$$\frac{-0.15}{8 \times 10^{-3}} = -18.75 \text{ dioptres.}$$

It can be calculated what radius of curvature would be needed to change this to −16.75 dioptres, as such a change would provide a reading add of 2 dioptres. This value is nearly 9 mm. On the other hand if the effect is calculated of adding the profile of FIG. 7 to the 8 mm radius base curve, the new surface is found also to be a curve of radius nearly 9 mm. The difference in the phase zone plate concept is that this new curvature only extends as far as the boundary of the first full-wave zone. At that point a sharp change is allowed in the surface location equivalent to a phase delay of one wavelength at the design wavelength chosen. It is found by calculation that this is the same step size as brings the surface back to the 8 mm radius curve. The profile of the second zone starts at this point and this too give a radius of curvature of nearly 9 mm. Again, this proceeds outwards until the boundary of the second zone. At this point it is one wavelength step size away from the 8 mm radius base curve. Thus the series of zones each having a radius of curvature of 9 mm is set on a curvature of radius 8 mm traced out by the edges of the zones. This 8 mm radius curve is also traced out by the lower edges of each step. The two 8 mm radius curves are in fact one step size apart.

The arrangement is illustrated in FIG. **10** which shows part of the rear surface of a bifocal contact lens comprising a plurality of concentric zones of the same size as in a phase zone plate, the zones being defined by steps **4** between smooth curved zone areas **5** of 9 mm radius of curvature, the step size being such that the step top edges lie on a curve of 8 mm radius of curvature and the step bottom edges lie on another curve of 8 mm radius of curvature. In FIG. **10**, which is not to scale, the step sizes are magnified more than the zone sizes in order to exaggerate the effect.

In the case of zones with stepped areas as shown in FIG. **6**, the 8 mm radius of curvature value is not changed, but the location of this surface is shifted at each step and returned at the end of each zone. FIG. **11** shows part of the rear surface of a bifocal contact lens comprising a plurality of concentric zones of the same size as in a phase zone plate, the zones being defined by steps **6** and each zone having three stepped areas **7**, **8** and **9** of 8 mm radius of curvature, the step sizes being such as to give general conformation to a base curve of 8 mm radius of curvature. Like FIG. **10**, FIG. **11** is not to scale. The only curvature which exists in this arrangement is the 8 mm radius, but because this is stepped back at each ⅓ zone the surface within each zone approximates to the 9 mm surface required for the add value.

Thus in both these arrangements a curvature of one radius is made discontinuous so that it approximates to another curvature of different radius, even though the other curvature does not exist at any one place. A convenient analogy is that of a tiled roof where each individual tile slopes at a given angle but the slope (or pitch) of the whole roof is at a different angle. By such discontinuous arrangement a lens incorporating a phase zone plate can effectively achieve two curvatures (and therefore two focal lengths and focal powers) from one general surface.

The manufacture of such surfaces can utilise thin-film deposition methods, particularly when this can be applied to a mould from which many lenses may be cast or moulded. A further method of manufacture is the direct cutting of the surface using a high precision lathe. The cutting point is often a single point diamond and surfaces of good optical quality can be achieved. Such lathes have computer control systems which can position the cutting diamond to within one micron and can return centre of rotation of the diamond-carrying arm to the same position within ±0.2 microns. From FIG. **10** it can be seen that a lathe set up to turn a radius of 9 mm could be shifted at each zone edge by the one wavelength delay step size and continue cutting the 9 mm radius until the second zone edge, etc. Alternatively, a lathe set up to cut 8 mm radius could be used to cut such a curve across the whole lens and then return to cut the same radius but at slightly lower depths at the positions marked as **8** and **9** on FIG. **11**.

From the foregoing it will be seen that the resultant lens surface is a smooth curve interrupted in a regular series of discrete steps of related size. The curvature of the smooth curve determines one focus of the bifocal action while the regular series of steps determines the other focus of the bifocal action. The proportion of the available light which goes into these foci is determined by the sizes of the steps.

It will be appreciated that any of the zones or steps within each zone may be shifted by an amount equal to one wavelength (or multiples of one wavelength) delay at the design wavelength. The purpose of this is to affect the rate of change-over of intensity between the two images as the wavelength of the incident light is changed. Thus, for example, the second zone may be raised by one wavelength and also the third or fourth zones. The performance of the phase zone plate at the design wavelength is impervious to shifts of one (or multiples of one) wavelength.

As specifically described above the diffractive power is given by a series of circular hills (or valleys) on the contact lens rear surface, i.e. a surface relief hologram. It will be appreciated that a surface relief hologram could instead be on the front surface of the contact lens. It will further be appreciated that the diffractive power could be provided by refractive index changes instead of surface relief or thickness changes, or by a combination of refractive index and thickness changes. In each case the changes should be such as to provide the required asymmetric retardation of light across each zone width. Yet further, although the contact lens is described above as having refractive power resulting from the material of the lens and the basic curvature of its surfaces, the contact lens could have zero refractive power so that its optical power is wholly diffractive. Still further, although the order of diffraction into one sign (described above as positive) of which light of the design wavelength is predominantly directed is preferably, as described above, the first order, some other order could be employed with the lens appropriately designed predominantly to direct light of the design wavelength into one sign of that other order of diffraction. The design wavelength of 400 nanometers (blue light) mentioned above is a particularly suitable design wavelength being well displaced from the 700 nanometers wavelength (red light) which is predominantly transmitted at zero order, but is of course given by way of example and some other design wavelength could be used.

I claim: