating annular rings of a zone plate, with curved or inclined optical facets of varying refractive indices which then function as Fresnel rings corresponding to the different focal powers desired. To counteract the inherent problems of a Fresnel lens with small annular zone widths where optical aberrations are introduced by diffraction effects, a zone plate is introduced. Thus, an ophthalmic lens according to the above patents would be a composite device comprised of a Fresnel lens and a zone plate.

A zone plate, essentially, is a diffraction optical device that consists of a series of concentric opaque rings of such predetermined width that rays from alternate half period elements are cut off. Such a device has some properties of a converging lens. Therefore, it has been attempted to use the combination of Fresnel lens and zone plate to approximate the function of a true refractive lens in either bifocal or multifocal configurations.

Anticipating the limitations presented by such a design, two of which are limited image brightness and limited dioptric power, another form of a multifocal ophthalmic lens has been proposed. Here the said lens is also a composite device as described above except that a phase shift multifocal zone plate is constructed in such a way that some of the zone plate focii actually coincide with some of the multifocal Fresnel lens focii. This is obviously done to increase image brightness at each of the focii. An ophthalmic lens designed on this basis will present two major drawbacks, both of which cannot be circumvented due to the inherent optical properties of such a device.

The first drawback is the fundamental problem of inadequate image brightness typical to such designs, especially considering the wide range of focal points in such a lens. The other drawback is the limited range of focal lengths achievable with such a device.

Specifically, if a bifocal lens of a certain power is constructed, a very limited additional power for near vision can be provided. Whenever an appreciable additional power is required, the said lens would be of very little value. The physical properties of light, such as wavelength and relative intensity, will fundamentally limit the performance of any multifocal ophthalmic lens, such as those proposed in U.S. Pat. Nos. 4,210,391; 4,340,283 and 4,338,005 mentioned earlier, especially when a small size is an absolute necessity, as is the case with contact or intraocular lenses.

It is paramount to keep in mind that any diffractive or composite diffractive lenses or devices are principally different from refractive lenses and only approximate a true refractive system.

Another type of an ophthalmic lens has been proposed in U.S. Pat. No. 4,418,991 (Joseph L. Breger). More specifically, a contact lens that would provide a distance correction at the center, while increasing the diopter adds away from the center would provide for intermediate and close viewing. (See Col. 5 lines 1 through 21 of Breger).

The dioptric power change in the above lens is achieved by progressively changing the radius of curvature of the posterior surface. A major limitation of such a lens is that the focal planes provided are not discrete but a progressive succession of innumerable possibilities, and therefore no truly sharp focal planes may be provided.

Another drawback is that the images produced will be located on substantially different areas of the retina which as is commonly known do not have the same sensitivity. Still another factor limiting the performance of such a lens will be its absolute dependence on the position relative to the pupil and the pupil size as well as its dilation. It is a common knowledge that to achieve a continuously ideal position with a contact lens is not frequently possible. To control the pupil size or dilation relative to changing luminosity is even more difficult. It is important to note that lenses of progressive power change designs share common drawbacks and limitations regardless of whether the distance vision is in the center or toward the edges of the viewing area. Obviously the limiting factors are not equivalent but their presence severely curtails the performance of such or similar lenses in one way or another.

Still another design of a multifocal ophthalmic lens is proposed in French Patent No. 1,319,800 by Sohnges. The lens in question would have discrete dioptric powers provided by concentric circular zones. The preferred version has the distance vision portion in the center of the lens and increasing dioptric power toward the periphery will provide intermediate and near vision. Although the formed images will be clearer than in progressive power increase or decrease designs, the performance of the lens in question will be limited due to a critical dependence on pupil size, centration of the lens relative to the pupil, ambient illumination as well as due to the creation of images on substantially different areas of the retina. Essentially the drawbacks of this design are similar to the ones in the progressive power change lenses differing mainly in the fact that the powers provided are discrete and not continuous.

Another form of an ophthalmic lens is described in W088/09950 (Valdemar Portney). The proposed lens has a plurality of concentric alternating zones with a continuously varying power within each zone as well as in transition from one zone to another. In one version, continuous alternating power is accomplished by a continuously changing curvature of the posterior surface of the lens. In another version continuous, alternating power variation is accomplished by creating non-homogeneous surface characteristics having refractive material indices which continuously vary in the lens radial direction. In other words, the optical portion of such a lens is comprised of a number of concentric zones. The distinctive characteristic of this design (page 9, lines 2 through 5) is that each zone is considered to include a complete cycle of powers from intermediate to high to intermediate to low, then back to intermediate.

Still another type of a multifocal ophthalmic lens is described in U.S. Pat. No. 4,798,608 (Dennis T. Grendahl). The invention pertains to an implantable intraocular lens containing a laminated structure comprising a