Chapter VIII

The Corneal Facsimiles of John Frederick William Herschel

INTRODUCTION

While writing of Chapter XII, with the title ***"Of the Structure of the Eye and of Vision"***, in the section ***"Light"*** of the volume IV of the *Encyclopaedia Metropolitana*, the English astronomer, *Sir John Frederick William Herschel* (1792-1871) put forward in 1827 the intriguing idea that it might be possible to correct a corneal irregularity by using an instrument designed to make an intaglio imprint from the affected cornea.
This suggestion is often identified with neutralization of the corneal dioptric power and the proposal to manufacture contact lenses for astigmatic and irregular corneas.

In the present chapter, it is proposed to:

a) analyze the texts which deal with this concept.

b) place those texts in the context of:
- *Herschel's* work,
- the work of several of his contemporaries and
- the knowledge in regard to ophthalmic optics in the first half of the 19th century,

c) carry out investigations of whether *Herschel* himself had, in actual fact, envisaged the neutralization of corneal dioptric power and the correction of astigmatism by a contact lens,

d) conclude by briefly reviewing the interpretations by contact lens historians of *Herschel's* contribution.

Taking into account that *Herschel* refers to *George Biddel Airy's* presentation, entitled ***"On a peculiar defect in the eye and a mode of correcting it"***, read on 21th February 1825 before the *Cambridge Philosophical Society*, this essential but rarely consulted document is transcribed too.

396 LIGHT.

Light. magnitude of the lens seen from the image, alone, whatever be the distance of the object. Now the apparent magnitude of the lens seen from the image is always much less than a hemisphere. Therefore (even supposing no light lost by reflection or refraction) the illumination of the image is always much less than that of the object. This is the case when the image is received on a screen which reflects all the rays, or when viewed by an eye behind it having a pupil large enough to receive all the rays which have crossed at the image. *à fortiori*, then, when the eye does not receive all the rays, must the apparent intrinsic brightness be less than that of the object. This supposes the object to have a sensible magnitude; but when both the object and its image are physical points, the eye judges only of absolute light; and the light of the image is therefore proportional to the apparent magnitude of the lens, as seen from the object. In the case of a star, for instance, whose distance is constant, the absolute light of the image is simply as the square of the aperture, and this is the reason why stars can be seen in large telescopes which are too faint to be seen in small ones. Part I.

Images are never so bright as their objects.

§ XII. *Of the Structure of the Eye, and of Vision.*

350. It is by means of optical images that vision is performed, that we see. The eye is an assemblage of lenses which concentrate the rays emanating from each point of external objects on a delicate tissue of nerves, called the retina, there forming an image, or exact representation of every object, which is the thing immediately perceived or *felt* by the retina.

Description of the eye. Fig. 70. Aqueous humour. Its composition. Refractive power. Cornea. Its figure an ellipsoid of revolution.

Fig. 70 is a section of the human eye through its axis in a horizontal plane. Its figure is, generally speaking, spherical, but considerably more prominent in front. It consists of three principal chambers, filled with media of perfect transparency and of refractive powers, differing sensibly *inter se*, but none of them greatly different from that of pure water. The first of these media, A, occupying the anterior chamber, is called the *aqueous humour*, and consists, in fact, chiefly of pure water, holding a little muriate of soda and gelatine in solution, with a trace of albumen; the whole not exceeding eight per cent.* Its refractive index, according to the experiments of M. Chossat,† and those of Dr. Brewster and Dr. Gordon,‡ is almost precisely that of water, viz. 1.337, that of water being 1.336. The cell in which it is contained is bounded, on its anterior side, by a strong, horny, and delicately transparent coat *a*, called the *cornea*, the figure of which, according to the delicate experiments and measures of M. Chossat,§ is an ellipsoid of revolution about the major axis; this axis, of course, determines the *axis of the eye*; but it is remarkable, that in the eyes of oxen, measured by M. Chossat, its vertex was never found to be coincident with the central point of the aperture of the cornea, but to lie always about 10° (reckoned on the surface) inwardly, or towards the nose, in a horizontal plane. The ratio of the semi-axis of this ellipse to the excentricity, he determines at 1.3; and this being nearly the same with 1.337, the index of refraction, it is evident, from what was demonstrated in Art. 236, that parallel rays incident on the cornea in the direction of its axis, will be made to converge to a focus situated behind it, almost with mathematical exactness, the aberration which would have subsisted, had the external surface a spherical figure, being almost completely destroyed.

Figure 8-1

John Frederic William Herschel, Encyclopaedia Metropolitana, 4, 1845, Section "Light", Paragraph XII, "Of the Structure of the Eye, and of Vision", upper part of page 396.

359. But these are not the only cases of defective vision arising from the structure of the organ, which are susceptible of remedy. Malconformations of the cornea are much more common than is generally supposed, and few eyes are, in fact, free from them. They may be detected by closing one eye, and directing the other to a very narrow, well-defined luminous object, not too bright, (the horns of the moon, when a slender crescent, only two or three days old, are very proper for the purpose,) and turning the head about in various directions. The line will be doubled, tripled, or multiplied, or variously distorted; and careful observation of its appearances, under different circumstances, will lead to a knowledge of the peculiar conformation of the refracting surfaces of the eye which causes them, and may suggest their proper remedy. A remarkable and instructive instance of the kind has recently been adduced by Mr. G. B. Airy (*Transactions of the Cambridge Philosophical Society.*)

Malconformations of the cornea.

Remarkable case.

Figure 8-2

John Frederic William Herschel, Encyclopaedia Metropolitana , 4, 1845, Section "Light". Paragraph XII "Of the Structure of the Eye and of Vision", page 398, marginal number 359
"Malconformations of the cornea".
This text is dedicated to astigmatism, which had just been discovered. Herschel describes in this chapter a pertinent technique that proves the existence of astigmatism.

1 - Source Documents: The passages in the Encyclopaedia Metropolitana

(Figures 8 – 1)

The passages quotes are part of an article by *Herschel*, entitled, "***Of the Structure of the Eye and of Vision***" in the section on "*Light*", in Volume IV of the *Encyclopaedia Metropolitana* (1).

To commence, different passages from the above section will be examined, in the order in which they occur that might suggest neutralization of corneal dioptric power and the manufacture of a contact device. These are found on:

- page 398 at marginal number 359,
- a note at the foot of page 398,
- and on page 400, at marginal number 368.

1.1. - "*Malconformations of the Cornea*" (page 398, marginal number 359)

(Figure 8 – 2)

The chapter "***Malconformations of the cornea***" is dedicated to astigmatism, which had just been discovered. *Herschel* describes in this chapter a pertinent technique that proves the existence of astigmatism (2):

"But these are not the only cases of defective vision arising from the structure of the organ, which are susceptible of remedy. Malconformations of the cornea are much more common than is generally supposed, and few eyes are, in fact, free from them. They may be detected by closing one eye, and directing the other to a very narrow, well-defined luminous object, not too bright (the horns of the moon, when a slender crescent, only two or three days old, are very proper for the purpose) and turning the head about in various directions. The line will be doubled, tripled, or multiplied, or variously distorted; and careful observation of its appearances, under different circumstances, will lead to a knowledge of the peculiar conformation of the refractive surfaces of the eye which causes them, and may suggest their proper remedy." (3)

1. The article bears the date of 12th December 1827 ("Slough, December 12, 1827"). A French translation of the first edition by Verlust and Quetelet appeared in 1829, followed by a German edition in 1831, the English version in the Encyclopaedia Metropolitana was published in 1830.
2. For a critical analysis of the diagnostic test resulting from the subject of this work, refer to : Enoch, J.M., Heitz, R.F., Lakshminarayanan, V., 1988.
3. Herschel 1845, p. 398.

1.2 - "Remarkable case, successfully remedied by glasses" (page 398, marginal number 359)

(Figure 8 – 3)

Then, with the subtitle ***"Remarkable case, successfully remedied by glasses"***, *Herschel* refers to the discovery, by *George Biddel Airy* (4), of astigmatism in one of his eyes and the correction of this which he achieved with a custom-ground spectacle lens possessing spherical and cylindrical surfaces:

"A remarkable and instructive instance of the kind has recently been adducted by Mr. G. B. Airy, (Transactions of the Cambridge Philosophical Society) in the case of one of his own eyes; which, from a certain defect in the figure of its lenses, he ascertained to refract the rays to a nearer focus in a vertical than in a horizontal plane, so as to render the eye utterly useless. This, it is obvious, would take place of the cornea, instead of being a surface of revolution, (in which the curvature of all its sections through the axis must be equal), were of some other form, in which the curvature in a vertical plane is greater than in a horizontal. It is obvious, that the correction of such a defect could never be accomplished by the use of spherical lenses." (3)

Remarkable case, successfully remedied by glasses. eye which causes them, and may suggest their proper remedy. A remarkable and instructive instance of the kind has recently been adduced by Mr. G. B. Airy, (*Transactions of the Cambridge Philosophical Society*,) in the case of one of his own eyes; which, from a certain defect in the figure of its lenses, he ascertained to refract the rays to a nearer focus in a vertical than in a horizontal plane, so as to render the eye utterly useless. This, it is obvious, would take place if the cornea, instead of being a surface of revolution, (in which the curvature of all its sections through the axis must be equal,) were of some other form, in which the curvature in a vertical plane is greater than in a horizontal. It is obvious, that the correction of such a defect could never be accomplished by the use of spherical lenses. The strict method, applicable in all such cases, would be to adapt a lens to the eye, of nearly the same refractive power, and having its surface next the eye an exact *intaglio* fac-simile of the irregular cornea, while the external should be exactly spherical of the same general convexity as the cornea itself; for it is clear, that all the distortions of the rays at the posterior surface of such a lens would be exactly counteracted by the equal and opposite distortions at the cornea itself.† But the necessity of limiting the correcting lens to such surfaces as can be truly ground in glass, to render it of any real and everyday use, and which surfaces are only spheres, planes, and cylinders, suggested to Mr. Airy the ingenious idea of a double concave lens, in which one surface should be spherical, the other cylindrical. The use of the spherical surface was to correct the general defect of a too convex cornea. That of the cylindrical may be thus explained. Suppose parallel rays incident on a concave cylindrical surface, A B C D, in a direction perpendicular to its axis,
Fig. 71. as in fig. 71, and let S S′ P P′ Q Q′ T T′, be any laminar pencil of them contained in a parallelepiped infinitely

Figure 8-3

John Frederic William Herschel, Encyclopaedia Metropolitana , 4, 1845, Section "Light", Paragraph XII "Of the Structure of the Eye and of Vision", page 398, marginal number 359 "Remarkable Case, Successfully remedied by glasses."
Herschel refers to the discovery, by George Biddel Airy, of astigmatism in one of his eyes and the correction of this which he achieved with a custom-ground spectacle lens possessing spherical and cylindrical surfaces.

4. George Biddel Airy (1801 - 1892), Professor of Mathematics and Astronomy at the University of Cambridge. Levene devoted a study to him (1977, 224-257).

1.3 - A Method of Correcting an Irregular Cornea using an Intaglio 'Facsimile' Imprint

The proceure that *Airy* used is only applicable to corneas with regular astigmatism. It is not, however, effective for corneas with irregular astigmatism. In such cases, *Herschel* takes his inspiration from *Airy's* previous achievement and recommends that one should use a lens with a posterior surface consisting of an intaglio 'facsimile' imprint symmetrical to and a three-dimensional mirror-image of the corneal irregularity but with an anterior surface of the same convexity as that of a normal cornea:

"The strict method, applicable in all such cases, would be to adapt a lens to the eye, of nearly the same refractive power, and having its surface next the eye an exact intaglio facsimile of the irregular cornea, while the external should be exactly spherical of the same general convexity as the cornea itself; for it is clear, that all the distortions of the rays at the posterior surface of such a lens would be exactly counteracted by the equal and opposite distortions at the cornea itself." (3)

1.4 - The Footnote of Page 398

(*Figure 8 – 4*)

* Wollaston, on Semi-decussation of the Optic Nerves, *Philosophical Transactions*, 1824.
† Should any very bad cases of irregular cornea be found, it is worthy of consideration, whether at least a temporary distinct vision could not be procured, by applying in contact with the surface of the eye some transparent animal jelly contained in a spherical capsule of glass; or whether an actual mould of the cornea might not be taken, and impressed on some transparent medium. The operation would, of course, be delicate, but certainly less so than that of cutting open a living eye, and taking out its contents.

Figure 8-4

John Frederic William Herschel, Encyclopaedia Metropolitana, 4, 1845. Chapter "Light" Paragraph XII "Of the Structure of the Eye and of Vision". Notes at the foot of page 398.
In this footnote, Herschel describes two other propositions concerning how to achieve the visual correction of irregular corneal astigmatism. First he describes the use of "some transparent animal jelly contained in a spherical capsule of glass", and then, as an alternative, the fabrication of a mould taken from the irregular cornea which could be "impressed on some transparent medium".

A reminder at the end of this sentence directs us to a note at the foot of the page, where *Herschel* describes two other propositions concerning how to achieve the visual correction of persons affected by irregular corneal astigmatism. First of all, he describes the use of *"some transparent animal jelly contained in a spherical capsule of glass"*, and then, as an alternative, the fabrication of a mould taken from the irregular cornea which could be *"impressed on some transparent medium"*:

"Should any very bad cases of irregular cornea be found, it is worthy of consideration, whether at least a temporary distinct vision could not be procured, by applying in contact with the surface of the eye some transparent animal jelly contained in a spherical capsule

of glass; or whether an actual mould of the cornea might not be taken, and impressed on some transparent medium. The operation would, of course, be delicate, but certainly less so than that of cutting open a living eye, and taking out its contents." (5)

1.5 - The Neutralization of the Corneal Dioptric Power of Fish Eyes (page 400, marginal number 368)

(Figure 8 – 5)

In the eyes of fishes, the humours being nearly of the refractive density of the medium in which they live, the refraction at the cornea is small, and the work of bringing the rays to a focus on the retina is almost wholly performed by the crystalline. This lens, therefore, in fishes is almost spherical, and of small radius, in comparison with the whole diameter of the eye. Moreover, the destruction of spherical aberration not being producible in this case by mere refraction at the cornea, the crystalline itself is adapted to execute this necessary part of the process, which it does by a very great increase of density towards the centre. (Brewster, *Treatise on New Philosophical Instruments*, p. 268.) The fibrous and coated structure of the crystalline lens is beautifully shown in the eye of a fish congulated by boiling.

Figure 8-5

John Frederic William Herschel, Encyclopaedia Metropolitana, 4 1845, Chapter "Light", Paragraph XII, "Of the Structure of the Eye and of Vision", page 400, marginal number 368, "Eyes of fishes".
Herschel refers to the neutralization of the corneal dioptric power by water of fish eyes, where he recognizes that contact with water eliminates the corneal refraction.

It is interesting to note that two pages further on, at marginal number 368 of the same document, *Herschel* refers to the phenomenon of neutralization of the corneal dioptric power by water. He does this while describing the optics of fish eyes, under the title of ***"Eyes of fishes"***, where he recognizes that contact with water eliminates the refraction of fish eyes:

"In the eyes of fishes, the humours being nearly of the refractive density of the medium in which they live, the refraction of the cornea is small, and the work of bringing the rays to a focus on the retina is almost wholly performed by the crystalline. This lens, therefore, in fishes is almost spherical, and of small radius, in comparison with the whole diameter of the eye. Moreover, the destruction of spherical aberration not being producible in this case by mere refraction of the cornea, the crystalline itself is adapted to execute this necessary part of the process, which it does by a very great increase of density towards the center. (Brewster, Treatise on New Philosophical Instruments, p. 268.) The fibrous and coated structure of the crystalline lens is beautifully shown in the eye of a fish coagulated by boiling." (6)

5. Herschel 1845, p. 398, note 2.
6. Herschel 1845, p. 400, marginal number 368.

2 - Discussion

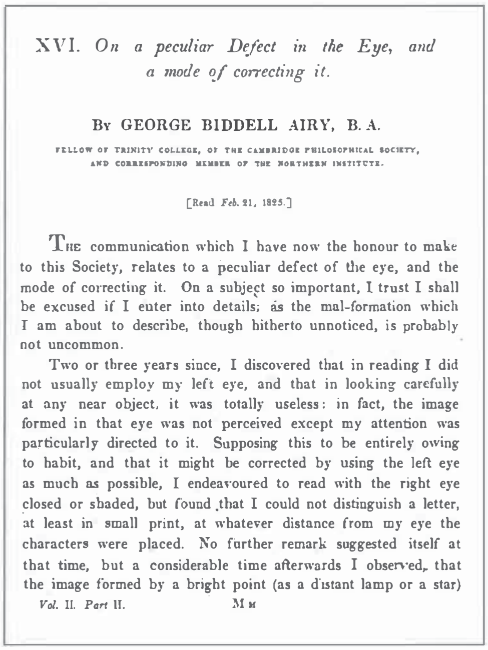
2.1 - Analysis of Herschel's Publication

(Figure 8 – 6)

Herschel's publication takes into account discussions on astigmatism following *Young*'s works and the discovery by *Hawkins* and by *Airy* of their own corneal astigmatism. *Airy* had corrected his own regular corneal astigmatism by an sphero-cylindrical spectacle lens. *Herschel* tried to extrapolate this procedure to irregular corneal astigmatism. (7)

To achieve this, he envisages three possibilities:

- a lens of which the surface directed towards the eye would be an intaglio facsimile, or three-dimensional 'mirror-image', that would correspond with the exact contour of the irregular cornea but in reverse form and of which the other surface would be without irregularities,
- a jelly of animal origin held up against the surface of the eye by a glass cupola that would smooth out corneal irregularities,
- the utilization of an ocular mould in order to produce a counter-imprint of the corneal relief on a transparent substance.



XVI. *On a peculiar Defect in the Eye, and a mode of correcting it.*

By GEORGE BIDDELL AIRY, B. A.

FELLOW OF TRINITY COLLEGE, OF THE CAMBRIDGE PHILOSOPHICAL SOCIETY, AND CORRESPONDING MEMBER OF THE NORTHERN INSTITUTE.

[Read *Feb.* 21, 1825.]

The communication which I have now the honour to make to this Society, relates to a peculiar defect of the eye, and the mode of correcting it. On a subject so important, I trust I shall be excused if I enter into details; as the mal-formation which I am about to describe, though hitherto unnoticed, is probably not uncommon.

Two or three years since, I discovered that in reading I did not usually employ my left eye, and that in looking carefully at any near object, it was totally useless: in fact, the image formed in that eye was not perceived except my attention was particularly directed to it. Supposing this to be entirely owing to habit, and that it might be corrected by using the left eye as much as possible, I endeavoured to read with the right eye closed or shaded, but found that I could not distinguish a letter, at least in small print, at whatever distance from my eye the characters were placed. No further remark suggested itself at that time, but a considerable time afterwards I observed, that the image formed by a bright point (as a distant lamp or a star)

Vol. II. Part II. Mm

Figure 8-6

Georg Biddel Airy, "On a Peculiar Defect in the Eye and a Mode of Correcting it". Transactions of the Cambridge Philosophical Society, 2, 1827, 267-271.

The three propositions have as a common aim the duplication, but in negative form, of the corneal surface irregularity. Two of them utilize a device placed in direct contact with corneal tissue.

- the first proposition requires that '*a lens*' of the same refractive index as the eye would be needed, and *Airy* used such a lens for the correction of corneal astigmatism. *Herschel* does not refer specifically to the corneal refractive index, but rather to that of the whole eye. This ambiguity could lead one to suppose that the lens was placed either in a spectacle frame as *Airy* did, or, alternatively, in direct contact with the eye itself,
- the '*transparent animal jelly*' referred to in the second proposition, whose fluidity would smooth out the corneal irregularities, would require to be held there by a glass capsule of spherical curvature. *Herschel* imagines a product originating from an animal and probably derived from gelatin. (8)

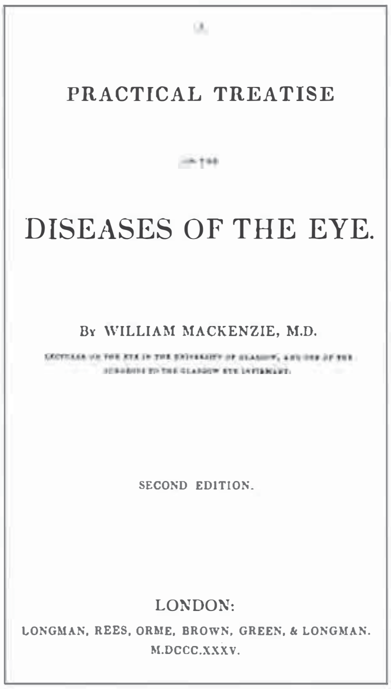
7. For the works of Hawkins and those of Airy that come out from the framework of this publication, it is interesting to consult Levene (1977, p. 214 - 219).
8. Gelatin, obtained by boiling in water collagen taken from animal conjunctival tissue, melts at 25 degrees Celsius and does remain in its gelatinous state on contact with the eye.

One is unable to pronounce, as a matter of factual information, on whether *Herschel* was convinced of the feasibility of correction of corneal irregularities by the placement on the eye of a lens with an irregular posterior surface, of a jelly or of another transparent substance. In any event, there is no evidence that he tried to put his idea into practice.

We should note that in the passage on the optics of fish eyes in water, *Herschel* is aware that water placed in contact with the eyes of fish largely eliminates their refraction. However, he makes no connection between the description of neutralization of the corneal dioptric power of the fish eyes and the correction of irregular astigmatism by contact with a medium of the same refractive index such as he had described two pages earlier.

2.2 - Herschel's Publication in the Context of the Knowledge of his Era

Herschel's idea of neutralizing irregular corneal astigmatism by means of a lens cut to match an intaglio facsimile in reverse relief and taken from a pathological cornea reverberated favorably amongst some British ophthalmologists in the course of the following years. This is particularly true in the case of *William Mackenzie,* Professor of Ophthalmology in Glasgow. He was the author of a treatise on eye diseases that, in addition to four English language editions, had also been translated into two French and one German edition. (9)


PRACTICAL TREATISE

DISEASES OF THE EYE.

By WILLIAM MACKENZIE, M.D.

SECOND EDITION.

LONDON:
LONGMAN, REES, ORME, BROWN, GREEN, & LONGMAN.
M.DCCC.XXXV.

Figure 8-7

William Mackenzie, "A Practical Treatise on the Disease of the Eye" (2rd edition, 1835).

2.2.A - William Mackenzie

(Figure 8 – 7)

In the three first editions of his ***"A Practical Treatise on the Diseases of the Eye"*** *Mackenzie* refers to *Herschel*'s idea in the chapter on "*Conical Cornea*":

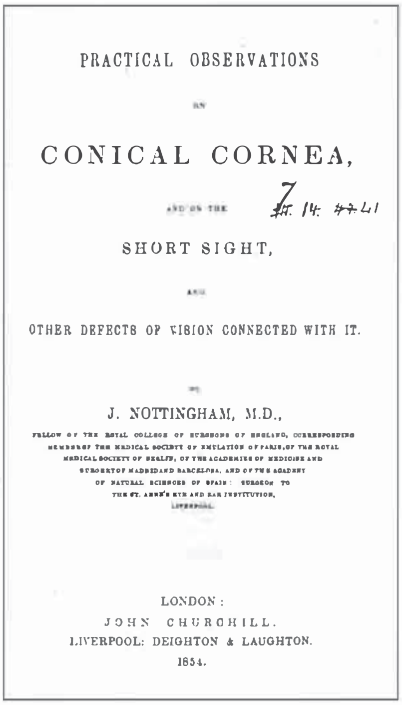
"Sir John Herschel suggests, as worthily of consideration, in very bad cases of irregular cornea whether at least a temporary distinct vision could not be procured, by applying in contact with the surface of the eye, some transparent animal jelly contained in a spherical capsule of glass; or whether an actual mould of the cornea might not be taken and impressed on some transparent medium. The operation, says he, would, of course, be delicate, but certainly less so than cutting open a living eye, and taking out its contents." (10)

Further on, in the chapter with the title *"Irregular Refractions"* and without giving any reference, this is taken up in the text with the citation from the first proposition of *Herschel*, inspired by *Airy*:

9. French translation with notes and comments by Laugier and Richelet, 1844. For works and life of William Mackenzie, a famous surgeon in Glasgow, see Hirschberg's detailed study Vol. XXIII, § 679-683.
10. Mackenzie 1840 (3rd edition), p. 590.

"***Irregular Refraction.*** *- The correction of such a defect could never be accomplished by the use of spherical lenses. The strict method, applicable in all such cases would be to adapt a lens to the eye, of nearly the same refractive power, and having its surface next the eye an exact intaglio facsimile of the irregular cornea, while the external surface should be exactly spherical, and of the sale genera as the cornea itself". (11)*

However, in 1854, in the fourth edition of his book, *Mackenzie* recognizes that, even if the mold of the eye did not present any difficulties, this lens would nevertheless be unusable, because the eye would not tolerate it. This would lead one to suppose that he had tried to put *Herschel's* proposal into practice. (12)


PRACTICAL OBSERVATIONS

CONICAL CORNEA,

SHORT SIGHT,

OTHER DEFECTS OF VISION CONNECTED WITH IT.

J. NOTTINGHAM, M.D.,

LONDON:
JOHN CHURCHILL.
LIVERPOOL: DEIGHTON & LAUGHTON.
1854.

Figure 8-8

J. Nottingham, "Practical Observations on Conical Corneal and on the Short Sight, and other Defects of Vision connected with it", 1854.

2.2.2 – Nottingham

(Figure 8 - 8)

J. Nottingham, surgeon to the Liverpool Eye and Ear Infirmary, wrote a paper, which appeared in 1854 on "*Practical Observations on Conical Cornea*" and touched on the optical correction of this condition. He also suggested "*lenses with posterior surface corresponding to the front of the eye, and anteriorly of regular figure.*" (13) He referred to "*lenses of transparent animal jelly, contained in capsules of glass, to be placed on the front of the eye, and kept there as long as the patient will bear spectacles of this kind.*" However, he did not define the wearing time of these original and probably very uncomfortable 'spectacles'.

This concept of *Herschel* seems therefore to have been known to his contemporaries. Nevertheless, numerous hurdles remained to be crossed for putting it into practice because this constituted a risky act in view of the absence of antibiotics and anti-inflammatory agents.

11. Mackenzie 1840, (3rd edition) p. 796.
12. This 4th edition was translated in 1857 by Warlomont and Testelin in French language.
13. Nottingham J. 1854, p. 246.

3 - Herschel, Corneal dioptric Power Neutralization and Contact Lenses

It is regrettable that *Herschel* did not make the connection between the correction of corneal astigmatism and the neutralization of corneal refractive power in the eyes of fishes described two pages later, because, otherwise he would have defined the principal attribute of contact lenses, i.e. the neutralization of the corneal dioptric power and its replacement by a new optical surface.

It is also probable that, at the time of the discussions on the correction of corneal astigmatism, *Herschel* had considered the construction of a glass device mounted in a spectacle frame, just as *Airy* had to ask "*a workman named Fuller*" to grind a sphero-cylindrical lens suitable for mounting in a spectacle frame. The utilization of a gelatinous mass of animal origin in the second proposition also required, according to his description, the covering of the anterior surface by a regular spherical glass copula free of astigmatism that he could have fixed in a spectacle frame.

It is also noteworthy in this regard that the utilization of glass would not itself have corrected the corneal astigmatism by reason of the difference of the refractive index between glass (n: 1.52 for crown glass, higher as 1.62 for flint glass) and the cornea (n: 1.37 for the cornea and the schematic eye of *Gullstrand*). Besides, the index of refraction of the human cornea was not known at the beginning of the 19[th] century.

Further reference to physiological and mechanical problems relating to an irregular structure closely applied to the cornea, whether placed under the lids or held in a glass cupola fixed to a spectacle frame, is not necessary. We must accept that *Herschel's* idea could not be put into practice, as *Mackenzie* appears to have concluded. In these modern times, the idea remains impractical, notwithstanding the efforts of some people to equate the idea of a gelatinous mass to the concept of soft contact lenses.

In *Herschel*'s vindication, one should emphasize that no material available in his era had the refractive index and properties for even an approximate neutralization of corneal refractive power or the fabrication of and accurate negative three-dimensional facsimile model of the corneal profile. Even in our times, the correction described by *Herschel* would not be possible any more. One could compare the jelly covered by the glass cupola to a structure comprising the superimposition of a rigid contact lens ('piggyback lens') over a soft contact lens manufactured from a corneal mould, such as has never previously been achieved even to this day.

Reference to the text of *Airy* does allow us to be sure that *Herschel* had not thought of a system of neutralization of the corneal dioptric power by contact and *Airy* corrected his own astigmatism by what was effectively an sphero-cylindrical spectacle glass.
On the other hand, *Herschel* does not utilize any neutralization liquid and does not make any connection with the neutralization of the corneal dioptric power by immersion of the eye of the fish. He seeks to neutralize, i.e. eliminate as *Airy* did, the irregularity of the cornea by means of a material of the same refractive index and of which the anterior surface would have an optical effect. This is a hypothesis that has not achieved practical realization even in modern times.

It is true that *Herschel* introduced the following listed concepts that:

- of the neutralization of the irregularities in the cornea by a medium (either a glass lens or an animal jelly) capable of being placed in contact with the eye,
- of neutralization of the optical effect of the cornea of the eyes of fishes by immersion in water,
- of the corneal impression with intention to fabricate a matching intaglio facsimile in negative form of the irregular cornea, (14)
- of a corrective device made out of jelly held in position by some form of glass capsule.

It is incorrect to equate with contact lenses the device *Herschel* refers to, because:

- in regard to his **first proposition**, that of '*a lens*' of glass, which was *"of nearly the same refractive power"*, and of which the posterior surface would be *"an exact intaglio facsimile of the irregular cornea"*, it is evident, not only that this device would be technically impractical, but that it would also be intolerable if it were to be placed in contact with the eye. A contact lens neutralizes corneal irregularity by means of a compatible liquid, with physiological tolerance by the eye as an essential requirement, such as is not the case with the lens proposed by *Herschel*.
No element of the relevant passage (and with particular respect to his reference to *Airy)* indicates that *Herschel* imagined placing the '*lens*' under the lids and in contact with the cornea. It is clear that he only envisaged a lens fixed in a spectacle frame, as *Airy* had proposed for regular astigmatism,

- the **second proposition** to utilize *"some transparent animal jelly contained in a spherical capsule of glass"* does not fill any of the criteria enunciated for contact lenses. It would certainly be tempting to imagine that *Herschel*, knowing the relatively low melting point of gelatin, would have envisaged letting it melt under the glass cupola. There is however no textual evidence to support this hypothesis. *Herschel* attributes an essential optical role to gelatin material that he would apply in contact with the surface of the eye and does not envisage that such a material might melt or be diluted with tears.
Besides, there is no element suggesting that *Herschel* might have foreseen the placement of the spherical glass capsule under the eyelids. It is evident that he envisaged rather a capsule held by a spectacle frame,

- the **third proposition** of putting into practice *"an actual mould of the cornea [...] impressed on some transparent medium"*, appeared to him a "*delicate operation*", but nevertheless one that was capable of being carried out. It seems, however, that the trials carried out along these lines by *Mackenzie* were not fruitful. There is no real suggestion that the negative facsimile intaglio obtained could have been placed in contact with the eye. It is possible that *Herschel* had envisaged adapting it to a spectacle frame.

14. The interest of a corneal mould is limited in view of the fact that a rigid contact device should not be in direct contact with corneal tissues. When, following Dallos, a corneal mould was used to manufacture contact lenses; the manufacturer took care to hollow out by grinding the corneal portion in order to create a space for lachrymal circulation thereby avoiding contact between cornea and lens. It is possible that, in the future, a new hydrophilic material can be of a quality sufficient for their toleration in direct contact with irregular corneal tissue, while at the same time having a regular external surface.

The likely ocular tolerance of the 'transparent medium' thus fashioned is not referred to in the text. It is probable that *Herschel* was thinking simply about fashioning the posterior surface of a spectacle glass lens matching the mould and did not envisage any ocular contact.

It should also be noted that *Herschel* never imagined that the theoretical speculations put out in this article would be applied in practice. Amongst his contemporaries, both *Mackenzie* and *Nottingham*, were unsuccessful in their attempts to apply what *Herschel* proposed.

It is difficult to attribute to *Herschel* the primacy of the idea to carry out neutralization of the corneal refractive power by a liquid, there being no connection between the immersion of the eyes of fishes in a neutralizing liquid (as described on page 400) and the correction of irregular corneal astigmatism by a lens or a jelly held in a cupola (as described on page 398). One can only regret that *Herschel* did not bring together the ideas, which were described within an interval of two pages because that combination of his ideas would have perhaps allowed him to describe a system of neutralization and correction of corneal dioptric power by ocular contact.

4 - History of an erroneous Attribution and of some Misinterpretations

4.1 - The French Attributions (1893)

The attribution to *Herschel* of the priority of the invention of contact lenses goes back to the year 1893. In arbitration of the controversy, which occurred at the Congress of the French Society of Ophthalmology between opponents *Eugène Kalt* and *David Sulzer*, each claiming to have invented contact lenses, *Panas* decided:

"The astronomer Herschel had had the idea of applying glass shells to the surface of the eye to correct the irregular curvature of the cornea."

« L'astronome Herschel avait eu l'idée d'appliquer à la surface de l'œil des coques de verre destinées à corriger la courbure irrégulière de la cornée. » (15)

Sulzer in his turn used the same argument the following year to challenge *Fick's* priority in the invention of contact lenses:

In fact, the theoretical solution to this problem goes back to a much earlier date. In the Treatise on Light by J. F. W. Herschel, translated by Verlust and Quetelet, Paris 1829, we find the following passage (T. I, p.185): 'The strict method, applicable in all such cases, would be to adapt a lens to the eye, of nearly the same refractive power, and having its surface next to the eye an exact intaglio facsimile of the irregular cornea, while the external should be exactly spherical and of the same general convexity as the cornea itself; Should any very bad cases of irregular cornea be found, it is worthy of consideration, whether at least a temporary distinct vision could not be procured, by applying in contact with the surface of the eye some transparent animal jelly contained in a spherical capsule of glass; or whether an actual mould of the cornea might not be taken, and impressed on some transparent medium.'
This idea is reproduced in the celebrated work of Mackenzie in still more explicit fashion (French translation by Warlomont and Testelin, Paris 1857, T.II, page 138)."

« En réalité la solution théorique de ce problème remonte à une date bien antérieure. Dans le traité de la lumière par J.F.W. Herschel, traduit par Verlust et Quetelet, Paris 1829, nous trouvons le passage suivante (T .I, p.185) : « La méthode la plus exacte, en pareil cas, serait « d'employer une lentille de même pouvoir réfringent que l'œil, dont la surface antérieure « serait parfaitement sphérique et de même rayon que la cornée, tandis que la surface du côté « de l'œil offrirait en creux un fac-similé exact de toutes les irrégularités de la cornée ...Dans « certains cas de conformation vicieuse de la cornée, il serait intéressant d'examiner si « quelque gelée animale transparente mise en contact avec cette tunique, et contenue par une « capsule de verre ne pourrait pas rendre la vision distincte, ou s'il ne serait pas possible « d'avoir directement une empreinte de la cornée... ». Cette idée est reproduite de façon encore plus explicite dans l'ouvrage célèbre de Mackenzie (traduction française de Warlomont et Testelin, Paris 1857, T. II, p.138). » (16)

15. Panas 1893, p. 308. See details on this controversy in Chapters XI: Eugène Kalt's Optical Treatment of Keratoconus and Chapter XIII: The Decade after the Invention.
16. Sulzer, 1894, p. 236 - 237.

4.2 - The German Attributions (1894, 1932)

In his controversy with *Sulzer*, *Fick* stated that he was unaware of the priority of *Herschel*, but he also disputed the interpretation that had been proposed to him by arguing that *Herschel's* idea did not correspond to contact lenses, as this author was proposing a facsimile of the irregular cornea, which was unrealizable. On the other hand, *Herschel* was attributing the correction to a transparent animal jelly held against the eye and not by a contact lens (the spherical cupola) or by the intermediate liquid:

"Furthermore, one finds, in the two sentences of Herschel that Mr. Sulzer cited, two ideas which do not correspond exactly to my idea which I later described as a contact spectacle. The first sentence speaks, in effect, of a contact glass of which the inner surface would be a facsimile of the irregular cornea. Such would be, nowadays, an unrealizable assignment, even for the most skilled optician. In the second sentence, Herschel speaks of a transparent animal jelly that would be applied with a glass shell against the cornea and he raises the question if one could not produce a kind of corneal mould; in this passage Herschel seems therefore to attribute the optical effect not to the glass shell but to the gel. Besides, it can be concluded from the two sentences and exactly as Mackenzie concluded, that Herschel in no way attempted to put is ideas into practice."

Übrigens sind in den beiden, von Herrn Sulzer angeführten Sätzen Herschel's zwei Gedanken ausgesprochen, die sich doch nicht mit dem Denken, was ich später als Contactbrille beschrieben habe. Denn der erste Satz spricht von einem Contactglase, dessen Innenfläche ein Facsimile der unregelmäßig gekrümmten Hornhaut sein soll, eine Forderung, die wohl auch dem kühnsten Optiker von heutzutage unerfüllbar scheinen dürfte. Im zweiten Satze spricht Herschel von einer tierischen durchsichtigen Gallerte, die mittelst einer Glasschale gegen die Hornhaut gedruckt werden soll und wirft die Frage auf, ob sie nicht gerade ein Abguss der Hornhaut herstellen lasse; hier scheint Herschel die optische Leistung nicht der Glasschale, sondern der Gallerte zugedacht zu haben. Außerdem geht aus jenen beiden Sätzen, desgleichen aus der Wiedergabe Mackenzie's deutlich hervor, dass Herschel keinerlei Versuche gemacht hat, seine Ideen zu verwirklichen." (17)

Following this period, the idea that *Herschel* contributed to the development of contact appliances was spread around with little reserve.

After 1932, in his history of contact lenses, *Much* refers to *Herschel*'s citations:

"Certainly, his contribution was a uniquely theoretical one, bit it contained nevertheless the principle used today of attributing the optical effect to the milieu situated between the cornea and the lens, under which he placed furthermore a transparent animal gel."

"Wohl war sein Beitrag ein lediglich theoretischer, aber er enthielt doch schon das heutige eingeführte Prinzip, die optische Wirkung dem zwischen Hornhaut und Haftglas befindlichen Medium, als welches er allerdings eine "durchsichtige, tierische Gallerte" für notwendig hielt, zu überlassen." (18)

17. Fick, 1894, p. 422.
18. Much, 1932, p. 390.

4.3 - Later Attributions

In his Report on contact glasses to the Société d'Ophtalmologie de Paris, in 1937, *Haas* reproduced large extracts from *Herschel's* translation in French language by *Verlust* and *Quetelet*. He draws the following conclusion:

"One can judge from this paper that Herschel had established by means of his reasoning all the possibilities of a present-day contact lens, but nothing authorizes us to think that he made the slightest start in its implementation."

« On peut juger par cette lecture, que Herschel avait établi, par le raisonnement, toutes les possibilités du verre de contact actuel, mais rien ne nous autorise à penser qu'il ait fait le moindre commencement de réalisation. » (19)

In 1938, *Mann* came to the following conclusion after a citation and very fair appreciation:

"There is no evidence that he ever attempted to do it, but he undoubtedly grasped most of the essentials." (20)

Mandell also shared this opinion:

"It does not appear that Herschel had any intention of trying to reduce this principle to practice and actually make a contact lens, but from the standpoint of optical principles, his description is very clear." (21)

More recently, there reappeared some fanciful interpretations, which, unfortunately, have been recopied and amplified several times. Thus, *Mackie* mixed the proposals of 'animal jelly contained in a glass capsule' with the proposal of 'intaglio glass lens' and produces a 'molded glass containing jelly':

"Sir John Herschel (1830) the English astronomer who, commenting on Airy's invention of lenses to correct astigmatism, speculated on the possibility of eliminating this defect by applying to the eye a glass capsule containing a transparent animal jelly in contact with the cornea, the glass being moulded to correspond to the shape of the eye." (22)

This idea of a 'contact glass' made by casting of gelatin moulds had probably been inspired by *Town:*

"Contact glasses were first used by Herschel in 1827. [...]. Herschel's contact glasses were made by casting from gelatin moulds." (23)

19. Haas, 1938, p. 65.
20. Mann, 1938, p. 110.
21. Mandell, 1988, p. 7.
22. Mackie in Duke-Elder 1970, p. 713. The amalgamation between the propositions of animal gelatin and a molded contact lens leaves one to suppose that Mackie did not consult Herschel's original text. Mackie's flawed text in Duke-Elder unfortunately serves as a reference for numerous authors, as the following citations show.
23. Town 1939.

Following a suggestion by *Chalkley*, that *Herschel* suggested making corneal contact lenses, *Walls* pointed out:

"Herschel probably did not have corneal contact lenses in mind. [...] Here is a detailed suggestion of a contact lens, and even of the molded plastic lens type [...]. But I do not believe that Sir John Herschel literally contemplated what we now call a corneal lens [...] Like his father and his aunt Sir John was an astronomer. His work is not free of errors concerning the eyen and he certainly know nothing about it from operative standpoint." (24)

For other historians, *Herschel* would have been the first to correct optically, the irregularities in pathological corneas and would have even worn contact lenses himself in order to correct his sight which had been weakened by corneal scars, but he would not have tolerated them for any prolonged period by reason of corneal metabolic problems and irritation of the eyes:

"He thought that a glass shell filled with gelatin would correct the vision, and so was the first to use contact lenses to correct pathological conditions of the cornea giving rise to irregular astigmatism." (25)

"He demonstrated that a glass cupola filled with gelatin could improve his vision and he was thus the first person to utilize a contact lens for the correction of an astigmatism."

"Er [...] bewies, dass eine mit Gelatine unterfütterte Glasschale sein Sehvermögen bessern konnten und war damit der erste Mensch , der eine Kontaktlinse zur Korrektur eines Astigmatismus benutzte." (25)

and also:

"Herschel [...] tried in 1823 to correct his eyesight which had deteriorated because of corneal scarring. With this aim, he filled little glass cups with gelatin and places these on the eye. There followed from this grave disturbances of corneal metabolism and signs of irritation which cause the experiments to fail in the long term."

"Herschel [...] der 1823 seine durch Hornhautnarben beeinträchtigte Sehschärfe zu bessern suchte. Er unterfütterte kleine Glasschälchen mit Gelatine und setzte sie aufs Auge. Dabei kam es zu schweren Störungen des Hornhautstoffwechsels, Reizerscheinungen ließen die Versuche auf die Dauer Scheitern " (26)

Sabel, who reproduced in facsimile an extract of *Herschel*'s text, attributes to his compatriot the role of the great clinical innovator:

"To this man, therefore, should go the honor of envisaging the more important of the present –day areas of clinical application of the contact lens." (27)

This viewpoint is certainly controversial, but somewhat less so than other unpardonable errors which have been circulated in the last few years. (28)

24. Walls 1950, p. 501.
25. Ruben 1975, p. 1, and in a German translation: Ruben 1978, p. 1.
26. Roth 1978, p. 28.
27. Sabell 1980, p. 1-4.
28. Thus the distortions in spelling Herschel's name: "Hischel" (Albert 1996, p. 119), "Hershal" (Rubin 1996, p. S102).

Appendix 1

Transcription of :

John Frederick William Herschel
Of the Structure of the Eye, and of Vision

Encyclopaedia Metropolitana, 4, Light, § 12, 396-404, 1845

Page 398, § 359
(*in the margin*: Malconformations of the cornea)
But these are not the only cases of defective vision arising from the structure of the organ which are susceptible of remedy. Malconformations of the cornea are much more common than is generally supposed, and few eyes are, in fact, free from them. They may be detected by closing one eye, and directing the other to a very narrow, well-defined luminous object, not too bright, (the horns of the moon, when a slender crescent, only two or three days old, are very proper for the purpose) and turning the head about in various directions. The line will be doubled, tripled, or multiplied, or variously distorted; and careful observation of its appearances, under different circumstances, will lead to a knowledge of the peculiar conformation of the refracting surfaces of the eye which causes them, and may suggest their proper remedy.

(*in the margin* : Remarkable case, successfully remedied by glasses)
A remarkable and instructive instance of the kind has recently been adducted by Mr. G. B. Airy (*Transactions of the Cambridge Philosophical Society*) in the case of one of his own eye; which, from a certain defect in the figure of its lenses, he ascertain to refract the rays to a nearer focus in a vertical than in a horizontal plane, so as to render the eye utterly useless.
This, it is obvious, would take place if the cornea, instead of being a surface of revolution, (in which the curvature of all its sections through the axis must be equal,), were of some other form, in which the curvature in a vertical plane is greater than in a horizontal. It is obvious, that the correction of such a defect could never be accomplished by the use of spherical lenses. The strict method, applicable in all such cases, would be to adapt a lens to the eye, of nearly the same refractive power, and having its surface next the eye an exact intaglio fac-simile of the irregular cornea, while the external should be exactly spherical of the same general convexity as the cornea itself; for it is clear, that all the distortions of the rays at the posterior surface of such a lens would be exactly counteracted by the equal and opposite distortions at the cornea itself. But the necessity of limiting the correcting lens to such surfaces as can be truly ground in glass, to render it of any real and everyday use, and which surfaces are only spheres, planes, and cylinders, suggested to Mr. Airy the ingenious idea of a double concave lens, in which one surface should be spherical, the other cylindrical. The use of the spherical surface was to correct the general defect of a too convex cornea. That of the cylindrical may be thus explained. Suppose parallel rays incident on a concave cylindrical surface A B C D, in a direction perpendicular to its axis, as in Fig 71, and let *S S' P P' Q Q' 'T T'*, be any laminar pencil of them contained in a parallelepiped infinitely

Foot note page 398
Should any very bad cases of irregular cornea be found, it is worthy of consideration, whether at least a temporary distinct vision could not be procured, by applying in contact with the surface of the eye some transparent animal jelly contained in a spherical capsule of glass; or whether an actual mould of the cornea might not be taken, and impressed on some transparent medium. The operation would, of course, be delicate, but certainly less so than that of cutting open a living eye, and taking out its contents.

Page 400 § 368
(in the margin :* Eyes of fishes*)
In the eyes of fishes, the humors being nearly of the refractive density of the medium in which they live the refraction at the cornea is small, and the work of bringing the rays to a focus on the retina is almost wholly performed by the crystalline. This lens, therefore, in fishes is almost spherical, and of small radius, in comparison with the whole diameter of the eye. Moreover, the destruction of spherical aberration not being producible in this case by mere

refraction at the cornea, the crystalline itself is adapted to execute this necessary part of the process, which it does by a very great increase of density towards the center. (Brewster, *Treatise on New Philosophical Instruments*, p. 268) The fibrous and coated structure of the crystalline lens is beautifully shown in the eye of a fish coagulated by boiling.

APPENDIX 2

TRANSCRIPTION OF :

George Biddel Airy
On a Peculiar Defect in the Eye, and a mode of Correcting it

Transactions of the Cambridge Philosophical Society, 2, Part II, 1827, 267-272, XVI

By George Biddel Airy, B.A.
Fellow of Trinity College, of the Cambridge Philosophical Society,
And corresponding member of the Northern Institute.
[Read Feb. 21, 1825]

The communication, which I have now the honour to make to this Society, relates to a peculiar defect of the eye, and the mode of correcting it. On a subject so important, I trust I shall be excused if I enter into details, as the mal-formation, which I am about to describe, through hitherto unnoticed, is probably not uncommon.

Two or three years since, I discovered that in reading I did not usually employ my left eye, and that in locking carefully at any near object, it was totally useless: in fact, the image formed in that eye was not perceived except my attention was particularly directed to it. Supposing this to be entirely owing to habit, and that it might be corrected by using the left eye as much as possible, I endeavoured to read with the right eye closed or shaded, but found that I could not distinguish a letter, at least in small print, at whatever distance from my aye the characters were placed. No further remark suggested itself a that time, but a considerable time afterwards I observed, that the image formed by a bright-point (as a distant lamp or a star) in my left eye, was not circular, as it is in the eye which has no other defect than that of being near-sighted, but elliptical, the major axis making an angle of about 35° with the vertical, and its higher extremity being inclined to the right. Upon putting on concave spectacles, by the assistance of which I saw distant objects distinctly with my right eye, I found that to my left eye a distant lucid point had the appearance of a well defined line, corresponding exactly in direction, an nearly in length to the major axis of the ellipse above-mentioned. I found also that if I drew upon paper two black lines crossing each other at right angles, and placed the paper in a proper position, and at a certain distance from the eye, one line was seen perfectly distinct, while the other was barely visible: upon bringing the paper nearer to the eye, the line which was distinct now disappeared, and the other was seen very well defined. All these appearances indicated that the refraction of the eye was greater in the plane nearly vertical, than in that at right angles to it, and that consequently it would not be possible to see distinctly by the assistance of lenses with spherical surfaces. I found, indeed, that by turning a concave lens obliquely, or by locking directly thought a part near the edge, I could see objects without confusion; but in both cases, the distortion produced in their figure was such, that I could not hope to make any use of the left eye without some more effectual assistance.

My object now was to form a lens witch should refract more powerfully the rays in one certain plane, than those in the plane at right angles to its; and the first idea was to employ one whose surfaces should be cylindrical and concave, the axes of the cylinders crossing each other at right angles, and their radii being different. To shew that this construction would effect my purpose, it is only necessary to imagine the lens divided into two lenses by a plane perpendicular to its axis; then it is easily seen that the refraction of one will not be perceptibly altered by that of the other, and that the whole refraction will be the combination of the two separate refractions. The rays in one plane will be made to diverge entirely by the refraction of one lens and those in the other plane by that of the other lens. If then r and r' be the radii of the surfaces, and n the refractive index, and parallel rays be incidents, the rays in one plane after refraction will diverge from a point whose distance is r/n-1, and those in another plan from a point whose distance is r'/n-1. This construction then was sufficient; but for the facility of grinding, and for the diminution of the curvatures, it appeared preferable to make one surface cylindrical, the other spherical; both concave. Let r be the radius of the cylindrical surface, R that of the spherical: then the refraction in the plane passing thought the axis of the cylindrical surface, being entirely effected by the spherical surface, parallel rays in this plane after refraction will diverge from the distance R/n-1: while the refraction in the plane perpendicular to the axis being caused by both surfaces, parallel rays, in this plane, will on their emergence, diverge from the distance

$$\frac{1}{n-1 \quad (1/R + 1/r)}$$

To discover the necessary data, I made a very fine hole with the point of a needle in a blackened card, which I caused to slide on a graduated scale; then strongly illuminating a sheet of paper, and holding the card between it and the eye, I had a lucid point upon which I could make observations with great ease and exactness. Then resting the end of the scale upon the cheek-bone, and sliding the card on the scale, I found that the point at the distance of 6 inches, appeared a very well defined line inclined to the vertical about 35°, and subtending an angle of 2° (by estimation): at the distance of 31/2 inches it appeared a very well defined line at right angles to the former, and of the same apparent length. It was necessary therefore to make a lens, which when parallel rays were incident, should cause those in one plane to diverge from the distance 3 ½ inches, and those in another plane to diverge from the distance 6 inches. Making the expressions above equal to these numbers, and supposing n = 1,53, we find R = 3,18, r = 4,45. To prevent if possible the eye from becoming more shot-sighted, I fixed upon the values R = 3 1/3, r = 4 ½.

After some ineffectual applications to different workmen, I at last procured a lens to these dimensions from an artist named Fuller, of Ipswich. It satisfies my wishes in every respect. I can now read the smallest print at a considerable distance with the left eye, as well as with the right. I have found that vision is most distinct when the cylindrical surface is turned from the eye: and as when the lens is distant from the eye, it alters the apparent figure of objects by refracting differently the rays in different planes, I judged it proper to have the frame of my spectacles made so as to bring the glass pretty close to the eye. With these precautions I find that the eye which I once feared would become quite useless, can be used in almost every respect as well as the other.

The publication of this case, I imagine, may be not without utility. I believe it has generally been found, that where the direction of the axis of the eye is distorted, the sight of the eye is defective, but not lost: and the distortion is by many ascribed to the disuse of the eye, which is occasioned by this defect. If it should be found that the defect is at all similar to that which I have described, it can be perfectly corrected. The examination of the defect in the manner which I have detailed is very easy; and it is merely necessary to write down fully the appearance of the brilliant point at different distances, in order to enable the theorical optician to invent a glass which shall make the vision of the eye distinct. If the defects arise from insensibility of the nerve, or opacity of the humours, they are beyond his power: but any fault in the refracting surfaces it is possible to correct.

Since I procured this lens, I have been informed that a foreign artist has made spectacle-glasses with cylindric surfaces of different radii for general use. What his object can be I am quite unable to imagine; certainly no one whose eyes are not defective can seen with them distinctly. With my right eye which (by the method for examination above described) I find to have no other defect than short-sightedness, I am unable to read any thing in the lens made for my left eye. After many inquiries I have not been able to discover that this construction has been used to correct any defects in the eye, or even that a defect similar to that which I have described, has ever been noticed. In laying before this Society the notices of a case which appears at once novel and important, I trust that I shall not be thought to have trespassed unprofitably upon their time.

G.B. AIRY

Trinity College,
Feb. 5, 1825