PROGRESSIVE POWER OPHTHALMIC LENS HAVING A PLURALITY OF VIEWING ZONE WITH DISCONTINUOUS POWER VARIATIONS THEREBETWEEN

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of co-pending patent application Ser. No. 389,043 filed on Aug. 16, 1973, now abandoned, and further relates to co-pending applications Ser. No. 389,942 entitled "Progressive Power Ophthalmic Lens" and Ser. No. 389,044 entitled "Multifocal Lens", both co-pending applications being filed on Aug. 16, 1973 and both now abandoned.

BACKGROUND OF THE INVENTION

This invention is related to ophthalmic lenses in general and is more particularly concerned with novel progressive power and multifocal ophthalmic lenses in which the distortion is either so controlled that a wearer perceives vertical lines as vertical throughout most of the viewing area of the ophthalmic lens or the degree of distortion is severely diminished.

The human eye is a sensitive yet relatively simple organ. It contains a lens on the outer surface for receiving light from various objects in the field of view of the eye. A retina is positioned behind the lens to serve as a viewing screen for those rays focused by the lens onto the retina. A series of muscles surround the lens and act upon the lens to increase or decrease its curvature and focal length in order to focus upon objects which are either near to the eye or at a distance. When the normal eye views relatively distant objects, the lens and the muscles are in a relaxed position. In this position, the ideal lens has the proper curvature on its surface to focus the distant object on the retina. Upon the observance of objects at close range, the eye muscles act on the lens to increase its curvature and decrease the focal length of the lens sufficiently to focus the image of the near object onto the retina. This ability of the eye to adjust itself for varying object distances is commonly known as "accommodation". As the age of a human being increases, his power of accommodation generally decreases. This results from the fact the eye muscles become stiff and weak. For example, a child can normally change the focal power of his eye by at least 14 diopters. In a middle age person, the power of accomodation is often reduced to about 3 diopters, and in old age, the power of accomodation may disappear entirely.

For a long time, scientists and optical engineers have attempted to find solutions to this problem of decreasing accomodation with age. Probably the most common means which has been devised for treating this condition is to construct the corrective ophthalmic lens utilized by the person with decreased accomodation with a plurality of spherical surfaces. These are commonly known as bifocal and trifocal lenses depending upon whether the lens in question contains two or three spherical portions. In the bifocal lens, two separate segments of different dioptric focal powers are provided. The power of one segment is such that vision through it permits focusing on nearby objects such as reading matter while the other segment corrects the vision for viewing distant objects. In a trifocal ophthalmic lens a third spherical segment is interposed between the previously mentioned two segments to provide a measure of clear vision to the wearer intermediate between the dioptric focal powers of the distance and reading segments of the lens. The other surface of the mutlifocal ophthalmic lens is then provided with either a spherical or toric surface designed specifically to adapt the multifocal lens to the particular ophthalmic prescription of the wearer.

Certain major difficulties are, however, encountered by the users of mutlifocal ophthalmic lenses. Firstly, there is a line of sharp demarcation optically between the various segments of the multifocal lens. When the line of sight scans across this dividing line, a "jump" usually occurs in the image perceived by the wearer. It is difficult for the wearer to become accustomed to this sensation and to make allowances for it in normal life. Secondly, persons having severely reduced accomodation are unable to focus clearly on objects lying at distances between those distances at which the various segments are designed to focus. Thirdly, particularly in younger people having reduced accomodation powers, it is often difficult to convince some individuals that they require multifocal ophthalmic lenses for vision purposes. This is generally attributed to the fact that decreased accomodation is associated with oncoming age. The standard multifocal lens has a distinct line of demarcation between the various segments which is readily apparent to people in the vicinity of the wearer. Therefore, as well as the optical problems which exist with multifocal ophthalmic lenses, also certain cosmetic problems exist.

The obvious general solution to these problems is to place an intermediate viewing zone between the distance viewing zone and the reading zone which progresses in dioptric focal power from that of the distance viewing portion to that of the reading portion. By attempting this solution, an ophthalmic lens is provided in which both the optical and cosmetic problems may be solved in that there are neither lines of optical jump between distinct segments nor are there cosmetically obvious lines between the various segments. Furthermore, all intermediate focal powers between the distance and reading portions are provided such that the wearer is able to perceive objects at any distance clearly through a portion of this intermediate zone. Such a lens is known commonly as a progressive power ophthalmic lens. An excellent survey of such lenses was provided by A. G. Bennett in the October and November 1970, and February and March 1971 issues of *The Optician.* In this work, the various attempts are discussed which have been made to provide such progressive power ophthalmic lenses by various scientists and optical engineers over approximately the last 70 years.

All progressive power lenses of the prior art have suffered from at least one common failing. As a necessary concomitant of an aspherical surface such as is found in the progressive power lenses, a certain amount of astigmatism and distortion is inherently found in the refractive surface, particularly in the peripheral portions of the transitional zone. The distortion causes a swimming or rocking effect when the wearer's head is moved within the visual environment. This effect has served to cause many wearers of such ophthalmic lenses to become nauseated and has definitely prevented the wide acceptance of this type of eyewear. Furthermore, the astigmatism causes blurring of vision through the affected areas of the lens. This effect is, of course, objectionable as well.

Distortion occurs whenever astigmatism is present in the refracting surface. Thus distortion, like astigmatism,