focal points, a situation which is inherrent in the usual multifocal lens designs.

Other objects and advantages of the present invention will be more fully apparent from the following description of the preferred embodiments when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the cross-section of a pattern of concentric conical surfaces demarcating the half wave zones of a phase plate.

FIG. **2** shows a front view of a phase plate illustrating the circular intersections of the conical half wave zones at the interface I.

FIG. **3** shows a cross-sectional view of a portion of a phase plate with optical facets implanted into the odd zones only.

FIG. **4** shows a cross-sectional view of a portion of a phase plate formed without any non optical ledges by smoothly merging the optical facets of the odd and even zones.

FIG. **5** shows a cross-sectional view of a portion of a bifocal plane plate formed by ion implementation in accordance with one embodiment of the present invention.

FIG. **6** shows a cross-sectional view of a portion of a trifocal phase plate formed by ion implantation in accordance with another modification of the present invention.

FIG. **7** is a cross-sectional view of a portion of a multifocal phase plate lens-mirror, with the lens formed by ion implantation in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the embodiment of the invention as shown in FIG. **5**, we have by way of illustration, the anterior surface I of a carrier lens or body CL divided into five concentric zones, bounded by radii r_1–r_5, in such a manner as to form a bifocal phase plate. The carrier lens or body of course, is constructed according to the usual principles governing the design of an optical lens with the surfaces I and B either spherical, sphero-cylindrical, or of any other appropriate lens design. The spherical, sphero-cylindrical, or aspherical power F of the carrier lens depends, according to the standard lens formulas, on the curvatures of the anterior and posterior surfaces I and B respectively, the center thickness CT, and refractive index of the carrier lens. These parameters are in turn, determined by the intended use of the multifocal phase plate and the materials available. For example, the posterior surface B may be shaped so as to minimize off axis optical aberrations if the multifocal phase plate is to be used as a spectacle lens. Standard optical materials such as glass, plastic, etc., or any other optically refracting materials may be used in the fabrication of this and all subsequent embodiments.

In this present configuration, a zone is determined as odd if it is bounded on the outside by a radius r_n with n being an odd integer, and even if n is an even integer. The optical facets of the odd zones correspond in inclination to the particular focal power $+1/d$, while the optical facets of the even zones correspond to the particular focal power $-1/d$. The inclinations of the facets must be constructed according to the principles of Fresnel zones as discussed by H. Ruhle in his U.S. Pat. No. 3,004,470, and in this case all have a common depth of $\lambda/2\ (n''-n')$ where λ is the wavelength of light, n'' is the index of refraction of the optical facets, and n' is the index of refraction of the carrier lens.

A particular advantage of this configuration, is the elimination of shadow effects caused by non optical ledges separating the optical facets in usual Fresnel lens constructions.

The spacing of the annular zones is of course given by the zone plate formula for r_n. In particular, the radii r_n, demarcating the boundaries between the annular zones are determined by $r_n=\sqrt{nd\lambda}$, where $n=1, 2, 3, \ldots, \lambda$ is equal to the wavelength of light under consideration, and d represents a focal length.

The new and important feature of the embodiment, and of all the subsequent embodiments, is the particular focussing power of the optical facets. In my invention the optimal image quality occurs when the Fresnel zone focii of the optical facets, coincide with the zone plate focii at $\pm d/N$ with N an integer. Furthermore, since we are dealing with a spectacle lens in this embodiment, we have chosen λ, the wavelength under consideration, to be equal to 555 nm. This is of course close to the wavelength to which the human eye will accommodate under normal viewing situations. The wavelength under consideration will be different for other uses of my invention.

A fabrication method for producing such a lens is that of ion implantation into a smooth surfaced carrier lens. This procedure is discussed by J. F. Ziegler in his article "Fabrication or Correction of Optical Lenses," IBM Technical Disclosure Bulletin, Vol. 12, No. 10, Mar. 1970, pp. 1573–1575. The Fresnel zones are actually formed by the imbedding of contaminants into the carrier lens or body CL which thereby alters its refractive index. Of course the formation of different zones may require different contaminants.

Another embodiment of the present invention, which utilizes ion implantation, is shown in FIG. **6**, where we are illustrating a trifocal phase plate. Here the first and fourth zones have echelettes for focussing light to the focal point $-d/2$; the second and fifth zones have echelettes for focussing light to the focal point $+d/2'$ while the third and sixth zones have no imbedded echelettes at all which will result in providing the focal power of the carrier lens itself.

In FIG. **7** we see a compound lens-mirror system. The mirror M has a reflective surface B, and onto this surface an optically refractive material is deposited to form a lens CL. The Fresnel zones are than formed in the lens by ion implantation. All of the design features illustrated in FIGS. **5** and **6** are directly applicable, and will produce different and useful embodiments of a multi-focal phase plate lens-mirror.

It should be understood, of course, that the foregoing disclosure relates only to the preferred embodiments of the invention, and that numerous modifications or alterations may be made therein, without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is new and desired to be protected by letters Patent is:

1. A multiple focal power optical device comprising: body means having a plurality of alternating annular, concentric zones, bounded on the outside by radii r_n, with $n=1, 2, 3, \ldots$;

first focal power means within at least some of the zones for directing incident parallel light to a first focal point $+d/N$, with N an integer;