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Galilean telescopic system for the partially sighted

New application of the Fresnel lens

DANIEL R. GERSTMAN AND JOHN R. LEVENE

From the Indiana University Clinic for the Partially Sighted, and the Physiological Optics Laboratory, Bloomington, Indiana

A Galilean telescope consists of a convex objective lens separated from a concave ocular lens by the sum of their secondary focal lengths. The optical system is an afocal one, *i.e.* the incident and emergent light are parallel. The magnification (M) of this afocal system is obtained by dividing the dioptric power of the ocular (F_2) by the dioptric power of the objective (F_1),

$$i.e.\quad M = -F_2/F_1 = -f_1/f_2,$$

where f_1 and f_2 represent the focal lengths of the objective and eyepiece, respectively.

Galilean telescopic systems aid the partially sighted by producing an apparent magnification of the conjugate retinal image. Typically, the telescopic systems used by the partially sighted are of two varieties: the spectacle telescope (in which the telescope is worn in the spectacle plane) (Appendix 1), and the contact-spectacle-lens telescope (in which the contact lens serves as an eyepiece and the spectacle lens as the objective) (Appendix 2). Theoretically, there is also the contact-lens telescope, which should be mentioned in passing (Appendix 3). The usual types of telescopic spectacles, for examples the Bier, Feinbloom, Keeler, Stigmat, Zeiss, etc., are very large, heavy, cumbersome, and generally poor cosmetically. From an optical point of view, they induce a restricted visual field, varying between 7° and 20°, depending upon the magnification. Consequently, the mobility of the patient is extremely limited, and many practitioners consider the reduced visual field intolerable, claiming that, if the patient was not legally blind before wearing the telescope, he would become legally blind, by definition, if he wore a telescope permitting so small a field.

To overcome some of the above difficulties, the contact-spectacle-lens telescopic system was conceived and developed. This system usually consists of a lenticular ophthalmic lens (objective) and a concave contact lens (eye-piece) separated by the sum of their secondary focal lengths, equivalent in this case to the vertex distance, *i.e.* the distance between the spectacle plane and the corneal apex. Optically, the contact-spectacle-lens telescope offers the distinct advantage of a large field of view, ranging from 43° to 50°. We should point out that the magnifications attained with such an optical system, and the new Fresnel system, to be described below, offer no distinct advantage over those produced by systems mentioned previously, *e.g.* the Bier-Hamblin type. Cosmetically, however, the appearance of the contact-spectacle-lens telescope is still objectionable. In view of the above remarks, the following system is recommended as it alleviates the shortcomings of the various systems to which we

Address for reprints: Prof. D. R. Gerstman, Division of Optometry, Indiana University, Bloomington, Indiana 47401, U.S.A.

have referred. The recent development in the field of ophthalmic optics of the Fresnel press-on lens has proved satisfactory when used in conjunction with the conventional spectacle lens. A Fresnel lens consists of a series of ever-increasing prisms concentrically arranged and moulded into a polyvinyl chloride membrane measuring approximately 1 mm. thick. Typically, it is applied to the ocular surface of an existing lens and is held against it by capillary attraction. This system has been found particularly useful as a substitute for the thick cataract lens with which many objectionable optical and cosmetic factors are encountered.

We should like to suggest a new construction of a contact-spectacle-lens telescopic system incorporating the Fresnel lens (Figure). This innovative application of the Fresnel lens in conjunction with the contact-spectacle-lens telescopic system has not been reported previously in the literature.

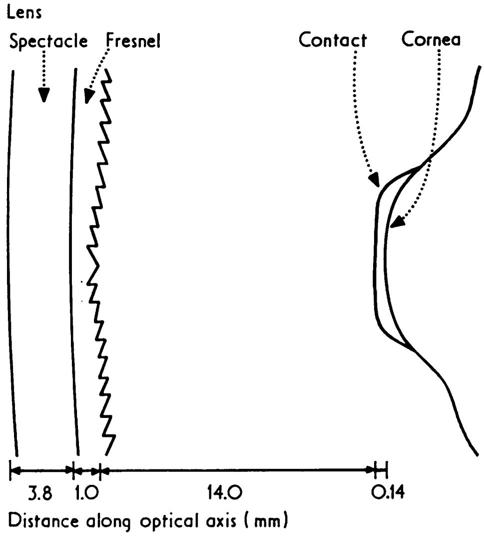

FIGURE *Contact—spectacle—Fresnel lens telescope*

The following case history illustrates the successful manner in which the Fresnel lens may be applied.

A man aged 29 years, a bilateral aphakic, first attended the Indiana University Clinic for the Partially Sighted in 1967. His visual problems dated back to May, 1963, at which time he was receiving medication for optic neuritis. The optic neuritis was followed by bilateral retinal detachments, and he subsequently received detachment surgery to the left eye. In 1964 he underwent bilateral cataract surgery. For the present purpose we shall confine our attention exclusively to the optical treatment of the left eye for distance vision.

Examination

There was a restricted visual field in the left eye. The unaided visual acuity for distance was nil in the right eye and 20/700 (6/200 –) in the left.

He was wearing the following prescription:

Right + 10·75 D sph. = Nil
Left + 11·25 D sph., – 1 D cyl., axis 165° = 20/400 – (6/120 –)

The keratometer readings were:

Right 42·00 at 3°; 44·50 at 93°
Left 42.25 at 6°; 44·87 at 96°

Static retinoscopy findings were:

Right Not possible
Left +14·00 D sph., −2·5 D cyl., axis 170° = 20/400− (6/120−)

Subjective refraction, left eye only, using simple and compound centred systems, was as follows:

(1) (Spectacles): +13·75 D sph., −3·5 D cyl., axis 10° = 20/350− (6/100−)
(2) (Telescope): 2×Bier-Hamblin = 20/350 (6/100); Field: vertical 25 cm., horizontal 33 cm. at 10 ft.
(3) (Telescope): 2·5×Selsi = 20/200 (6/60); Field: vertical 26 cm., horizontal 32 cm. at 10 ft.
(4) (Contact-spectacle-lens telescope):

(*A*) −24·5 *D sph. contact lens*

radius base curve	7·80 mm.
optical zone	8·00 mm.
centre thickness	0·14 mm.
overall diameter	9·00 mm.
radius peripheral curve one/width	8·794 mm./0·3 mm.
radius peripheral curve two/widths	12·250 mm./0·2 mm.
design	plus carrier to drop
colour	clear

(*B*) +6 *D sph. spectacle lens*

base curve	+10·00 D sph.
centre thickness	3·80 mm.
coating	anti-reflection
design	AO Tillyer

(*C*) +20 *D sph. Fresnel press-on lens*

thickness	1·00 mm.
material	polyvinyl

The above detailed system of a contact-spectacle-Fresnel lens telescope yielded a distance visual acuity of 20/200 (6/60) to 20/180− (6/48−) with a field at 10 ft of 90 cm. vertical and 190 cm. horizontal.

Let us now consider a +24 D sph. converging lens system. We should note that it can appear in three forms: glass lenticular, plastic aspheric lenticular, and Fresnel-spectacle lens system.

The Table (overleaf) compares thickness, weight, cosmesis, and cost for the three forms of +24 D sph. systems (assuming a 42 mm. round eye size); from this may be appreciated some practical reasons for incorporating the Fresnel press-on lens in high-powered lens systems, in addition to the optical advantages (increased visual acuity and wider visual field) of the telescopic systems discussed above.

Summary

The disadvantages of existing telescopic systems are discussed. A new telescopic system incorporating a Fresnel press-on lens is outlined, and case history illustrating the use of the system is presented. The optical superiority of the Fresnel system, in terms of increased visual acuity and field of vision, is discussed. Comparison between existing high-power converging systems and the Fresnel system are delineated in terms of optical considerations, thickness, weight, cosmesis, and cost.

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Table *Comparison of the three high-power converging systems*

Lens	*Thickness (mm.)*		*Weight (g.)*	*Aperture or button size (mm.)*	*Cosmesis*	*Approximate cost ($)*
	Centre	*Edge*				
(1) +24 D sph. lenticular glass	25·9	2	9·5	25	Poor	17.00 each
(2) +24 D sph. aspheric lenticular plastic	12·1	2	11·9	40	Fair	17.00 each
(3) +4 D sph. glass spectacle	3·8	1·2	8·9	42	Excellent	2.00 each
+20 D sph. Fresnel lens	1·0	1·0	1·3			4.95 each
Combined totals for System 3	4·8	2·2	10·2			6.95 each

The lenticular glass and aspheric lenticular plastic systems have a centre thickness respectively five times and twice as great as the spectacle-Fresnel system. System 1, *i.e.* the lenticular glass system, was marginally lighter than the Fresnel system, but this fractionally lighter weight is obtained at the expense of other factors, *e.g.* effective aperture size.

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