ZONED MULTI-FOCAL CONTACT LENS

CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part of U.S. Ser. No. 06/541,454 filed 10-13-83 now U.S. Pat. No. 4,704,016.

FIELD OF THE INVENTION

This invention relates to contact lenses and in particular to bifocal and trifocal contact lenses.

Conventional bifocal contact lenses can be divided into two main types, i.e.

1. Concentric bifocals in which the distance vision zone is in the centre and the reading or near vision zone is a peripheral ring or toroid around the central area. Occasionally the zones are reversed.

2. Bifocals which resemble scaled-down spectacle bifocal lenses. These lens comprise two D-shaped segments, the lower segment being the near vision zone.

In the case of the first type, the size of the central zone is critical, particularly if the lens is fitted tightly to the cornea so that little movement occurs on blinking. The amount of light entering the eye from the distant and near vision zones must be approximately equal, otherwise vision will be biased towards either distance or reading. As the pupil diameter is not static but varies according to the brightness of the light, a compromise must be made in selecting the size of the central zone. This problem is made worse by the fact that the different in pupil size between the maximum and minimum varies from person to person.

Bifocal lenses of the second type generally have to be fitted slightly looser so that the lens can move over the cornea. In this case, when the wearer is looking straight ahead the line dividing the two segments is below the centre of the pupil, while for reading the opposite situation applies. Thus the location of the dividing line between the distance and reading zones is critical for satisfactory fitting of this type of lens. Although variations in pupil size are less important in the case of this type they can affect the result.

for these reasons a large measure of trial and error inevitably occurs in fitting bifocal lenses of both of the above types, and the practitioner therefore requires a very large inventory to cover all the necessary permutations.

DESCRIPTION OF THE PRIOR ART

It has been proposed in U.S. Pat. Nos. 4,340,283; 4,338,005 and 4,210,391 (all to Allen L. Cohen) to utilise multi-focal Fresnel zone plate designs in the construction. However, Cohen forms his zones on the front surface of the lens and the effective optical surface is modified to an unpredictable and variable extent by a tear layer of varying thickness on the front surface. Also, in order to obtain the diffraction phenonema required for such devices to work, very narrow zone widths are required.

SUMMARY OF THE INVENTION

A major object of this invention therefore is to provide bifocal lenses wherein pupil diameter and pupil fluctuations have little or no influence on the fitting of the lenses. In order to avoid unnecessary repetition the term "bifocal" is used in the following description and

claims to include trifocal lenses, where the context admits.

According to one aspect of the present invention, there is provided a bifocal contact lens having concave and convex lens surfaces and wherein at least a central vision area is divided into a plurality of concentric zones, at least some of the concentric zones being formed in the concave lens surface, and alternate concentric zones having a steeper curvature than the adjacent zone whereby the concave lens surface has a stepped configuration and the lens has two focal lengths.

The alternate concentric zones can be regarded as a series of alternating near and distant vision zones and the curvatures of the posterior and anterior surfaces calculated on this basis. The sum of the areas of such distant vision zones should preferably be substantially equal to the sum of the areas of such near vision zones. for example, the ratio of the total distant vision areas to the total near vision areas will generally be in the range of from about 60:40 to 40:60.

It is unnecessary for the whole surface of the lens to be divided into zones of different powers since it is only the portion of the lens which covers the pupil at its maximum dilation which is normally used in vision correction. Thus, the portion of the surface of the lens which is formed in such concentric zones is normally restricted to an optically central part of the lens having a diameter of about 5 to 6 mms.

In most lenses in accordance with the invention there will be at least 2 of each type of vision zone (i.e. distant and near) and usually there will be more zones, e.g. 6 or 8 or more. Typically, a lens will be formed with 3 to 6 zones of each kind.

One way of ensuring that the amount of light transmitted through near vision zones is substantially equal to that transmitted through the distant vision zones is to construct the zones so that they are of substantially equal area. However, it is usually convenient (and better results are obtained in practice), to provide a central distant vision zone which is surrounded by concentric zones of alternating power and a final peripheral zone having a power which is suitable for near vision.

Instead of forming all the vision zones on the back surface of the lens, these may be distributed between the posterior and anterior surfaces. This may be advantageous when larger, near addition powers are required or for patients having a particularly aspherical cornea. Another advantage is that the individual zones may be wider, e.g. twice the width of zones formed only on the back, concave surface.

In constructing the concentric zones, the aim is to form the alternating steeper and flatter curves to a depth which is such that in use a continuous tear film exists between the cornea and the back of the lens. It has been found that provided the depth of the cuts in the back surface of the lens do not exceed about 0.05 mm, a generally continuous tear film will be maintained when the lens is worn.

The concentric zones, which have a steeper curvature, will fill with tear fluid and constitute a series of annular positive tear lenses between the plastics lens and the cornea. Since the difference in refractive index between most plastics materials and tear fluid is much less than between plastics and air, a partial neutralisation will occur. For most plastics, the refractive index is such that the power difference between the near and distance vision zones in air will be about three times the