

Chapter 13

The Decades after the Invention

Introduction

After their invention by *Fick*, *Kalt* and *A. Müller*, contact lenses (1) were also used from 1892 in Paris and in Lyon (France) by *David Sulzer* and *Henri Dor*, respectively. These two ophthalmologists of Swiss origin helped to popularize the concept of optical correction by contact lenses throughout the French-speaking area.

This period was also notable for its altercations. The first altercation occurred when *Sulzer* opposed *Kalt* and *Fick*, and the second when *Fick* later opposed *Lohnstein*.

It became quickly apparent that contact lenses were unsuitable for a wearing time of beyond a few hours. Their poor toleration, linked with the difficulty of their manufacture, brought a period of progressive decline in its wake. Nevertheless, some opticians continued to manufacture contact lenses in Paris and in Switzerland until opticians in Germany took over this activity on the eve of World War I.

This chapter reproduces and analyzes those documents relevant to the years immediately following the invention of contact lenses, as follows:

the publications of *Sulzer* and *Dor* (between 1892 and 1895),
successive controversies between *Sulzer* and *Fick*, followed by *Sulzer* and *Kalt* (1893),
and finally *Fick* and *Lohnstein* (1896),
an analysis of publications concerning contact lenses and corneal dioptric power neutralization, as revealed in the literature of the last ten years of the 19th century and the first few years of the 20th,
a discussion and commentary regarding the evolution of contact lens terminology, the indications for the use of contact lenses for optical and medical purposes, plus certain technical aspects of their manufacture,
finally, a description of how contact lens historians responded to the decades following their invention.

1 – Source Documents

1.1 – Sulzer’s Ground Contact Lenses

Year	Publication
1892	<i>Sulzer: Communication to the French Society of Ophthalmology: "La Correction optique du Kératocône, de l'Astigmatisme irrégulier et de l'Astigmatisme cicatriciel" (The Optical Correction of Keratoconus, Irregular Astigmatism and Cicatricial Astigmatism)</i>
1892	<i>Sulzer (read by Javal): Communication to the French Academy of Medicine: "Présentation d'appareil" (Device presentation)</i>
1892	<i>Dor : Communication to the Société des Sciences Médicales de Lyon : " Sur les verres de contact " (Concerning Contact Glasses)</i>
1893	<i>Sulzer - Kalt controversy on priority, in discussion of Chevallereau's presentation to the French Society of Ophthalmology: "Traitement du Kératocône" (Treatment of Keratoconus)</i>
1895	<i>Sulzer: Communication to the Paris Society of Ophthalmology "Note sur la Construction des Verres de Contact" (Note on the Manufacture of Contact Glasses)</i>
1896	<i>De Spéville: Communication to the Paris Society of Ophthalmology "Un Fait curieux Observé avec le Verre de Sulzer" (An unusual Observation with the Sulzer Glass)</i>

Table 13 - 1

Synopsis of Sulzer's and Dor's communications and publications with reference to contact lenses between 1892 and 1896.

1.1.1 – Sulzer’s Interest in Corneal Astigmatism

After *Helmholtz* had invented the keratometer, corneal measurement procedures were perfected, notably by *Javal* and *Tscherning* in Paris. The Paris ophthalmologist *David Sulzer*, who had recently emigrated from Geneva to the French capital, allied himself with those attempting to introduce a form of photokeratometry by photographing the reflex from an illuminated grill that was projected onto the cornea.

Sulzer’s Studies on Corneal Topography

On May 6, 1891, *Sulzer* presented a communication on the measurement of corneal astigmatism to the *French Society of Ophthalmology* entitled “**La Forme de la Cornée et son Influence sur la Vision**” (*The Corneal Shape and its Influence on Vision*). There, he described the first results of his measurements on corneal sphericity made with a photographic keratometer in about a hundred eyes. While announcing that the details of this research would be published (2), *Sulzer* observed that the shape of the cornea deviated perceptibly from the ellipsoid that *Helmholtz* had described and that there could exist a difference of astigmatism between the central and peripheral parts of the cornea. He drew the following conclusions from these measurements:

- “1.) *Those corneas in which central astigmatism is absent usually have peripheral astigmatism against the rule;*
- 2.) *Those corneas that have mild central with-the-rule astigmatism usually have no astigmatism or mild astigmatism against the rule in the periphery; i.e., the mild central with-the-rule astigmatism generally diminishes from the center towards the periphery;*
- 3.) *The opposite is generally true for corneas that have central against-the-rule astigmatism or high with-the-rule astigmatism. Here, the peripheral parts of the corneas are more astigmatic than the center;*

4.) *Those corneas that have medium with-the-rule astigmatism (from 2 to 2.5 D) often show the same amount of astigmatism in the central and peripheral parts.*”

- “1. Les parties périphériques des cornées sans astigmatisme central présentent généralement un astigmatisme contraire à la règle;
 2. Les parties périphériques des cornées, à astigmatisme direct faible au centre, sont sans astigmatisme ou présentent un astigmatisme indirect léger; c’est-à-dire, l’astigmatisme direct faible diminue généralement du centre vers la périphérie;
 3. Le contraire a généralement lieu dans les cornées à astigmatisme central indirect et à astigmatisme direct fort. Ici les parties périphériques sont plus astigmatiques que leur centre;
 4. Dans les cornées à astigmatisme direct moyen (de 2 à 2.5 dpt) on trouve souvent la même quantité d’astigmatismes pour le centre et pour les parties périphériques.” (3)

According to *Sulzer*, these changes in the amount of astigmatism in different parts of the cornea would explain variations in the results obtained between the subjective optometric and the objective methods, notably retinoscopy and keratometry, the latter providing only the measurement of an annular area concentric with the visual axis. *Sulzer’s* work received a favorable reception, as *Tscherning* emphasized in the discussion:

“Because it is the first step along the path we must follow if we wish to develop more precise concepts than are current at the present time regarding the shape of the human cornea.”

“Parce que c’est le premier pas dans le chemin qu’il faut suivre, si nous voulons arriver à avoir sur la forme de la cornée humaine des notions plus exactes que celles qui ont cours jusqu’à présent.” (4)

1.1.2 - The Presentation of Contact Lenses to the French Society of Ophthalmology (1892)

(Appendix 13 – 1)

The Optical Correction of Keratoconus

A year later, on May 2, 1892, *Sulzer* (5) presented a paper to the annual congress of the *French Society of Ophthalmology* under the title “*La Correction optique du Kératocône, de l’Astigmatisme irrégulier et de l’Astigmatisme cicatriciel*” (*The Optical Correction of Keratoconus, Irregular Astigmatism and Cicatricial Astigmatism*). This represented the completion of his research on the corneal asymmetries that he had presented during the previous year.

Sulzer had extended his measurements to patients with keratoconus, irregular astigmatism and cicatricial astigmatism, indicating on this occasion that the optical correction of these three conditions by conical or inclined cylindrical lenses was doomed to failure:

“Studying the shape of conical and irregular corneas convinced me that there was little

CORRECTION OPTIQUE DU KERATOCONE ET DE L-ASTIGMATISME IRRÉGULIER

M. SULZER (de Genève). — En appliquant un ménisque concavo-convexe, ayant un rayon égal au rayon de courbure moyen de la cornée, et en remplissant l'espace existant entre la cornée et ce verre par une solution ayant l'indice de réfraction de la cornée et de l'humour aqueuse, la solution salée physiologique par exemple, on parvient à exclure la cornée et, par conséquent, ses irrégularités, de l'acte de la vision. Ces verres ramènent à la normale l'acuité visuelle dans tous les cas où son amoindrissement est dû à des irrégularités de

Figure 13-1

Sulzer’s presentation on contact lenses to the annual congress of the *French Society of Ophthalmology*. On May 2, 1892, *Sulzer* presented a paper with the title “*La Correction Optique du Kératocône, de l’Astigmatisme Régulier et de l’Astigmatisme Irrégulier*” (*The Optical Correction of Keratoconus, Regular Astigmatism and Irregular Astigmatism*) describing his recent observations on ground contact lenses.

(SULZER David E., “La correction optique du k ratoc ne de l’astigmatisme r gulier et de l’astigmatisme irr gulier”, *Bulletins et M moires de la Soci t  Fran aise d’Ophthalmologie*, 10, 1892, 113-120. - Excerpt page 113)

hope of correcting the effect of these corneas on vision by conical spectacle glasses, as Mr. Galezowski had attempted, or by inclined cylindrical glasses following the suggestion of my distinguished teacher, Mr. Javal."

"L'étude de la forme des cornées coniques et irrégulières m'avait montré qu'il y avait peu d'espoirs de corriger leur influence sur la vision par des verres coniques, comme l'avait essayé M. Galezowski, ou par des cylindres inclinés, comme me l'avait suggéré mon maître éminent M. Javal." (6)

The assumption that one could prepare a "photographic tracing" (déalque photographique) of the irregular corneal topography in order to manufacture a corresponding spectacle glass lens seemed interesting to him (7). However, he concluded that such a tracing could not be realized for spectacle lenses in a practical way because centering was not maintained when the eyes moved:

"For some time, I had imagined using keratoscopic photographic images in order to grind glasses capable of correcting these irregular corneas. These keratoscopic images, by indicating all the irregularities of the cornea, could serve as a guide for grinding corrective lenses, assisted by retouching where necessary. Such a lens could, under certain circumstances, produce regular images of the deformed circles, as shown by photography of the keratoscopic images. In this way, the keratoscopic images could serve, not only as a guide for the manufacture of lenses, but also as a means for control. The realization of this concept encountered two difficulties: the technical difficulty of grinding the lenses, which would have been achievable only in certain cases, and the impossibility of maintaining the corrective lenses in such a position that their differently curved elements would remain in relation with those portions of the cornea that they were intended to correct. Not only would it be difficult to place the lenses in this position for a given direction of regard, but the slightest ocular movement would necessarily throw them out of that position."

"Pendant quelque temps, j'avais songé à utiliser l'image kératoscopique photographiée pour tailler des verres correcteurs de ces cornées irrégulières. L'image kératoscopique qui indique toutes les irrégularités de la cornée pourrait servir de guide pour tailler, à l'aide de la retouche locale, des lentilles correctrices. Une telle lentille devrait former, dans certaines circonstances, une image régulière des cercles déformés de la photographie de l'image kératoscopique. Ainsi l'image kératoscopique pouvait servir non seulement de guide pour la fabrication des lentilles, mais aussi comme moyen de contrôle.

La réalisation de cette idée rencontra deux difficultés : la difficulté technique de la taille de la lentille, qui pour certains cas, il est vrai, aurait été surmontable, et l'impossibilité de maintenir la lentille correctrice dans une position telle que ses éléments différemment courbés restent en rapport avec les éléments cornéens qu'ils étaient destinés à corriger. Non seulement il est difficile de placer la lentille dans cette position, pour une direction déterminée du regard, mais le moindre mouvement oculaire doit déranger la disposition prise." (6)

By bringing such a lens closer to the eye, this obstacle would be overcome. Furthermore, in this instance, it would no longer be necessary to provide the posterior surface of the lens with the contour from the tracing of the irregular cornea, as the space between the lens and the cornea could be filled with a liquid having the same refractive index as the cornea, as *Fick* demonstrated:

"There remained one sole means of overcoming this difficulty, namely that of applying the lens directly to the cornea. This changes the situation completely. By replacing the space left free between the cornea and a concavo-convex meniscus with a liquid that is applied directly to the cornea and has a refractive index, which is equal to both the

cornea and the aqueous humor; it is possible to substitute an artificial refracting surface for the cornea. There is no longer any question of grinding an irregular surface with the aim of correcting the corneal irregularities. It is simply necessary to apply a portion of a sphere with a regular surface onto the cornea.

Thanks to the studies of Mr. A. Fick, it has come to be accepted that the human eye tolerates a concavo-convex meniscus applied to the cornea, separated from it by a bed of 1/150th fructose solution, the index of refraction of which is equal to that of both the cornea and the aqueous humor.”

“Il restait un seul moyen d’éviter cette difficulté: celui d’appliquer la lentille directement à la cornée. Le problème change alors complètement: en remplissant l’espace laissé libre entre la cornée et un ménisque concave-convexe, appliqué directement sur la cornée, par un liquide, ayant l’indice de réfraction de la cornée et de l’humeur aqueuse on peut substituer à la cornée une surface réfringente artificielle. Il ne s’agit plus de tailler une surface irrégulière, corrigeant les irrégularités de la cornée. Mais simplement d’appliquer sur la cornée une surface régulière, une calotte sphérique.

Grâce aux travaux de M. A. Fick, il est acquis qu’un ménisque concave-convexe, appliqué sur la cornée et séparé d’elle par une couche d’une solution de sucre de raison au 150e, solution dont l’indice de réfraction est égal à celui de la cornée et de l’humeur aqueuse, est toléré par l’œil humain.” (8)

Description of the Contact Lens

Sulzer describes to his colleagues this new method of refractive correction, which he designates as a “verre de contact” (contact glass).

	Back radius	Diameter/ Size
Optic zone	8.00 mm	12.00 mm
Scleral zone	12.00 mm	2.00 to 2.50 mm
Total diameter	14.00 to 15.00 mm	

Table 13 - 2

Characteristics of the contact lens presented in 1892 by Sulzer.

This lens consists of:

an optic zone, having an 8.00-mm back

optic zone radius and 12.00 mm of primary optic diameter

a scleral zone of 13.00-mm back radius and of 2.00-mm to 3.00-mm width,

in other words, a scleral contact lens with an total diameter of 14.00 mm to 15.00 mm.

Sulzer describes this lens as follows:

“These glasses consist of a central portion of a sphere, the radius of curvature of which is equal, for the concave surface, to the average curvature of the anterior corneal surface (8 mm). The base of this portion of a sphere has a diameter of 12 mm. It has a band of 2 mm to 2 ½ mm of width, cut in a sphere of 13-mm radius. The concave surface of this band, which faces the same direction as the concave surface of the portion of the sphere, is applied to the sclera. It is held in position by the eyelids, both above and below. A contact glass placed thus will remain permanently in place whatever may be the movements of the eyes or head.”

“Ces verres sont composés d’une calotte sphérique centrale dont le rayon est égal, pour la surface concave, au rayon de courbure moyenne de la surface

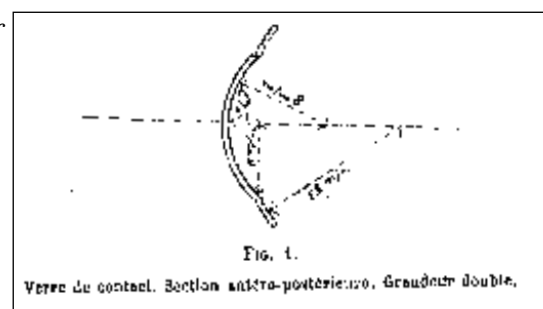


Figure 13-2

Diagram of the contact lens according to Sulzer. Sulzer illustrates his paper entitled "La Correction Optique du Kératocône, de l'Astigmatisme Irrégulier et de l'Astigmatisme Cicatriciel". (The Optical Correction of Keratoconus, Irregular Astigmatism and Cicatricial Astigmatism) by two drawings of contact lenses.

Legend : "Contact glass. Antero-posterior section. Twice actual size" (Verre de contact. Section antéro-postérieure. Grandeur double)

The diagram is annotated as follows:

- 8 mm for the back optic zone radius,
- 13 mm for the back scleral zone radius,
- 12 mm for the primary optic diameter

(SULZER David E., "La correction optique du k ratoc ne de l'astigmatisme r gulier et de l'astigmatisme irr gulier", Bulletins et M moires de la Soci t  Fran aise d'Ophthalmologie, 10, 1892, 113-120. - Figure 1 p.117)

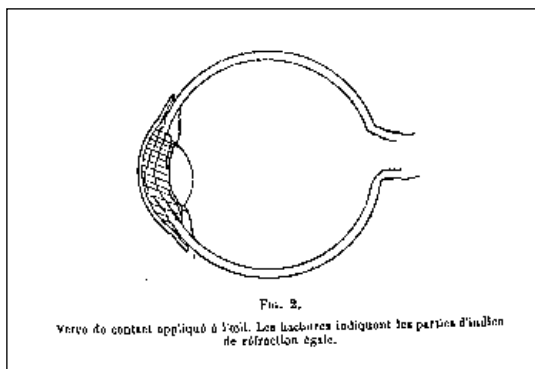


Figure 13-3

Diagram of the Sulzer's contact lens applied on an eye. Sulzer illustrates his paper, entitled "La Correction Optique du Kératocône, de l'Astigmatisme Irrégulier et de l'Astigmatisme Cicatriciel" (The Optical Correction of Keratoconus, Irregular Astigmatism and Cicatricial Astigmatism) with the diagram of an eye fitted with a contact lens.

Legend: "Contact glass applied to the eye. The hatching indicates the portions of equal refractive index" (Verre de contact appliqué à l'œil. Les hachures indiquent les parties d'indice de réfraction égale).

Note that the diagram of the eye represents an irregular and conical cornea. However, Sulzer is making an approximation in attributing the same refractive index to the aqueous humor, tears and cornea. The corneal refractive index is higher than that of either of the two liquids.

(SULZER David E., "La correction optique du k ratoc ne de l'astigmatisme r gulier et de l'astigmatisme irr gulier", *Bulletins et M moires de la Soci t  Fran aise d'Ophthalmologie*, 10, 1892, 113-120. - Figure 2 p. 118)

ant rieure de la corn e (8 mm). La base de cette calotte a un diam tre de 12 mm. Elle porte un bord de 2   2 1/2 mm de largeur, d coup  dans une sph re de 13 mm de rayon. La surface concave de ce bord, qui est dirig  du m me c t  que la surface concave de la calotte, s'applique sur la scl rotique. En haut et en bas, il est retenu par les paup res. Un verre de contact ainsi dispos , reste compl tement en place quels que soient les mouvements des yeux ou de la t te." (9)

According to Sulzer, a contact lens placed on a normal eye will slightly reduce visual acuity. For an eye with an irregular cornea, however, such a lens will allow a visual acuity as good as that in a normal eye fitted with a contact lens:

"A normal eye, after it has been fitted with a contact glass, sees a little less well than it does without a glass. Thus, the normal visual acuity is reduced to 5/6. An eye with an irregular cornea, whether this is due to irregular astigmatism or to keratoconus, sees as well with a contact glass as would a normal eye with the same glass."

"Un  il normal, arm  d'un verre de contact, voit un peu moins que sans verre. L'acuit  normale, par exemple, est abaiss e   5/6. Un  il   corn e irr guliere, qu'il s'agisse d'un astigmatisme irr gulier ou d'un k ratoc ne, voit avec un verre de contact aussi bien qu'un  il normal arm  du m me verre." (9)

Clinical Applications

Sulzer finished his presentation with three cases from clinical practice: he described two patients with oblique astigmatism, one with 6.00 D of astigmatism and the other with 2.50 D. He added one patient with keratoconus. All three were improved by the application of contact lenses:

"The first patient is a painter, age 26. He had never seen well at a distance or up close with his left eye. With the ophthalmometer, an astigmatism of 6.5 D with an oblique axis was noted. The best subjective correction was obtained using a 4.0 D convex cylinder lens at vertical axis. While the unaided eye had a visual acuity of 5/50, this improved to 5/15 with this glass. The No 3 line of the Snellen chart was read with difficulty with this glass. With the contact glass, however, the visual acuity improved to 5/5 and the smallest letters were read easily. The corneal meridian with the highest 'refringency' had a radius of 6.75 mm, whilst the meridian with the lowest 'refringency' had a radius of 8 mm. The eye thus corrected had a hyperopia of 4.0 D. It is apparent that, by changing the anterior surface curvature of the contact glass, depending on the case, one could provide emmetropia immediately.

The second case concerned the left eye of a female, age twenty-six. The unaided visual acuity for this eye was 5/50; the best subjective spectacle glass correction was obtained with a convex cylinder of 2.25 D at axis 30 degrees, which improved her visual acuity to 5/30. Ophthalmometry indicated astigmatism of 2.5 D, the 'most refingent meridian' having an axis of 20 degrees. A contact glass improved her visual acuity to 5/6 and

allowed her to read the smallest print with a +2.0 sphere glass.

The third patient, [...] is an artist with a six-year history of bilateral keratoconus, refractory to any cylindrical or spherical correction for the previous two years. The visual acuity of the right eye is 'counting fingers' at a distance of 3 meters, but this improved to 4/5 with the application of a contact glass."

"Dans le premier cas, il s'agit d'un peintre, âgé de vingt-six ans, qui n'a jamais bien vu, ni de loin, ni de près, de son œil gauche. A l'ophtalmomètre, on constate un astigmatisme de 6,5 D. à axe oblique. La meilleure correction subjective fut obtenue par le cylindre convexe 4,0 axe vertical. Tandis qu'à l'œil nu l'acuité visuelle était de 5/50e, elle était avec ce verre 5/15e. Les caractères n° 3 de Sn furent déchiffrés difficilement avec ce verre. Avec le verre de contact, l'acuité visuelle était de 5/5e et les caractères les plus fins furent lus facilement. Le méridien le plus réfringent de la cornée avait un rayon de 6 mm 75, tandis que le moins réfringent était de 8 millimètres, l'œil ainsi corrigé présentait une hypermétropie de 4,0 D. Il est évident qu'en changeant la courbure de la surface antérieure du verre de contact selon le cas, on peut instituer l'emmétropie d'emblée.

Dans le second cas, il s'agit de l'œil gauche d'une dame âgée de vingt-six ans. Cet œil a, sans verre, une acuité de 5/50e: la meilleure correction subjective est obtenue avec un cylindre convexe de 2,25 axe 30 degrés, qui améliore l'acuité à 5/30e. L'ophtalmomètre indique un astigmatisme de 2,5 D, le méridien le plus réfringent étant à 20 degrés. Un verre de contact relève l'acuité visuelle à 5/6e et permet de lire, en combinaison avec le verre sphérique + 2,0, les plus fins caractères.

« Le troisième malade, [...] est un artiste, atteint depuis six ans, d'un kératocône double, réfractaire depuis deux ans à toute correction cylindrique ou sphérique. L'acuité de son œil droit, qui compte les doigts à une distance de 3 mètres, est relevée à 4/5e par l'application d'un verre de contact." (10)

Contact Lenses with Diaphragms

Finally, *Sulzer* proposed the manufacture of contact lenses with diaphragms by covering their back surface with an opaque enamel picture of the iris while leaving a stenopaic hole in the center. These lenses, which *Fick* also described, could be of great benefit in those cases where an optical iridectomy had been carried out, either for improvement of the visual acuity or for cosmetic reasons:

"For those patients who have corneal opacities in addition to irregularities of corneal shape, you can combine the stenopaic method with the application of contact glasses. By covering the interior surface of the central portion of the sphere with opaque enamel with the same color as the iris and leaving a small hole in relation to the less opaque parts of the cornea, you can obtain a satisfactory optical result that is also cosmetically pleasing."

"Pour les cas, où il y a, à côté des irrégularités de forme de la cornée des opacités de cette membrane, on peut combiner la méthode sténopéique avec l'application des verres de contact. En couvrant la surface intérieure de la calotte centrale d'un émail opaque de la couleur de l'iris et en laissant une petite ouverture vis-à-vis des parties cornéennes les moins opaques, on obtiendra un résultat à la fois optique et esthétique." (11)

Comment on Fick's Contact Lenses

In the passage under consideration, *Sulzer* makes an assessment of *Fick's* studies, revealing that the contact shells used by this author were of blown glass and that their inferior quality explained the poor results which he obtained:

"The contact glasses used by Mr. Fick were blown glasses. If you examine a blown lens on the ophthalmometer, you discover, without exception, a number of irregularities, although it appears perfectly regular when examined through a loupe. These irregularities easily explain the unsatisfactory results obtained by Mr. Fick. After many

attempts using trial and error, I was finally able to obtain ground contact glasses.”

“Les verres de contact employés par M. Fick étaient des verres soufflés. Quand on examine un verre soufflé à l’ophtalmomètre, on y découvre sans exception nombre d’irrégularités, quoiqu’il paraisse absolument régulier vu à travers une loupe. Ces irrégularités expliquent facilement les résultats peu satisfaisants obtenus par M. Fick. Après beaucoup de tâtonnements, je suis arrivé à faire tailler des verres de contact.” (11)

This remark regarding *Fick’s* contact lenses was, in the course of the following years, at the center of violent altercations between these two physicians. The contact lenses used by *Sulzer* were ground (as indicated in a footnote on page 119) and manufactured by the opticians *Benzoni*, rue du Stand, Geneva, Switzerland and by *Berthiot*, 207 rue Saint-Martin, Paris.

1.1.3 - Sulzer’s Note to the Academy of Medicine (1892)

(Appendix 13-2)

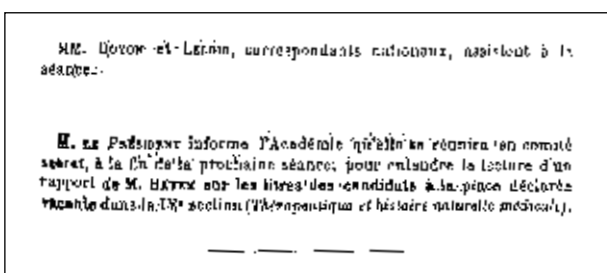


Figure 13-4

Sulzer’s note on contact lenses.

On May 10, 1892, the following note was read by Emile Javal to the French Academy of Medicine.

(JAVAL Emile, “Présentation d’appareil”, Bulletin de l’Académie Nationale de Médecine, 27, 1892, 673. - Page 673)

Sulzer arranged to present his ground contact lenses to the *French Academy of Medicine*, with the expectation of thus establishing his priority rights. The ophthalmologist and member of the Academy, *Javal*, who initiated *Sulzer’s* research work on corneal astigmatism, delivered the following presentation to the Academy on May 10, 1892:

“Device presentation:

I am honored to present to the Academy a small ocular prosthetic device that

will fill a need recognized by ophthalmologists over many years. It consists of a glass capsule with two adjacent curvatures such that it can be applied to the cornea and sclera at the same time. Dr. Sulzer, who introduced this device, reports that a patient was able to tolerate it for sixty-four hours without any difficulty. In any event, this device is destined to be very helpful indeed to those patients with irregular corneas who are unable to wear conventional glasses. Those who have actually used this new device have been incomparably satisfied.”

“Présentation d’appareil:

J’ai l’honneur de présenter à l’Académie un petit appareil de prothèse oculaire répondant à un desideratum depuis longtemps formulé par les ophtalmologistes. Il s’agit d’une capsule de verre ayant deux courbures successives, de façon à pouvoir s’appliquer sur la cornée et sur la sclérotique en même temps. M. le Dr. Sulzer, qui a été l’instigateur de cet appareil, rapporte qu’un malade a pu le supporter pendant soixante-quatre heures sans aucune gêne. En tout cas, il est appelé à rendre de très grands services aux personnes à cornée irrégulière qui ne peuvent supporter les verres jusqu’ici en usage. Ceux qui s’en sont servis ont, en effet, éprouvé une satisfaction incomparable.” (12)

The *Bulletin of the Academy of Medicine* includes the following comment: “transfer for review by Messrs *Panas*, *Gariel* and *Javal*” (renvoi à l’examen de MM. *Panas*, *Gariel*, *Javal*). The report concerning the review by these three academicians is not preserved in the archives of the Academy, if indeed it was ever written and submitted. (13)

1.1.4 – Sulzer’s Concept of an “Improved” Contact Lens (1895)

The reality seemed less optimistic than was expressed by communications to scientific meetings and publications. Soon, contact lenses were no longer mentioned at international congresses or in publications with a wide readership.

M. SULZER. Note sur la construction des verres de contact.
 - Les principales difficultés rencontrées dans l'exécution de ces verres se rapportent à diverses exigences spéciales qui sont :
 -1° La nécessité de subordonner la courbure des surfaces à la forme de la sclérotique chez les divers patients.
 -2° L'absolue précision de ces surfaces, qui doivent permettre une vision nette, en dépit des courbures de court rayon ;

Figure 13-5

Sulzer's note of an "improved" contact lens.

This "Note sur la Construction des Verres de Contact" (Note on the Manufacture of Contact Glasses) was read at the Paris Society of Ophthalmology in January 1895.

(SULZER David E., "Note sur la construction des verres de contact", Bulletin de la Société d'Ophthalmologie de Paris, 8, 1895, 15-18 - Excerpt page 15)

It is necessary to consult the proceedings of the *Paris Society of Ophthalmology* for the year 1895 in order to find a new clue in the form of a “*Note sur la Construction des Verres de Contact*” (Note on the Manufacture of Contact Glasses). Sulzer lists the difficulties in the manufacture of contact lenses that are effectively usable and tolerated by the eye (14).

The Three Requirements for good Tolerance

Sulzer lists three requirements for lens tolerance: the contact lens should conform well to the sclera, have well-polished surfaces, and finally a good edge profile:

“The main difficulties in producing these lenses depends on a number of special requirements, including:

the need to harmonize the curvature of the surfaces with the shape of the sclera of the varied patients,

the absolute precision of these surfaces, which should allow clear vision notwithstanding short radii of curvature.

the edges of the scleral portion, which must be perfectly innocuous, requiring that they be perfectly smoothed and polished.”

“Les principales difficultés dans l'exécution de ces verres se rapportent à diverses exigences spéciales qui sont :

1° La nécessité de subordonner la courbure des surfaces à la forme de la sclérotique chez les divers patients.

2° L'absolue précision de ces surfaces, qui doivent permettre une vision nette, en dépit des courbures de courts rayons.

3° La parfaite innocuité des bords de la partie sclérale, lesquels doivent être, pour cela parfaitement adoucis et polis.” (15)

Sulzer recalls that there are two procedures for manufacturing contact lenses, namely glass blowing and glass grinding.

The Blowing Procedure

This method has the advantage of producing light and thin contact lenses. Experience has, however, demonstrated that these lenses are unacceptable because of their poor optical quality and the internal tension of the material:

“There could appear to be every reason to produce the required glasses by the method of blowing: the necessary lightness of these and their thinness could not apparently be better brought about than by means of the enameller’s blowlamp.

In fact, all attempts along these lines were unsuccessful. Either the surfaces did not

acquire a regular shape at the blowlamp or the material became furrowed by threads and by impurities that inhibit vision.

Finally, the more-or-less melted parts took different local densities relative to each other and, therefore, also different refractive indices. In addition, the rapid quenching that proceeded by cooling created, in the piece submitted to blowing, this peculiar molecular state caused by tension within the glass so-called 'Batavian tears.' An even greater danger for the eye results thereof, in that fracture of the piece could happen unexpectedly and after a time interval be impossible to predict."

"Il paraît tout indiqué d'obtenir, par la méthode du soufflage, les verres dont il s'agit: leur légèreté nécessaire, la faible épaisseur de toutes leurs parties ne paraissent pouvoir être mieux réalisée qu'à l'aide de la lampe d'émailleur.

Cependant, tous les essais pratiques tentés dans cette voie sont restés infructueux. Ou les surfaces ne venaient pas, à la lampe, avec une forme régulière de révolution, ou bien la matière se sillonnait de fils, d'impuretés qui gênaient la vision.

Enfin les parties plus ou moins fondues prenaient, les unes par rapport aux autres, des densités locales différentes et, par suite, des indices de réfraction également différents. La trempe rapide qui s'opérait par le refroidissement créait, en outre, dans la pièce soumise au soufflage, cet état moléculaire particulier, qui est caractérisé par la tension des larmes bataviques. De là danger d'autant plus grand pour l'œil, que la rupture de la pièce pouvait se produire inopinément et dans un délai impossible à prévoir." (16)

The Grinding Procedure

The glass grinding process requires exceptional manual dexterity, taking into account that the contact lens is formed from two spherical concentric surfaces of different curvature, both in their front and back surfaces and that the transition between these surfaces has to be smoothed out. We also learn that *Sulzer* had made drainage grooves in the scleral portion with the purpose of favoring the drainage of tears and eliminating air bubbles:

"In regard to applying the normal procedures used for grinding optical surfaces to the pieces in question, it was necessary, in attempting this, to expect major difficulties. It is, in fact, not just a simple spherical surface, but also two surfaces intersecting at their common diameter.

It was mandatory, furthermore, to connect the central bowl to the scleral border by means of a mild deformation of the external spherical curvature. Finally, it was necessary to give different radii to the interior and exterior curvatures.

In order to obtain homogeneity of the material and a state of equilibrium allowing it to resist possible deformation, notwithstanding the elasticity of the glass, it appeared necessary to take the piece from a suitably chosen cubic mass of plain glass.

The greatest practical difficulty was encountered in the execution of the central bowl. It was not necessary to think of giving to the hand of the artist the 'come and go' that has the result of constantly crossing the successive directions of polishing, for one could only operate following the common diameter of adjacent surfaces at the pole of the central portion of the sphere. It would be beyond the parameters and intention of this short note except to describe the special skill adopted by the excellent worker charged with this task. However, you can imagine the difficulty of the execution of this task.

Once the glass was cut and polished, it remained to provide the scleral band with one or more grooves intended for the evacuation of tears or air bubbles. There, too, the practical difficulties were numerous. However, as they do not, strictly speaking, concern the actual refraction, I will spend no further time describing these."

"Quant à appliquer aux pièces dont il s'agit les procédés habituels usités pour la taille des surfaces

optiques, il fallait, en le tentant, s'attendre à de grandes difficultés. Il ne s'agit plus ici, en effet, d'une simple surface sphérique, mais de deux surfaces se coupant sur leur diamètre commun.

Il fallait, en outre, raccorder la cuvette centrale au bord scléral par une légère déformation de la courbure sphérique extérieure. Enfin, il fallait donner aux courbures intérieures et extérieures des rayons différents. Pour obtenir l'homogénéité de la matière et un état d'équilibre qui permit, malgré l'élasticité du verre, de s'opposer aux déformations possibles, il a paru nécessaire de prendre la pièce dans une masse cubique de verre plein, convenablement choisi.

La plus grande difficulté pratique a été rencontrée dans l'exécution de la cuvette centrale. Il ne fallait pas songer à donner à la main de l'artiste le va-et-vient qui a pour résultat de croiser constamment les directions successives du polissage, car on ne pouvait opérer que suivant le diamètre commun des surfaces aboutissant au pôle de la calotte centrale. Ce serait sortir des bornes et du but de cette simple note que de décrire le tour de main particulier qui a été adopté par l'excellent ouvrier chargé de ce travail, mais on devine les difficultés de l'exécution.

Le verre taillé, poli, il restait à ménager dans le bord scléral une ou plusieurs gouttières destinées à l'évacuation des larmes ou des bulles d'air. Là encore, les difficultés pratiques ont été nombreuses, mais comme elles n'intéressent pas la réfraction proprement dite du système, nous n'y insisterons pas." (17)

The Improvement of Manufacturing

There remained the difficulty that was linked to the quality of the scleral zone and to finishing its peripheral edge. To both of these aspects *Sulzer* rightly attached great importance. *Sulzer* also published the following technical note written by *Séguy*, the engineer that the opticians *Benoist and Berthiot* commissioned in order to find a solution for these problems:

“Technical note:

As a point of departure for this interesting study, I began by studying carefully, under microscopic observation and high magnification, that part of the glass that was required to rest on the eye. I noted that the part of the lens required to adhere strongly made a sharp edge at the periphery of the contact glass and that the adherent surface showed marked granulation.

According to the indications and following the experience of Mr. Dr. Sulzer reported by Messrs Benoist and Berthiot, I was compelled to recast the surfaces that adhere to the eye in a very delicate manner because these had been found to be somewhat too rough and therefore fatiguing.

While this operation was expected to be simple and easy to perform, it was actually enormously difficult to carry out; amongst other things, the ground crystals cannot be easily heated without breaking them; in addition, this fusion could be achieved only at the periphery. For that reason, there even formed a differential of expansion that, even when the lens margin bordering process succeeded at the moment of the operation, the glass was forced to break when it cooled.

After numerous failures and the loss of several of these contact glasses, I was at the point of abandoning these attempts at edging, when I had the idea of making use of a sterilizer oven, the temperature of which would be elevated very slowly. I then took a sterilizer with a wire gauze support in the middle of its interior, on which I placed my contact glass. I then added another support made of asbestos in order to raise the contact glass above the wire gauze and to move it without touching any cold instrument (thereby avoiding breakage) into a flame activated by enameller's bellows and at the same temperature as the sterilizer oven. By turning the lens in the flame, I obtained a smoothing out by fusion of the perimeter edges and I had only to transport the contact glass back with the same precautions taken for placing it in the sterilizer, where the temperature dropped slowly, thereby annealing the treated area.

When, after cooling, you take these glasses and lightly rub them on the eye, you note an

ideal softness compared with other lenses that have not undergone this treatment. You should take into account the experience of the difference, visually undetectable but enormous in sensation. The painful burning and the resultant inflammation are greatly attenuated.

Moreover, when you put these contact glasses that have been treated under the objective of a microscope, you will observe the complete disappearance of those granulations described in my first remarks, as well of as the sharp angle of the perimeter, the sole causes of the inflammation.”

“*Note technique:*

Comme point de départ de cette intéressante étude, j’ai commencé par me rendre compte, en l’observant au microscope et à l’aide d’un fort grossissement, de la partie qui devait porter sur l’œil au moment de la mise en service. J’ai constaté que la partie qui devait adhérer fortement formait un angle vif, c’est-à-dire au périmètre du verre de contact, et que la surface adhérente présentait une granulation prononcée.

Selon les indications, après expérience de M. le Dr. Sulzer et transmises par MM. Benoist et Berthiot, je devais essayer de refondre d’une façon extrêmement légère les surfaces adhérentes à l’œil, qui avaient été trouvées un peu trop rugueuses et par cela fatigantes.

Cette opération, qui à dire paraissait simple et très réalisable, offrait des obstacles énormes à l’exécution ; entre autres les cristaux taillés ne peuvent être chauffés facilement sans se briser ; de plus cette fusion ne devait s’exercer que sur le périmètre et par cela même formait une différence de dilatation, qui, dans le cas de réussite du bordage au moment de l’opération, le forçait à briser, lors du refroidissement.

Après de nombreux insuccès et la perte de plusieurs de ces verres de contact, j’allais abandonner ces tentatives de bordage, lorsque j’eus l’idée de me servir d’une étuve dont la température serait élevée très lentement. Je pris donc une étuve ayant intérieurement au centre un support en toile métallique, sur lequel je fis reposer mon verre de contact, puis j’ajoutais un autre support en amiante destiné à soulever le verre de contact de dessus la toile métallique, et à le transporter, sans le mettre en contact avec aucun outil froid pour éviter de le faire casser, dans un rayon de feu actionné par un soufflet d’émailleur et à la même température que l’étuve ; en tournant ce verre dans le rayon de feu on obtient un adoucissement par fusion des bords périmétriques et l’on n’a plus qu’à retransporter avec les mêmes soins le verre de contact pour le replacer dans l’étuve, où la température s’abaisse régulièrement et forme recuisson de la pièce travaillée.

Lorsqu’après refroidissement l’on prend ces verres et que légèrement on les frotte sur l’œil on constate par comparaison une douceur idéale, que n’ont pas ceux qui n’ont pas subi cette préparation, et il faut se rendre compte par l’expérience de la différence qui existe, différence inconcevable à la vue et si grande à la sensation. La pénible cuisson et l’inflammation produite sont de beaucoup atténuées.

Du reste, lorsqu’on replace ces verres de contact, ainsi préparés sous l’objectif du microscope, on observe la disparition complète des granulations relatées dans nos premières observations et de l’angle vif du périmètre, seuls motifs et seules causes de l’inflammation.” (18)

With this communication dealing on technical and manufacturing aspects, *Sulzer* put the final touch on his research articles and publications on contact lenses.

In order to appreciate the efficaciousness of these modifications and the improvement in patient toleration of *Sulzer’s* lenses following these technical changes, we have two informative testimonies available for study:

the first, dating from 1895, is that of *Oger de Spéville*, a contemporary of *Sulzer* and a dispenser of contact lenses made by *Benoit-Berthiot*;

the second is that of *Haas*, who, in 1937, measured the parameters of a contact lens that had belonged to *Sulzer*.

Spéville’s Observation (1895)

The observation of *Spéville*, *Sulzer’s* contemporary, was presented in 1895 at the *Paris Society of Ophthalmology* under the title: “**Un Fait Curieux Observé avec le Verre de Sulzer**” (*An Unusual Observation about Sulzer’s Glass*). *Spéville* reported that, in the

case of a patient affected with keratoconus, “improved heat-treated Sulzer glasses” had permitted the extension of the wearing time from about 10 minutes to three or four hours:

“A time ago, I had the opportunity to observe a thirty-year-old woman with very pronounced bilateral keratoconus, especially in the right eye. The patient was unable to read with the right eye, whereas, with her left eye, she read quite small print from about 10 centimeters away. On two different occasions, I had her try Sulzer’s contact glasses for about two weeks, which produced perfect vision in both eyes, but the glass could be tolerated only for several minutes, to the great despair of the patient. These two initial trials were made with contact glasses that had never been given the heat treatment. Since Mr. Sulzer spoke to us about the recent improvements to his glass, I made a third attempt (this time with an improved glass) and the result is remarkable. Not only does the patient tolerate the lens, but she keeps it in for the following three or four hours, without strain and without irritation, especially in the left eye; in the right eye, where the keratoconus is extremely pronounced, the glass provokes tearing and considerable irritation after a few minutes. The visual acuity for near and far is considerably improved. It is equal to 1 for distance vision and she could easily read #1 print from a short distance in De Wecker’s charts with both eyes.”

cette cause m’a confirmé encore plus dans mon opinion. L’observation de Despagne ajouta un nouveau fait de vérité optique.
M. DE SPÉVILLE. Un fait curieux observé avec le verre de Sulzer. — J’ai eu l’occasion d’observer ces temps derniers, chez une femme de 30 ans, un cas de double kératocône très prononcé, surtout à droite. La malade ne peut pas lire avec l’œil droit; tandis qu’avec l’œil gauche, elle lit les caractères assez fins à 10 centimètres environ. À deux reprises différentes, je lui ai fait essayer pendant une quinzaine de jours le verre de contact de Sulzer, avec lequel l’acuité visuelle des deux yeux devient parfaite, mais le verre ne peut être toléré que pendant quelques minutes, au grand désespoir de la malade. Ces deux premiers essais du verre de contact furent faits avec des verres qui n’avaient pas été passés au feu. Depuis que M. Sulzer nous a parlé des derniers perfectionnements apportés à son verre, j’ai tenté un troisième essai (avec un verre perfectionné) et le résultat est remarquable. Non seulement la malade supporte le verre, mais elle le garde trois et quatre heures de suite, sans fatigue et sans irritation, surtout à gauche; à droite, où le kératocône est extrêmement prononcé, le verre provoque au bout de quelques minutes du larmoiement et une grande gêne. La vision de loin et de près est considérablement améliorée. Elle est égale à 1 pour la vision à distance et les caractères n° 1 du livre de Wecker sont lus couramment de près et cela des deux yeux.” (19)

Figure 13-6

Spéville’s presentation on Sulzer’s “improved” contact lens. Oger de Spéville’s observation on “Un Fait Curieux Observé avec le Verre de Sulzer” (An Unusual Observation about Sulzer’s Glass), read at the Paris Society of Ophthalmology in May, 1895. (SPEVILLE Oger de, “Un fait curieux observé avec le verre de Sulzer”, Bulletin de la Société d’Ophthalmologie de Paris, 8, 1895, 106-107 - Excerpt page 106).

“J’ai eu l’occasion d’observer ces temps derniers chez une femme de trente ans, un cas de double kératocône très prononcé, surtout à droite. La malade ne peut pas lire avec l’œil droit, tandis qu’avec l’œil gauche, elle lit les caractères assez fins à 10 centimètre environ. À deux reprises différentes, je lui ai fait essayer pendant une quinzaine de jours le verre de contact de Sulzer, avec lequel l’acuité visuelle des deux yeux devient parfaite, mais le verre ne peut être toléré que pendant quelques minutes, au grand désespoir de la malade. Ces deux premiers essais du verre de contact furent faits avec des verres qui n’avaient pas été passés au feu. Depuis que M. Sulzer nous a parlé des derniers perfectionnements apportés à son verre, j’ai tenté un troisième essai (avec un verre perfectionné) et le résultat est remarquable. Non seulement la malade supporte le verre, mais elle le garde trois et quatre heures de suite, sans fatigue et sans irritation, surtout à gauche; à droite, où le kératocône est extrêmement prononcé, le verre provoque au bout de quelques minutes du larmoiement et une grande gêne. La vision de loin et de près est considérablement améliorée. Elle est égale à 1 pour la vision à distance et les caractères n° 1 du livre de Wecker sont lus couramment de près et cela des deux yeux.” (19)

The Evidence from Haas

In his report on “**Les Verres de Contact**” (*The Contact Glasses*), presented on November 14, 1937, at the plenary session of the Paris Society of Ophthalmology, Haas wrote:

“I have personally had in my hands a contact glass that Mr. Sulzer had once given to Mr. L. Dupuy-Dutemps, with which the latter was kind enough to

Type	ground, double curvature
Front optic zone	spherical, exempt from astigmatism
Back optic zone radius	7.707 mm
Primary optic diameter	12.50 mm
Size of the scleral zone	approximately 2.25 mm
Power	- 0.25 diopter
Total diameter	slightly > 17.00 mm

Table 13 - 3

Characteristics of the contact lens used by Sulzer as described by Haas in 1937.

entrust me. I performed an examination of this lens at the Institut d'Optique Théorique et Appliquée and found that it is made from a material with a refractive index of 1.499, for the green mercury ray. Its total diameter is a little greater than 17 mm, of which 12.5 mm represents the corneal portion. The radius of curvature of the back corneal surface is the same both at the center and at the edge: 7.707 mm. The thickness is 0.6 mm at the center and 0.51 at the edge. The glass examined in air is slightly divergent, less than 0.25 diopters. Having examined it personally with the Javal ophthalmometer, I noted that the front surface was free of astigmatism. This glass was probably ground."

"J'ai eu personnellement entre les mains un verre de contact que M. Sulzer avait autrefois donné à M.L Dupuy-Dutemps, et que celui-ci a bien voulu me confier. Il résulte de l'examen de ce verre, fait à l'Institut d'optique théorique et appliquée, qu'il est fait d'une matière dont l'indice de réfraction, pour la raie verte du mercure, est 1,499. Son diamètre total est un peu supérieur à 17 mm, dont 12,5 mm pour la partie cornéenne. Le rayon de courbure de la face cornéenne postérieure est le même au centre qu'au bord: 7,707 mm. L'épaisseur au centre est 0,6 mm ; au bord 0,51. Le verre examiné dans l'air est légèrement divergent, moins de 0,25 dioptrie. L'ayant examiné moi-même à l'ophthalmomètre de Javal, j'ai constaté que la face antérieure était exempte d'astigmatisme. Ce verre est très probablement taillé." (20)

According to this description, the *Sulzer* lens that *Haas* examined in 1937 had *different parameters from those provided in 1892 for the original model*:

the back optic zone radius had a higher curvature (7.70 mm as compared with 8.00 mm), the total diameter was greater (17.00 mm compared with 14.00 mm to 15.00 mm). Both are ground, afocal lenses.

The optician *Berthiot* pursued commercialization of the "new contact glasses, ground as a single piece from a block of crown glass, following the recommendations of Dr. *Sulzer*" for several more years. This was what his catalogue and advertising material had indicated, according to *Fick*. Sales were, however, not particularly successful (21).

Various reservations were expressed: there were comments that *Sulzer* had never indicated the duration of the wearing time his patients had attempted and that the contact lenses either slid from side to side, irritating both eyes and pupils, or that they adhered so strongly that they interfered with corneal metabolism, to the extent of causing corneal asphyxiation. In a historical retrospective to be written in 1916, some twenty years later, *Siegrist* wrote a severe judgment on the efficaciousness of the *Sulzer* lenses and their tolerance by patients:

"His [Sulzer's] publication also indicates that he did not dispense contact glasses for patients to wear on a temporary basis, with the result that we have no precise information from him regarding the really practical usefulness of contact glasses. Sulzer also seems not to have proceeded further with his studies on the practical refractive correction of human eyes with contact-glasses."

"Aber auch aus seiner Publikation geht hervor, dass er die Kontaktgläser den Patienten nicht zum zeitweisen Tragen ausgehändigt hat, so dass wir durch ihn über die wirklich praktische Verwertbarkeit der Kontaktgläser nichts Genaueres erfahren. Sulzer scheint auch seine Korekturversuche mittels seiner Kontaktgläser praktisch an Menschen nicht weiter ausgeführt zu haben." (22)

1.2 – Dor’s Studies on Contact Lenses (1892)

I now come to *Henri Dor*, another French-Swiss ophthalmologist, former professor of Ophthalmology at Berne (Switzerland), then living at Lyon (France). Several months after *Sulzer*, *Dor* presented his results on the correction of keratoconus, myopia and astigmatism by means of contact lenses. This took place on November 2, 1892 (23). He made his presentation to the *Société des Sciences Médicales de Lyon* with the title “**Sur les Verres de Contact**” (*On Contact-Glasses*). After the traditional reference to the limitations and failures of spectacle lenses for the correction of patients with astigmatism and keratoconus, *Dor* noted the merits of *Fick’s* studies:

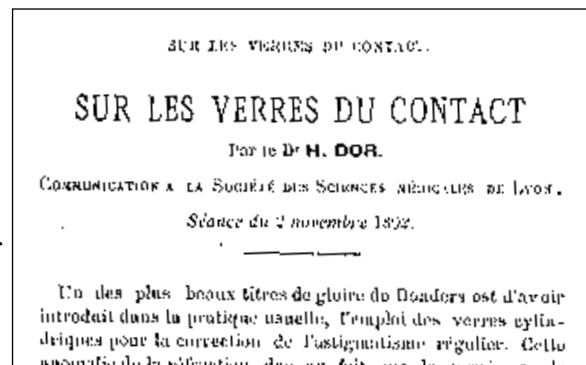


Figure 13-7

Dor's publication on contact lenses.

Dor's presentation “*Sur les Verres de Contact*” (*On Contact Glasses*) was read on November 2, 1892, before the *Société des Sciences Médicales de Lyon*.

(DOR, Henri, “*Sur les verres de contact*”, *Revue Générale d’Ophtalmologie*, 11, 1892, 493-497. - Excerpt page 493)

“*In 1888, [Fick] had the idea of totally suppressing the function of the cornea by replacing it with an artificial glass cornea with normal curvature that he applied directly onto the eye. He thus replaced the empty space between the glass shell and the eye with a liquid having the same refractive index as the cornea and aqueous. With this in mind, he used a 1/50th glucose solution.*”

“*[Fick] eut en 1888, l'idée de supprimer totalement l'action de la cornée, en la remplaçant par une cornée artificielle en verre, à courbure normale, qu'il appliquait directement sur l'œil en remplissant le vide, laissé entre la coque de verre et l'œil par un liquide présentant le même indice de réfraction que la cornée et l'humeur aqueuse. Il se servait dans ce but d'une solution de glucose à 1/50e.*” (24)

Dor referred to *Fick’s* article, which, however, he did not appear to have understood well. In fact, he attributed the term “*verre de contact*” (contact glass) to *Fick*, whereas, in his article, this author used the expression “*Contactbrille*” (contact-spectacles). *Dor’s* confusion with *May’s* translation of this term as “*contact-lens*” is even more incomprehensible in that he cited the original German article in the bibliographic reference (25):

“*The first glasses, to which Fick gave the name of contact glasses were made from blown-glass; however, the curvature obtained was not sufficiently regular and he succeeded in having one made by Abbe in which the cupola representing the cornea had exactly 8 mm radius of curvature, and this central cupola was continuous with a more flared-out part with a radius of curvature of 15 mm intended to rest on the sclera. Fick published satisfactory results, but, because his contact glass was one of a kind, no individual was able to repeat his experiments.*”

“*Les premiers verres, auxquels Fick donna le nom de verres de contact, étaient soufflés ; mais la courbure obtenue n'était pas suffisamment régulière et il réussit à en faire construire un par Abbé dans lequel la cupule représentant la cornée avait exactement 8 mm de rayon de courbure, et cette cupule centrale était continuée par une partie plus évasée destinée à reposer sur la sclérotique et présentant un rayon de courbure de 15 mm, Fick annonça des résultats satisfaisants ; mais comme son verre de contact était un exemplaire unique, personne ne put répéter ses expériences.*” (26)

1.2.1 - Benzoni's Ground Contact Lenses

Dor reported that, when he learned about Sulzer's communication, he had Benzoni, optician in Geneva (Switzerland), deliver two ground-glass contact lenses to him:

“At the last Congress of the French Society of Ophthalmology (May 1892), Sulzer made it known that his Geneva optician (Benzoni, rue du Stand) had succeeded in manufacturing similar glasses and that one could obtain these at his office. I had two samples supplied and I tell you I was unpleasantly surprised when I had to pay a charge of 80 francs; the optician informed me that this was a discounted price and that the real cost was 50 francs each. I have to add that this price no longer appears excessive to me since I have become aware of the difficulties of manufacture with particular regard to perfecting the curvature, which, even with Helmholtz's ophthalmometer, does not show the slightest irregularity in the different meridians.”

“A la dernière réunion de la Société française d'ophtalmologie (mai 1892), Sulzer annonçait que son opticien de Genève (Benzoni, rue du Stand) avait réussi à fabriquer des verres pareils et qu'on pouvait se les procurer chez lui. Je m'en fis expédier deux exemplaires, et j'avoue que j'ai d'abord été peu agréablement surpris lorsque j'eus à payer un remboursement de 80 francs; l'opticien ajoutait que c'était un prix de faveur, que le coût réel était de 50 francs pièce. Je dois toutefois ajouter que ce prix ne me paraît plus exagéré depuis que j'ai pu me rendre compte des difficultés de l'exécution et surtout de la perfection de la courbure, laquelle, même avec l'ophtalmomètre de Helmholtz, ne présente pas la plus petite irrégularité dans les différents méridiens.” (27)

1.2.2 - The Insertion of Contact Lenses

The insertion of contact lenses was performed under topical anesthesia using cocaine. The upper edge of the shell was raised with a hook and the liquid introduced with a dropper until all of the air was eliminated:

“It must be said that insertion is not very pleasant but, thanks to cocaine, is well tolerated. The hardest maneuver is not the insertion of the glass but the introduction of the liquid, which must fill the void between the glass and the cornea. In order to achieve that, one has to lift the upper lens border gently with a hook and allow the liquid to drop in with a dropper or a pipette, until the air bubble that is always there after simple application has been completely eliminated.”

“Il faut avouer que l'application n'est pas très agréable, mais grâce à la cocaïne, elle est bien tolérée. La manœuvre la plus difficile n'est pas la mise en place du verre, mais l'introduction du liquide qui doit remplir le vide entre le verre et la cornée. Il faut pour cela soulever légèrement le bord supérieur du verre avec un crochet, et laisser tomber le liquide avec un compte-gouttes ou une pipette, jusqu'à ce qu'on ait chassé complètement la bulle d'air qui existe toujours après la simple application.” (28)

1.2.3 - Clinical Applications

Dor presented a patient affected by keratoconus to the assembly. This patient had been wearing his lens for three hours a day, and he maintained that he had not been inconvenienced by it and had meanwhile benefited from a significant improvement in his visual acuity:

“The patient that I am presenting to you has bilateral keratoconus and both corneas are affected by central nebulae [...]. The visual acuity of the left eye (the better of the two

eyes) is equal to 20/70 for distance when he wears the hyperbolic spectacle glass of 1½ in series A of Rathenow. When squinting, he obtains also 20/70 with a -5.00 D spectacle lens. With the contact glass (and a -5.00 D. sph.), he obtains 20/60; but, what is most striking of all is that objects in the peripheral visual field are not distorted. 'There is no longer any atmosphere,' he says, 'I see the same as in vacuum.' He had believed until now that the surrounding atmosphere was sending out mistiness between him and the objects. For near vision, he reads Snellen #7 and, with a contact glass, Snellen #2 (without squinting). When squinting, even without a glass, he reads Snellen #1. The patient has been wearing his glass for the last three hours, and he indicates that he is not inconvenienced by it."

"Le malade que je vous présente est atteint de kératocône des 2 yeux avec tache centrale des 2 cornées [...] La vision de l'œil gauche (le meilleur) est égal à 20/70 avec le verre hyperbolique 1 ½ série A de Rathenow. En clignant des paupières, il obtient également 20/70 avec -5 D avec le verre de contact (et -5 D sph.) 20/60 ; mais ce qui le frappe le plus, c'est que les objets dans le champ visuel périphérique ne sont pas déformés. « Il n'y a plus d'atmosphère, dit-il, je vois comme dans le vide ». Il avait cru jusqu'ici que l'atmosphère mettait une buée entre nous et les objets. Vision de près : Snellen n° 7 ; avec le verre de contact Snellen n° 2 (sans cligner). En clignant même sans verre il lit Snellen n° 1. Le malade porte son verre depuis 3 heures, et il déclare n'en être pas incommodé." (29)

Dor completed his presentation with a table of nine other observations: myopes, who were little improved, hyperopes, patients with regular astigmatism, and others with irregular astigmatism:

"You will see in the table above that contact glasses primarily improve hypertropia and that in the cases of myopic astigmatism the result, excellent as it is for near objects, must be corrected for distance vision by a corresponding spherical spectacle glass. In fact, the contact glass, separated from the cornea by the layer of liquid, lengthens the ocular axis and produces an axial myopia by an amount which varies for different individuals, but which averages two diopters."

"On remarquera dans le tableau ci-dessus que les verres de contact améliorent surtout l'hypermétropie et que dans les cas d'astigmatisme myopique le résultat, très bon pour la vision d'objets rapprochés, doit être corrigé pour la vision à distance par le verre sphérique correspondant; c'est qu'en effet le verre de contact séparé de la cornée par la couche de liquide allonge l'axe optique de l'œil et produit ainsi une myopie axiale dont la valeur varie suivant les individus, mais qui, en moyenne, correspond à deux dioptries." (29)

As a postscript to his publication, Dor presented another patient with keratoconus corrected by contact lenses, who was considerably improved by these. He added the following commentary:

"Since the publication of my work, I have had the opportunity to observe a new keratoconus case without central corneal nebula in a young girl of 24 years. In this patient, the correction of the vision was still much greater (i.e., 1/80 to ½). I do not need to add that this achievable optical correction does not make the operation less essential. For, without operation, it is evident that the keratoconus would continue its evolution and that we would soon see the opacity appear in the central cornea."

"Depuis la rédaction de mon travail, j'eus l'occasion d'observer chez une jeune fille de 24 ans un nouveau kératocône sans tache centrale de la cornée. Ici la correction de la vision était encore beaucoup plus considérable de 1/80 à ½ - je n'ai pas besoin d'ajouter que cette correction optique possible ne rend pas moins nécessaire l'opération, car, sans opération, il est évident que le kératocône continuerait son

évolution et que nous verrions bientôt apparaître l'opacité du centre de la cornée." (29)

1.2.4 - Dor's Reservations

Dor concludes the presentation of his clinical experience with a remark that expresses his reservations about the use of contact lenses in patients affected with anomalies of refraction. On the other hand, he judges that contact lenses could be useful for diagnosis and clinical research:

"In summary, contact glasses such as we possess today are not very easy to use and they will not really be beneficial except in patients who have rather severe irregular astigmatism, with or without corneal nebulae, or in patients with keratoconus. On the other hand, they will prove very useful for the ophthalmologist to make an immediate diagnosis of irregular astigmatism. Finally, they will allow us, from a physiological standpoint, to eliminate the function of the cornea and to study today's still so controversial question regarding astigmatic contractions of the crystalline lens. In fact, it will be so easy for us to study the effects of cylindrical lenses on our own eyes that we will come to surmount the artificial astigmatism of the crystalline lens."

"En résumé, le verre de contact tel que nous le possédons aujourd'hui n'est pas d'une application très facile et il ne rendra de véritables services que dans les cas d'astigmatisme irrégulier considérable, soit sans, soit avec des taches de la cornée et dans les cas de kératocône. Par contre il sera très utile au médecin pour faire immédiatement le diagnostic de l'astigmatisme irrégulier. Enfin du point de vue physiologique il nous permettra, en éliminant l'action de la cornée, d'étudier la question encore si controversée aujourd'hui des contractions astigmatiques du cristallin. En effet il nous sera facile d'étudier sur notre propre œil les verres cylindriques, que nous arriverons à surmonter par l'astigmatisme artificiel du cristallin." (29)

The following year, *Michel* from the *Berne Ophthalmology Clinic* had taken up *Dor's* proposal to eliminate the refractive power of the cornea by a contact lens in order to study possible astigmatic contractions in his own eye (30). It is not impossible that *Dor*, having kept his connections with the *Berne Eye Clinic*, had informed *Michel* of his researches or had even inspired them.

1.3 - The Controversies

The decade following the invention of contact lenses also was noteworthy because of *Sulzer's* challenge of the priority rights of *Fick* and *Kalt*. Another controversy threw *Fick* into conflict with *Lohnstein* over the respective advantages of contact lenses and the hydrodiascope.

1.3.1 – The Sulzer - Fick Controversies (1892 – 1894)

Sulzer's Earliest Remarks and the Revelations of Fick's Mistake (1892)

In his communication to the *French Society of Ophthalmology* in May 1892, *Sulzer* credited *Fick* with his discovery of the principle of corneal dioptric power neutralization by means of a contact lens:

"Thanks to Fick's research, it is established that a concavo-convex meniscus applied to the cornea and separated from it by a glucose solution diluted 1/150, the refractive index

of which is equal to that of the cornea and the aqueous humor, is tolerated by the human eye.”

“Grâce aux travaux de Fick, il est acquis qu’un ménisque concave-convexe appliqué sur la cornée et séparé d’elle par une couche d’une solution de sucre de raisin au 150e, solution dont l’indice de réfraction est égal à celui de la cornée et de l’humeur aqueuse, est toléré par l’œil humain.” (31)

Year	Publication
1892	Sulzer's Communication at the French Society of Ophthalmology: "La Correction Optique du Kératocône, de l'Astigmatisme Irrégulier et de l'Astigmatisme Cicatriciel" (Optical Correction of Keratoconus, Irregular Astigmatism and Cicatricial Astigmatism)
1892	Fick's comment on Sulzer's communication: "Einige Bemerkungen über die Contactbrille" (Some Remarks on the Contactbrille)
1893	Sulzer-Kalt controversy on priority, in discussion with Chevallereau/Abadie: "Traitement du Kératocône" (Treatment of Keratoconus)
1894	Fick's protest, in response to Sulzer's summary of Dor's article: "Verwahrung" (Protest)
1894	Sulzer's reply to Fick's protest: "Antwort auf die Verwahrung des Herrn A.E.Fick" (Reply to Mr. A.E. Fick's Protest)
1894	Fick's reply: "Jedem das Seine" (To Each his Due)

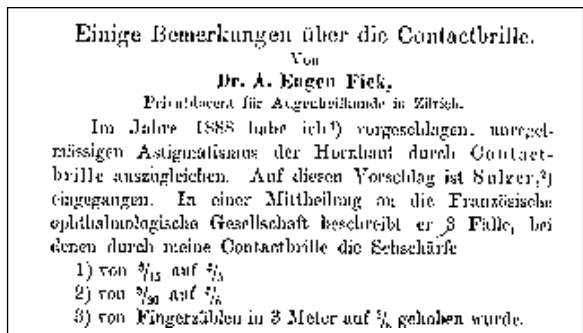
Table 13 - 4
Chronology of the controversies on contact lenses between Sulzer and Fick (1892 to 1894).

At the same time, however, Sulzer had also criticized the fact that Fick’s contact lenses were of blown-glass, that Fick was in error and, more seriously, that he had misled his readers by informing them that the contact lenses that he had used were of ground glass.

Sulzer had no hesitation in attributing to himself the primacy of the invention of the only contact lenses worthy of this title, i.e., ground-glass contact lenses, the only ones from which the irregularities had been removed and, for that reason, the only ones that were capable of giving satisfactory optical results:

“The contact glasses used by Mr. Fick were blown glasses. If one examines glass made from blown glass on the ophthalmometer, one always find a number of irregularities, although that glass appears absolutely smooth when viewed through a magnifying loupe. These irregularities readily explain the unsatisfactory results that Mr. Fick obtained. After much research by trial and error, I finally came to have the contact glasses made from ground-glass.”

“Les verres de contact employés par M. Fick étaient des verres soufflés. Quand on examine un verre soufflé à l’ophtalmomètre, on y découvre sans exception nombre d’irrégularités, quoiqu’il paraisse absolument régulier vu à travers une loupe. Ces irrégularités expliquent facilement les résultats peu satisfaisants obtenus par M. Fick. Après beaucoup de tâtonnements, je suis arrivé à faire tailler des verres de contact.” (32)



Fick’s Justification (1892)

Sulzer’s references in regard to the quality of the lenses used by Fick could not possibly leave the latter unmoved, and he replied vigorously to the criticisms in a letter dated July 25, 1892, to the *Klinische*

Figure 13-8
Fick's reply to Sulzer's objections.
In this publication, an open letter with the title: "Einige Bemerkungen über die Contactbrille" (Some Remarks about the Contactbrille), Fick replies to Sulzer's objections.
(FICK Adolf Eugen, "Einige Bemerkungen über die Contactbrille", *Klinische Monatsblätter für Augenheilkunde*, 30, 1892, 306-310. - Page 306)

Monatsblätter für Augenheilkunde under the title of **“Einige Bemerkungen über die Contactbrille”** (Some Remarks about the Contactbrille) (33). In this article, Fick confirmed his right to the priority in regard to the invention of the ‘Contactbrille’:

“In the year 1888, I made the proposal to correct irregular corneal astigmatism by means of a ‘Contactbrille.’ Mr. Sulzer followed up on my proposal. In a communication to the French Society of Ophthalmology, he described three patients in whom, with my ‘Contactbrille,’ visual acuity was improved from 5/15 to 5/5 in the first, from 5/30 to 5/6 in the second and from counting fingers from three meters to 5/6 in the third.”

„Im Jahre 1888 habe ich vorgeschlagen, unregelmässigen Astigmatismus der Hornhaut durch Contactbrille auszugleichen. Auf diesen Vorschlag ist Sulzer eingegangen. In einer Mittheilung an die Französische ophthalmologische Gesellschaft beschreibt er 3 Fälle, bei denen durch meine Contactbrille die Sehschärfe –1) von 5/15 auf 5/5, - 2) von 5/30 auf 5/6, -3) von Fingezählen in 3 Meter auf 5/6 gehoben wurde.” (33)

History of a Mistake

At this point, Fick explained that, actually, his first contact lenses were not of ground glass but were blown, contrary to what he had indicated in his publication. He indicated, by way of explanation, that he had made an honest mistake and that Professor Abbe of Jena had misled him:

“Sulzer claims on this occasion that I have had less good results because my ‘Contactbrille’ were not ground but blown. This statement is correct, in spite of the fact that it contradicts my published data. This situation came about in the following manner. Naturally, I never thought that I would achieve anything from the use of blown ‘Contactbrille’ (see page 285 of my article). I obtained four small glasses, without any written documentation, through the courtesy of Professor Abbe in Jena. It was with these that I achieved the results described by Sulzer, i.e., an improvement in visual acuity from 1/10 to 1/6 and from 1/20 to 1/6.”

“Sulzer erwähnt bei der Gelegenheit, dass ich weniger gute Ergebnisse gehabt habe, weil meine Contactbrillen nicht geschliffen, sondern geblasen waren. Diese Angabe ist richtig, obgleich sie den von mir veröffentlichten Angaben widerspricht. Die Sache hängt folgendermaassen zusammen. Natürlich habe ich nie daran gedacht, durch geblasene Contactbrillen etwas zu erreichen (siehe Seite 285 meines Aufsatzes). Durch die Güte des Herrn Professors Abbe in Jena erhielt ich, ohne briefliche Mitteilung, vier Gläschen, mit denen ich die von Sulzer erwähnten Ergebnisse erzielte, nämlich eine Steigerung der Sehschärfe von 1/10 auf 1/6 und von 1/30 auf 1/6.” (33)

Further requests to Abbe remained unanswered. Fick approached various opticians who refused his requests, with the exception of Suter in Basle (Switzerland). The latter’s attempts were unsuccessful:

“As I obtained no additional small glasses from Jena nor any information, I turned to a series of opticians with the request that they might grind ‘Contactbrille’ for me. Mr. Suter of Basle was kind enough to arrange that some work be done for me. Unfortunately, nothing useful came of that. Other opticians simply declined my proposal.”

“Da ich von Jena keine weiteren Gläschen, auch keine Auskunft erhielt, so wandte ich mich an eine Reihe von Optikern mit der Bitte, mir Contactbrillen zu schleifen. Herr Suter in Basel hatte die Güte, für mich arbeiten zu lassen; allein es kam nichts Brauchbares zu Stande. Andere Optiker lehnten meinen Antrag einfach ab.” (34)

In 1889, *August Müller's* thesis came to his attention (35). From *Fick's* point of view, *Müller's* "Hornhautlinsen" were no different from his "Contactbrillen". *Fick* forwarded the Jena contact shells as a model to the optician *Otto Himmler* in Berlin. This was how *Fick* learned that the contact lenses sent by *Abbe* were of blown glass and that it had not been possible to grind such thin lenses from a single piece of glass:

„Then, in the year 1889, a dissertation by August Müller came to my notice concerning 'Hornhautlinsen,' or, as I called them, 'Contactbrillen,' that Mr. Otto Himmler had ground in Berlin. I forwarded my little Jena glasses to him at that time and requested that he grind some new ones for me. It was only then, one year after my publication, that I learned through Mr. Himmler that the little Jena glasses were not ground, but that they were very well blown and that it was not possible to grind such thin glasses from a single piece."

“Da kam mir im Jahre 1889 eine Dissertation von August Müller zu Gesicht, in der von "Hornhautlinsen", oder, wie ich soche Gläschen genannt, von Contactbrillen die Rede ist, die Herr Otto Himmler in Berlin geschliffen hatte. Ich schickte nun diesem meine Jenaer Gläschen und bat ihn, mir einige neue zu schleifen. Jetzt erst, also ein Jahr nach meiner Veröffentlichung, erfuhr ich durch Herrn Himmler, dass die Jenaer Gläschen nicht geschliffen, sondern sehr gut geblasen seien, und dass es nicht möglich sein werde, so dünne Gläsche aus einem Stücke zu schleifen.” (34)

The Two-piece "Contactbrillen"

Following his request, the optician *Himmler* sent two contact lenses to *Fick*. They were of a new and original type, in that they consisted of two pieces of ground glass glued together, one part corneal and the other part scleral:

“After a little while, Mr. Himmler forwarded me two 'Contactbrillen,' one of which consisted of a glass cornea and a glass sclera, each glued together, and the other of a glass cornea and a metal sclera glued together. At the same time, he requested that I spare him similar commissions in future because he could not make a profit from them in spite of a price of 38 Marks.”

“Nach einiger Zeit schickte Herr Himmler zwei Contactbrillen, die eine aus Glashornhaut und Glas-Lederhaut, die andere aus Glashornhaut und Metall-Lederhaut zusammengesetzt; beide Glas-Hornhäute waren geschliffen und poliert. Gleichzeitig sprach er mir die Bitte aus, ihn in Zukunft mit ähnlichen Aufträgen zu verschonen, da er trotz eines Preises von 38 Mark nichts daran verdiene.” (34)

Fick had reserved these precious lenses for trials in patients affected by keratoconus and irregular astigmatism. He presented the results obtained in seven of these patients. Three of them had experienced no improvement with contact lenses. *Fick* listed several explanations for this, namely spherical aberration in the contact lens, astigmatism of the crystalline lens, and amblyopia. *Fick* ended his letter with a despairing comment deploring the failure of the German opticians to manufacture single-piece contact lenses, whereas the French opticians had succeeded:

“The French opticians achieved something that was impossible for the Germans, insofar as they did not consider it worth the effort. I hope that these comments will succeed in persuading German optical technology to set narrower limits for the 'impossible' and to seek to achieve the top rank even in projects 'presumed unprofitable.'"

“Den französischen Optikern ist somit gelungen, was die Deutsche für unmöglich, beziehungsweise für nicht der Mühe werth erklärt haben. Hoffentlich haben diese Zeilen den Erfolg, dass die Deutsche optische

Techik die Grenzen des 'unmöglich' etwas enger steckt und auch an 'ausgefallenen Arbeiten' den ersten Rang zu behaupten sucht. (46)

The polemic should have ended with this final thrust. In spite of that, a rebound occurred in the following year at *Fick's* instigation and took on a more aggressive tone.

Fick's Protest (1893)

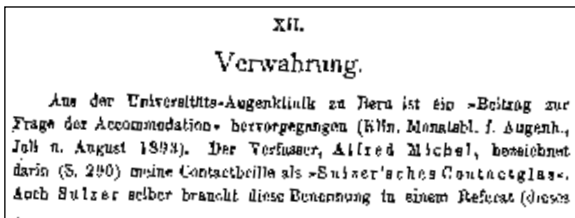


Figure 13-9

Publication of the second open letter from Fick to Sulzer: In his open letter, dated November 1893, entitled "Verwahrung" (Protest) to the Archives für Augenheilkunde, Fick expressed his irritation at the use of the term "Sulzer's contact glass".

(FICK Adolf Eugen, "Verwahrung", Archiv für Augenheilkunde, 28, 1894, 127-128. - Excerpt page 127).

In a letter dated November 5, 1893, which he addressed to the *Archiv für Augenheilkunde* and that was published at the beginning of the following year with the title "**Verwahrung**" (*Protest*) (37), *Fick* expressed his irritation at the use of the term "*Sulzer's contact-glass*" (*Sulzer'sche Contactglass*) in *Sulzer's* short summary of *Dor's* article, which appeared in this journal:

"Dor obtained very good results with Sulzer's contact glasses, essentially in patients with keratoconus. These were well tolerated by the patients."

"Dor hat mit den Sulzer'schen Contactgläser sehr gute Resultate erhalten, hauptsächlich in Fällen von Keratoconus. Dieselben werden von den Patienten wohl vertragen." (38)

Elsewhere, *Michel* had also used this expression in his publication on the study of accommodation. (43)

Fick protested vigorously:

" - 1.) The idea of optically eliminating the irregularly refracting cornea by means of contact glasses ground from a single piece is my intellectual property.

2.) In February 1892, I wrote a letter to my colleague, Mr. Sulzer, requesting that he clarify some points that I did not understand in his article entitled 'La forme de la cornée humaine et son influence sur la vision' (The Shape of the Human Cornea and its influence on vision). On this occasion, I proposed to submit his opinion on the optical nature of astigmatic amblyopia to a 'critical test' (experimentum crucis) with the help of my 'Contactbrille.' Mr. Sulzer accepted my proposal, and I forwarded to him one of the small contact glasses ground by Mr. Himmler of Berlin that was in two parts glued together, i.e., a corneal and a scleral part.

3.) Mr. Sulzer searched for and found in Paris an optician (L. Berthiot Company) who managed to grind small contact glasses from a single piece. These glasses were brought onto the market as 'new contact glasses, ground from a single piece of crown-glass following the recommendations of Dr. Sulzer.' (Mr. Strübin in Basle now also grinds small contact glasses from one piece that are, in my experience, more perfect and less expensive than those of L. Berthiot Company. Alfred Michel conducted his experiments with a Strübin contact glass.)"

"-1. Der Gedanke, die unregelmässig brechende Hornhaut eines Auges durch ein aus einem Stücke geschliffenes Contactgläschen optische auszuschalten, ist mein geistiges Eigenthum.

-2. Im Februar 1892 bat ich Herrn Collegen Sulzer brieflich um Aufklärung über einige, mir dunkel

gebliebene Punkte seiner Arbeit « *La forme de la cornée humaine et son influence sur la vision* ». Bei dieser Gelegenheit schlug ich ihm vor, seine Ansicht von der optischen Natur der « *Amblyopie astigmatique* » mit Hilfe meiner Contactbrille einem Experimentum crucis zu unterwerfen. Herr Dr. Sulzer ging auf meinen Vorschlag ein, und ich schickte ihm ein von Herrn Himmler in Berlin geschliffenes Contactgläschen, das aus zwei Stücken, Hornhaut und Lederhaut, zusammengesetzt war.

-3. Herr Dr Sulzer suchte und fand in Paris einen Optiker (Maison L. Berthiot), der es fertig brachte, Contactgläschen aus einem Stücke zu schleifen. Diese Gläschen wurden als « *Nouveaux* » verres de contact taillés d'une seule pièce dans une masse de crown-glass, suivant les indications « *du docteur Sulzer* » in den Handel gebracht. (Auch Herr Strübin in Basel schleift jetzt Contactgläschen aus einem Stücke, nach meiner Erfahrung vollkommener und billiger als das Haus L. Berthiot. Alfred Michel hat seine Versuche mit einem Strübin'sche Glase angestellt.)" (40)

Fick concluded with the renewal of his claim to priority in the invention of contact lenses:

"The facts enumerated above show that Mr. Dr. Sulzer and the Berthiot Company, respectively, have achieved an advance in technology (namely grinding from a single piece of glass). I must leave to the judgment of my professional colleagues whether this advance is sufficient to designate my contact glass as a 'Sulzer's glass.'"

*"Die vorstehend aufgezählten Thatsachen beweisen, dass durch Herrn Dr. Sulzer bzw. das Haus Berthiot allerdings ein technischer Fortschritt (Schleifen aus einem Stücke) erzielt worden ist. Ob derselbe aber genügt, mein Contactglas als « *Sulzer'sches* » zu bezeichnen, überlasse ich dem Urteile der Herren Fachgenossen"* (40)

Sulzer's Reply to Fick's Protest (1894)

Sulzer's rejoinder to Fick's protest was almost immediate. Hardly a hundred pages after Fick's article is his reply under the title: "*Antwort auf die Verwahrung des Herrn A.E. Fick*" (Reply to Mr. A.E. Fick's Protest).

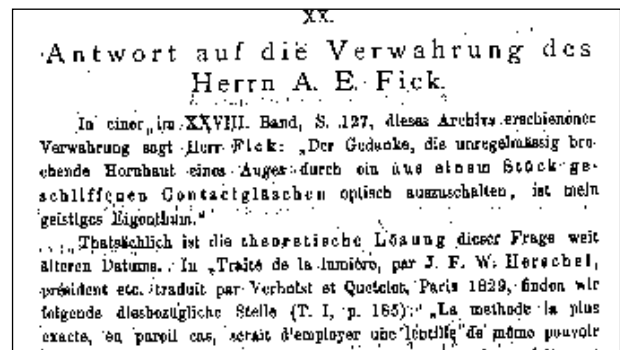


Figure 13-10

Sulzer's reply to Fick's open letter.

Sulzer's reply to Fick's open letter: "Antwort auf die Verwahrung des Herrn A.E.Fick" (Reply to Mr. A.E. Fick's Protest).

(SULZER David E., "Antwort auf die Verwahrung des Herrn A.E. Fick" Archiv für Augenheilkunde, 28, 1894, 236-237 - Excerpt page 236).

The following is Sulzer's own version of the priority in the invention of the contact lens, as it appeared:

"In a protest published on page 127 in volume XXVIII of this Archive, Mr. Fick made the following statement: 'The idea of optically eliminating the irregularly refracting cornea by means of contact glasses ground from a single piece is my intellectual property'.

In fact, the theoretical solution of this question belongs to a far earlier date. In J.F.W. Herschel's 'Treatise on Light,' we find the following relevant passage [...]."

"In einer im XXVIII. Band, S. 127, dieses Archivs erschienenen Verwahrung sagt Herr Fick: 'Der Gedanke, die unregelmässig brechende Hornhaut eines Auges durch ein aus einem Stück geschliffenes Contactgläschen optische auszuschalten, ist mein geistiges Eigenthum'.

Thatsächlich ist die theoretische Lösung dieser Frage weit älteren Datums. Im 'Traité de la lumière, par J.F.W.Herschel' finden wir folgende diesbezügliche Stelle [...]." (41)

After the citation of Herschel, to whom he attributes the priority of the idea of the contact lens, Sulzer questions the practical realization of this neutralization by the blown contact

lenses used by Fick: (42)

“With reference to the practical solution, Mr. Fick has made a negative contribution in his article published in this Archiv (1888, Vol. 18, p. 285). As I emphasized in my publication regarding contact glasses (‘La correction optique du k eratoc one, de l’astigmatisme irr egulier et de l’astigmatisme cicatriciel’ in Bulletin et M emoires de la Soci et e Fran aise d’Ophtalmologie, Vol X, p. 113, and Ann. d’ocul. T. CVII, p. 321) and as Mr. Fick himself later confirmed (Klin. Monatsbl. f. Augenh. September 1892), he used blown contact glasses for his published studies without being aware of the deficient method of their manufacture. In consequence of the inevitable irregularities in these blown glasses, the results obtained by him were such that they could not encourage the use of contact glasses.”

“In Bezug auf die praktische L osung hat Herr Fick in dem in diesem Archiv (1888, Bd.18, S.285) erschienenen Artikel einen negativen Beitrag geliefert. Wie ich in meiner Ver offentlichung  uber Contactgl aser (La correction optique du k eratoc one, de l’astigmatisme irr egulier et de l’astigmatisme cicatriciel, in Bulletin et m emoires de la soci et e fran aise d’ophtalmologie, Vol X, p.113, et Ann d’ocul. T. CVII, p.321) hervorhob und wie Herr Fick sp ater selbst best atigte (Klin. Monastbl. f. Augenh. 1892, September) hatte er zu seinen ver offentlichten Versuchen geblasene Contactgl aser verwendet, ohne von dieser mangelhaften Fabricationsweise unterrichtet zu sein. In Folge dieser unvermeidlichen Unregelm assigkeiten geblasener Gl aser waren die von ihm erhaltene Resultate solche, dass sie zur Anwendung von Contactgl asern nicht ermuthigen konnten.” (43)

Sulzer recalled that Kalt had also used ground contact lenses for the correction of the refractive errors in patients with keratoconus. (44) He went on to describe how he had used a two-piece contact lens that Fick had sent him as a model for the manufacture of lenses to be ground from one piece:

“Mr. Dr. Kalt attempted to correct keratoconus with ground contact glasses that did not have a scleral band and that had been ground in Paris by Verlin. On March 13, 1888, Mr. Panas communicated Kalt’s relevant experiments to the Paris Academy of Medicine. In the spring of 1892, I presented a communication to the French Society of Ophthalmology concerning one-piece ground contact glasses that were manufactured using a method formulated by the Geneva optician, Mr. Benzoni and me. I submitted the various stages of manufacture both to the French Society of Ophthalmology and to the Academy of Medicine in addition to circulating this information to a large number of opticians. The optician, L. Berthiot, 207 Rue St Martin, undertook their large-scale manufacture in Paris. I made use of a glass that Mr. Fick had forwarded to me as a prototype for these contact glasses. This particular contact glass consisted of two parts in combination and could not itself be used in practice.”

“Herr Dr. Kalt hat den Keratoconus mit von Verlin in Paris geschliffene Contactgl asern ohne Scleralrand zu corrigiren versucht. Seine diesbez ugliche Erfahrungen sind durch Herrn Panas am 13. M arz 1888 der Acad emie de m edecine de Paris mitgeteilt worden.

Im Fr uhjahr 1892 legte ich der franz osischen Ophthalmologengesellschaft aus einem St uck geschliffene Contactgl aser vor, die nach einer von Herrn Optiker Benzoni in Genf und mir ausgearbeiteten Methode – die verschiedenen Stadien der Fabrikation wurden sowohl der franz osischen Ophthalmologengesellschaft als der Acad emie de m edecine vorgelegt und haben bei einer grossen Zahl von Optikern circuliert – angefertigt worden waren. Die Fabrikation im Grossen hat das Haus L. Berthiot, 207 Rue St. Martin, Paris  ubernommen. Als Prototyp dieser Gl aser hat mir ein von Herrn Fick zugeschicktes, aus zwei St ucken zusammengesetztes und praktisch nicht verwendbares Contactglas gedient.” (43)

Sulzer concluded, in the course of affirming his claim regarding the denomination of

contact glasses as “*Sulzer’s contact glasses*” (verres de contact de *Sulzer*) for the ground contact lenses, the manufacture and quality of which corresponded with the indications he had given to the manufacturer:

“I am pleased to inform Mr. Fick that I apportion no further significance to the expression ‘Sulzer’s contact-glass’ than that of designating a particular type and quality of contact glasses.”

“Gerne erkläre ich Herrn Fick, dass ich den Ausdruck ‘Sulzer’sche Contactglas’ keine andere Bedeutung zumesse, als die der Bezeichnung einer bestimmten Art und Qualität von Contactgläsern.“ (43)

“To Each his Due” by Fick (1894)

A last clarification by *Fick* seemed to close this debate, which was conducted by means of revue articles. Under the eloquent title “*Jedem das Seine*” (*To Each his Due*), *Fick* submitted a letter bearing the date March 31, 1894, to the *Archiv für Augenheilkunde*. In that letter, he replied to four of the arguments contained in *Sulzer’s* letter.

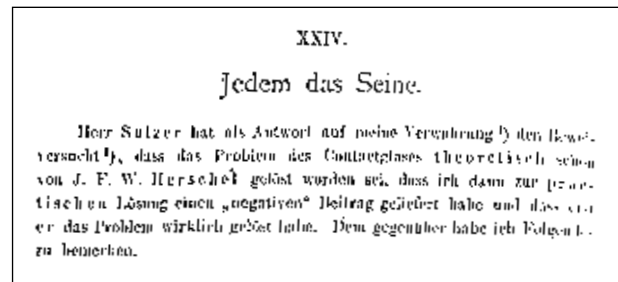


Figure 13-11
Fick's final reply to Sulzer.
Fick's clarification "Jedem das Seine" (To Each His Due).
(FICK Adolf Eugen, "Jedem das Seine", Archiv für Augenheilkunde, 28, 1894, 422-423 - Excerpt page 422).

If *Herschel* had already thought of contact lenses, which was something *Fick* admitted to not knowing, this would certainly have inspired *Sulzer* to attribute *Herschel’s* name to the contact lenses and not to his own. *Herschel’s* device did not correspond, in any event, to that of present-day contact lenses, as this author was proposing a facsimile of the irregular cornea, something that is impractical. Besides, *Herschel* was intending to correct the refractive error by means of a transparent animal jelly held up against the eye by the glass (45):

“1. - Unfortunately, I had overlooked the fact that Herschell had previously thought of contact glasses. On the other hand, Mr. Sulzer has not done any better in this regard, at least until the present. I have come to this conclusion from my reading of his publications and, above all, from the fact that he gave the name ‘Sulzer’ to the glass rather than calling it a ‘Herschel’ contact glass.

Furthermore, one finds, in the two sentences of Herschel that Mr. Sulzer cited, two ideas that do not correspondent exactly to my idea, which I later described as a ‘Contactbrille.’ 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 transparent animal jelly that would be applied with a glass shell against the cornea and he raises the question of whether one could not produce a kind of corneal mold; in this passage Herschel seems therefore to attribute the optical effect not to the glass shell but to the jelly.

Otherwise, those two sentences indicate precisely [...] that Herschel definitely did not carry out experiments in order to develop his ideas. Nevertheless, should anyone christen the contact glass with Herschel’s name, then I will not make any objection.”

“1. - Dass bereits Herschel an Contactgläser gedacht hat, habe ich leider übersehen. Herrn Sulzer ist es aber – bis auf die allerneueste Zeit wenigstens – nicht besser ergangen. Ich schliesse das aus seinen Veröffentlichungen und vor allem aus der Thatsache, dass er das Contactglas nicht Herschel’sches,

sondern Sulzer'sches genannt hat.

Uebrigens sind in den beiden, von Herrn Sulzer angeführten Sätzen Herschel's zwei Gedanken ausgesprochen, die sich doch nicht ganz mit dem deken, 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 gedrückt werden soll und wirft die Frage auf, ob sich nicht gerade ein Abguss der Hornhaut herstellen lasse ; hier scheint also Herschel die optische Leistung nicht der Glasschale, sondern der Gallerte zgedacht zu haben.

Ausserdem geht aus jenen beiden Sätzen, [...] deutlich hervor, dass Herschel keinerlei Versuche gemacht hat, seine Ideen zu verwirklichen. Immerhin, will Jemand das Contactglas auf den Nahmen Herschel's taufen, so werde ich dagegen keine Verwahrung einlegen." (45)

Fick took offense because Sulzer had designated his work as a bad contribution that could only discourage the use of contact lenses. The visual improvement observed in one of the patients did not support this. Furthermore, these trials were not so discouraging, as Sulzer had pursued them on Fick's advice and had even used a contact lens that he now declared to be unusable:

"2. – Mr. Sulzer calls my publication, 'Eine Contactbrille', a negative contribution [...] that has failed to encourage the use of contact glasses. With regard to this matter of the negative contribution, I draw attention to the fact that, previously, and with only my blown glass, I improved the visual acuity of an eye from 1/30 to 1/6. Concerning the failure of my first experiments to encourage the use of contact glasses, I mention that my letter with a proposal and information on that work was sufficient to give direct encouragement to Mr. Sulzer to experiment with the contact glass. For his first experiments, I forwarded to him a little ground glass that he now describes as being 'unusable in practice' because it was glued together from two pieces; However, this little glass performs optically in exactly the same way as the glasses that were ground from a single piece."

" 2. - Meine Arbeit ‚Eine Contactbrille‘ nennt Herr Sulzer einen negativen Beitrag [...], der zur Anwendung von Contactgläsern nicht habe ermutigen können. Was die Negativität betrifft, so verweise ich auf den Umstand, dass ich bereits mit meinen ersten, nur geblasenen Gläschen die Sehschärfe eines Auges von 1/30 auf 1/6 brachte. Und was das nicht Ermutigende meiner ersten Versuche betrifft, so erwähne ich, dass eine brieflicher Vorschlag von mir und Hinweis auf jene Arbeit genügte, gerade Herrn Sulzer zu Versuchen mit dem Contactglase zu ermuthigen. Zu seinen ersten Versuchen schickte ich ihm ein geschliffenes Glässchen, das Herr Sulzer jetzt als « praktisch nicht verwendbar » erklärt, weil es aus zwei Stücken zusammengesetzt war ; optisch leistet aber dies Gläschen ganz genau dasselbe, wie die späteren aus einen Stücke geschliffene Gläser." (46)

We also learn that Sulzer did not notice that Fick's "Contactbrille" were made of blown glass himself, but that it was Fick who communicated this to Sulzer by letter in the course of congratulating him for his studies on corneal topography and encouraging him to complete his experiments with contact lenses:

" 3. - Mr. Sulzer states: 'As I emphasized in my publication regarding contact glasses and as Fick himself later confirmed, he used blown contact glasses for his published studies, without being aware of the deficient method of their manufacture.' This sentence can cause erroneous misconceptions for the reader. I note, in this regard, that it was not Mr. Sulzer who discovered the blown nature of my first glasses, nor he who demonstrated this to me and forced me to acknowledge the fact; it was I myself who communicated the facts to him by letter before their publication!!!"

“ 3. - Herr Sulzer sagt: ‘wie ich in meiner Veröffentlichung über Contactgläser hervorhob und Fick später selbst bestätigte, hatte er zu seinen veröffentlichten Versuchen geblasene Contactgläser verwendet, ohne von dieser mangelhaften Fabricationsweise unterrichtet zu sein’. Dieser Satz kann nicht umhin, beim Leser irrige Vorstellungen hervorrufen. Ich bemerke daher, dass nicht etwa Herr Sulzer das Geblasensein meiner ersten Gläser herausgefunden, mir nachgewiesen und mich zur Anerkennung der Thatsache gezwungen hat, sondern dass ich selber jene Thatsache Herrn Sulzer vor ihrer Veröffentlichung brieflich mitgeteilt habe!!!.” (47)

Finally, *Fick* cited the testimony of a student from Geneva, in protest against the expression “*Sulzer’s contact-glass*” that this individual used:

“ 4. - Last semester, I demonstrated an experiment with the contact glass in the lecture I was giving. Then, one of my listeners said: ‘Isn’t that Sulzer’s contact glass?’ My listener came from Geneva and had heard a lecture by Mr. Sulzer on contact glasses. So, you see, completely uninvolved people use the designation ‘Sulzer’s contact glass’ with absolutely no indication whatsoever of a particular type (??) and quality (?) of contact glasses.”

“ 4. - Im letzten Semester zeigte ich in meiner Vorlesung einen Versuch mit dem Contactglas. Da sagt einer meiner Zuhörer : , das ist doch das Sulzer’sche Contactglas ?’ Der Zuhörer kam aus Genf und hatte einen Vortrag des Herrn Sulzer über Contactgläser gehört. Man sieht, ganz Unbeteiligte fassen die Bezeichnung , Sulzer’sche Contatglas’ keineswegs als Bezeichnung einer bestimmten Art (??) und Qualität (?) von Contactgläsern auf.” (47)

1.3.2 – The Sulzer–Kalt Controversy (1893)

Abadie’s Discussion of Chevallereau’s Communication

Another controversy also took place on May 3, 1893, at the Congress of the French Society of Ophthalmology. This controversy was between *Sulzer* and *Kalt* (48). During the discussion that followed *Chevallereau’s* communication on cauterization of the corneal apex, entitled “*Traitement du kératocône*” (*Treatment of Keratoconus*), several alternative treatments of keratoconus were described. *Abadie* reported the case of a patient who was affected by keratoconus and in whom cauterization of the cone had led to the loss of one eye. He had advised contact lenses for the other eye, “as recommended by Dr. *Sulzer* and the patient had been well satisfied”:

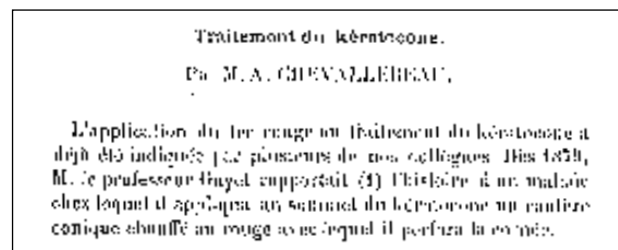


Figure 13-12

Chevallereau’s communication to the French Society of Ophthalmology, followed by Abadie’s discussion, who used the expression “Sulzer’s contact glas” during the discussion. In the same discussion, Kalt reminded his audience that he was the first person to treat keratoconus with contact lenses.
(CHEVALLEREAU A., “Traitement du kératocône”, *Bulletins et Mémoires de la Société Française d’Ophtalmologie*, 11, 1893, 385-392 - Excerpt page 385).

“I have had the opportunity to attend to a young man affected by a double keratotomy [*sic* - read: ‘keratoconus’] and I used the same method as Mr. *Chevallereau*, i.e., electrocautery of the cone summit. The immediate result was very satisfactory, but after two months, [...] a glaucomatous state developed for which no treatment was effective [...]. As I did not know what else to do for this patient in order to remedy his condition, I advised him to wear contact glasses recommended by Mr. *Sulzer* in his other eye; he is well satisfied with these.”

“J’ai eu l’occasion de soigner un jeune homme atteint d’une double kératomie (sic) et j’ai employé le même moyen que M. Chevallereau, c’est-à-dire la cautérisation au galvanocautère du sommet du cône. Le résultat immédiat fut extrêmement satisfaisant, mais au bout de deux mois [...] un état glaucomateux se développait que rien n’a pu enrayer [...]. Chez ce même malade ne sachant plus que faire pour remédier à son état je lui ai conseillé de porter sur l’autre oeil des verres de contact préconisés par M. Sulzer; il s’en trouve très satisfait.” (49)

Kalt’s Rectification

Kalt was present in the conference room and reminded his audience that it was not *Sulzer*; but rather *Fick* and himself, who were the first to have proposed the optical treatment of keratoconus with contact lenses:

“I permit myself to remind Mr. Abadie that the optical treatment of keratoconus was proposed at the same time by Mr. Fick in Switzerland and by me in France in 1887, in a communication to the Academy of Medicine. It was not proposed by Mr. Sulzer.”

“Je me permettrai de rappeler à M. Abadie que le traitement optique du kératocône a été préconisé en même temps, en Suisse par M. Fick, en France par moi en 1887, dans une communication à l’Académie de médecine, et non pas par M. Sulzer.” (50)

Sulzer’s Reply

Sulzer was also present in the conference room. He replied that the concept of contact lens application to the cornea was an old idea. However, *Fick’s* contact lenses were made from blown glass with irregular surfaces, whereas *Kalt’s* were unusable because they had no scleral zone and therefore did not adhere to the eye:

“The idea of applying glasses to the cornea is much more ancient than Mr. Kalt thinks. It goes back to the last century. However, the practical realization of this concept has encountered grave difficulties. The glasses used by Mr. Fick gave inadequate optical results because of the irregularity of their surfaces whereas Mr. Kalt’s glasses, lacking a scleral band, adhered too poorly to the eye to be of practical use.”

“L’idée d’appliquer des verres sur la cornée est bien plus ancienne que ne le pense M. Kalt. Elle remonte au siècle dernier. Mais la réalisation de cette idée a rencontré de grandes difficultés. Les verres employés par M. Fick donnaient des résultats optiques insuffisants à cause de l’irrégularité de leurs surfaces et les verres de M. Kalt, à défaut d’un bord scléral, adhéraient trop peu à l’œil pour pouvoir être utilisés.” (51)

Kalt’s retort was almost immediate. He reproached *Sulzer* for being ignorant of the fact that surface tension was sufficient to cause glass to adhere to a wet surface:

“Mr. Sulzer says that my shells adhere insufficiently to the cornea and that they do not grip. Mr. Sulzer seems to be unaware that adherence occurs by atmospheric pressure, such as happens between two moist glass plates.”

“M. Sulzer dit que mes coques adhéraient insuffisamment à la cornée, ne serraient pas. M. Sulzer ne paraît pas se rendre compte que l’adhérence se fait par la pression atmosphérique, comme il arrive pour deux plaques de verre mouillées” (52)

Panas’s Arbitration

Panas cut short the discussion by indicating that the concept of contact lenses went back further in time than these claims suggested and, in fact, dated back to *Herschel* (53):

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

“L’astronome Herschel, en effet, 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.” (54)

1.3.3 – The Fick - Lohnstein Controversy (1896)

Year	Publication
1896	<i>Lohnstein's publication on the hydrodiascope: "Zur Gläserbehandlung des unregelmässigen Hornhautastigmatismus" (Concerning the Treatment of Irregular Corneal Astigmatism by Lenses)</i>
1897	<i>Fick's open letter concerning Lohnstein's publication: "Hydrodiaskop und Contactglas (Offene Correspondenz)" (Hydrodiascope and Contact-glass - Open letter)</i>
1897	<i>Lohnstein's reply to Fick's open letter: "Erwiderung auf die vorstehende Bemerkung des Herrn Dr E.A.Fick in Zürich zu meinem Hydrodiaskop" (Reply to the Previous Comment by Dr. E.A. Fick of Zurich on my Hydrodiascope)</i>

Table 13 - 5

Chronology of the controversies on contact lenses between Fick and Lohnstein (1896 to 1897).

Lohnstein’s Hydrodiascope’s Alternative (1896)

In his description of the hydrodiascope in 1896, **“Zur Gläserbehandlung des unregelmässigen Hornhautastigmatismus”** (*Concerning the Treatment of Irregular Corneal Astigmatims by Lenses*), Lohnstein had made a comparison between his invention and Fick’s “Contactbrille”. (55)

Both systems depended on the same basic principle, i.e., that of corneal dioptric neutralization, but, according to Lohnstein, Fick’s “Contactbrille” (which he would not admit to having used from fear of injuring the summit of the corneal cone in keratoconus) had three major disadvantages: difficulty of insertion, risk of irritation of the ocular globe, and poor tolerance limiting its wearing time .

“Optically, Fick’s ‘Contactbrille’ is based on the same principle as the hydrodiascope, but it has the disadvantage that it can be inserted only with the help of a second person and it is possible that it, as a foreign body placed between the eyelids and the ocular globe, produces ocular irritation. I confess that I myself have never tried the contact glass, as that entity seemed too risky to me: this is especially true with keratoconus, where the cornea is already curved outwards, making it particularly unpleasant to wear a foreign body in front of the globe.”

“Optisch beruht Fick’s Contactbrille auf demselben Princip wie das Hydrodiaskop, hat aber den Nachtheil, dass sie nur mit Hilfe eines Zweiten angelegt werden kann und dass sie möglicherweise als ein Fremdkörper zwischen Lid und Bulbus einen Reiz auf den letzteren ausübt. Ich gestehe, dass ich selbst nie einen Versuch mit dem Contactglas gemacht habe, da mir die Sache zu riskant erschien; übrigens scheint es mir gerade bei Keratokonus, wo die Cornea an sich schon stärker vorgewölbt ist, besonders unangenehm einen Fremdkörper vor dem Bulbus zu tragen.” (56)

To this statement, he added that Fick had tried his lens only in a single case of keratoconus and that he had obtained, in that case, a dubious result:

“Fick himself tried out his glass on one keratoconus patient, whose visual acuity only showed minimal improvement from 6/60 to 6/36. This is a surprising result, from a

geometrical and optical point of view, because of the minimal improvement. If you exclude compromised retinal acuity, this minimal improvement could perhaps also be explained by ocular inflammation resulting from insertion of the glass. I do not know if the contact glass has been used by one patient for a lengthier period of time until now.”

“Fick selbst hat sein Glas nur an einem Keratokonus-Patientes versucht, dessen Sehschärfe von 6/60 sich nur auf 6/36 hob, Resultat, das vom rein geometrisch-optischen Standpunkte wegen seiner Geringfügigkeit überrascht und vielleicht - wenn man nicht herabgesetzte retinale Sehschärfe annehmen will - mit dem durch das Einlegen des Glases hervorgerufenen Reizzustand des Auges zu erklären ist. Ob das Contactglas bisher längere Zeit von einem Patienten benutzt worden ist, ist mir nicht bekannt.” (56)

Lohnstein also described the ease of placing the hydrodiascope as compared with contact lenses and how much better it was tolerated by the patient, as this device could be worn for up to eight hours a day without the appearance of epithelial inflammation. The hydrodiascope could also be useful for diagnosis on a daily basis.

Fick’s Reply (1896)

Fick replied to Lohnstein’s comments under the title **“Hydrodiaskop und Contactglas. (Offene Correspondenz)”** (Hydrodiascope and Contact Glass. - Open Letter) by dealing

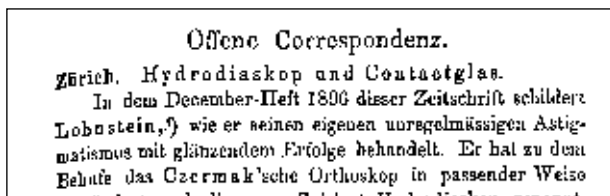


Figure 13-13

Fick's reply to Lohnstein as open letter to the *Klinische Monatsblätter für Augenheilkunde*.

Fick's reply to Lohnstein's comment: "Hydrodiaskop und Contactglas. (Offene Correspondenz)" (Hydrodiascope and Contact-glass - Open Letter),

(FICK Adolf Eugen, "Hydrodiaskop und Contactglas", *Klinische Monatsblätter für Augenheilkunde*, 35, 1897, 129-132. - Excerpt page 129).

with his arguments on a point-by-point basis. First, it was an error to maintain that contact lenses did not correct keratoconus. While it was true that the results obtained with blown contact shells were inadequate, he had, by contrast, obtained excellent results with ground contact shells, as Dor and Sulzer had also reported:

“Lohnstein indicates on page 417 that I tried out the contact glass only in a

single keratoconus patient, that I only improved the visual acuity from 6/60 to 6/36, and that this surprising result was perhaps explainable by inflammation produced by the glass. Lohnstein is incorrect with this supposition. Apparently, he is not aware that, in the year 1892, I gave a paper with the title “Einige Bemerkungen über die Contactbrille” (Some Remarks on the Contactbrille) and explained there that my first experiments were with small blown contact glasses. When I obtained small ground contact glasses, I also achieved better visual acuity. Dor and Sulzer, respectively, have communicated equally good but actually even better results; Sulzer, for example, improved the visual acuity of an eye from counting fingers at 3 meters to 5/6. I can therefore suppose that Lohnstein, too, with a suitable contact glass, would achieve the same visual acuity as with the hydrodiascope.”

“Lohnstein sagt auf S. 417, dass ich das Contactglas nur bei einem Keratokonuskranken versucht und die Sehschärfe von 6/60 nur auf 6/36 gebracht hätte, was überraschend und vielleicht durch die Reizwirkung des Glases zu erklären sei. Mit dieser Vermuthung hat Lohnstein nicht das Richtige getroffen. Offenbar ist ihm entgangen, dass ich im Jahre 1892 “Einige Bemerkungen über die Contactbrille” veröffentlicht und dabei erwähnt habe, dass meine ersten Versuche mit geblasenen Contactgläschen angestellt worden sind. Als ich geschliffene Contactgläschen erhielt, wurden auch bessere Sehschärfen erzielt. Ebenso gute, bzw. noch bessere Ergebnisse haben Dor und Sulzer mitgeteilt; so hat z.B. Sulzer die Sehschärfe eines Auges vom Fingerzählen in 3 Meter au 5/6 gebracht. Es ist also anzunehmen, dass auch Lohnstein mit einem passenden Contactglase dieselbe Sehschärfe bekommen würde wie mit dem Hydrodiaskop.“ (57)

A New Insertion Technique for Contact Lenses

At this point, we learn that *Fick* had changed his method of insertion of contact lenses in contrast to that described in his first publication. Now, he was adopting a technique inspired by the method of inserting ocular prostheses that are introduced under the superior eyelid before working them downwards by a rocking motion:

“Lohnstein is correct to envisage a major advantage for the hydrodiascope, in that the patient can place it in position and remove it independently. That is not the situation with the contact glass, at least not the situation if one follows method of introduction that I proposed in my initial studies. Today, I insert the small glass differently. I take it between the index and the thumb of my right hand so that its concavity faces upwards. I then fill it with saline or aqueous sugar solution, respectively. I open the lids as wide as possible using the index finger and thumb of the left hand and at the same time evert it in mild ectropion. The patient lowers his head as I do this and looks down. Now, I bring the filled glass close up to the eye, until the water touches the cornea, and then I release the lids; the glass sits there. Of course, one has to spread out an unfolded towel so that the small glass does not fall on the ground should the hand grasp fail. It seems to me not to be impossible that a dexterous patient without excessively tight lids could learn how to insert the glass independently in this manner. As far as removing it is concerned, I do it the old way; naturally, the patient can still more easily learn how to do this himself.”

“Lohnstein sieht mit Recht einen grossen Vorzug des Hydrodiaskopes darin, dass der Kranke es selbst aufsetzen und abnehmen könne. Mit dem Contactglas ist das nicht der Fall, wenigstens nicht, wenn man die Einführung so vornimmt, wie ich in meiner ersten Arbeit vorgeschlagen habe. Jetzt führe ich aber das Gläschen anders ein. Ich nehme das Contactglas zwischen Zeigefinger und Daumen der rechten Hand so, dass die Höhlung des Glases nach oben sieht; dann fülle ich sie mit Wasser, bezw. mit der Salz- oder Zuckerlösung. Mit Zeigefinger und Daumen der linken Hand öffne ich die Lider so weit als möglich und ectropioniere sie gleichzeitig ein wenig; der Kranke senkt dabei den Kopf und blickt ausserdem nach abwärts. Nun nähere ich das gefüllte Gläschen dem Auge, bis das Wasser die Hornhaut berührt und lasse die Lider los; das Gläschen sitzt. Natürlich muss durch ein ausgebreitetes Handtuch dafür gesorgt sein, dass das Gläschen nicht zur Erde fällt, falls der Handgriff misslingen sollte. Es scheint mir gar nicht unmöglich, dass ein geschickter Kranker mit nicht zu straffen Lidern es lernen kann, das Gläschen in dieser Weise sich selber einzuführen. Das Herausnehmen des Gläschens mache ich in der alten Weise; dies könnte der Kranke natürlich noch leichter selber erlernen.” (58)

The Enigma of Epithelial Clouding

In order to explain the appearance of corneal clouding, *Fick* reported his observations on a female patient with keratoconus in whom the contact lens, after insertion in the morning, provoked corneal clouding in the afternoon. He attributed these episodes of clouding to corneal immersion. Such problems should also have appeared with the hydrodiascope, but if *Lohnstein* had not observed them, it is because he was only wearing his hydrodiascope for one or, rarely, for two hours at a stretch. With certain patients, a form of habituation occurred, allowing the wearing of a contact lens for up to six hours, as was also the situation with rabbits who had worn the contact lenses for up to eight hours:

“In September 1896, a female patient with bilateral keratoconus consulted me [...]. I inserted the glasses in the morning and requested that she come back in the afternoon as soon as the glass started to bother her. Each time the patient reappeared, she had a massively red eye and corneal epithelial clouding. Following my earlier experiences, I had to suppose that the wetting of the corneal epithelium was at the origin of the clouding. Furthermore, if Lohnstein was not aware of this rapidly transient clouding,

this is probably due to the fact that he used his hydrodiascope 'on average for an hour at a time, very often a full 1 ½ hours and frequently even two hours and more.' In my experiments on rabbits, the small glasses were left in for six to eight hours and, in humans, up to six hours. The patient described above failed to become accustomed to the contact glass. I therefore had to interrupt the experiments because the patient was really not interested due to the poor visual acuity in her left eye."

"Im September 1896 suchte eine Kranke mit Hornhautkegel beider Augen bei mir Hülfe [...]. Ich legte der Kranke das Glas des Morgens ein und forderte sie auf, sich Nachmittags wieder einzustellen, sobald das Glas anfangs Beschwerden zu machen. Jedesmal erschien die Kranke mit mässig geröthetem Auge und mit Epitheltrübung der Hornhaut. Nach meinen früheren Erfahrungen muss ich annehmen, dass die Benetzung des Hornhautepithels die Ursache der Trübung ist. Wenn Lohnstein von dieser, übrigens schnell vorübergehenden Trübung nichts bemerkt hat, so ist das vermutlich dem Umstande zuzuschreiben, dass er sein Hydrodiaskop « durchschnittlich eine Stunde hintereinander, sehr oft auch schon 1 ½ Stunden, und mehrere Male sogar zwei Studen und mehr hintereinander » benutzt hat. Bei meinen Versuchen am Kaninchen wurden die Gläschen sechs bis acht Stunden, beim Menschen bis zu sechs Stunden liegen gelassen. Bei der letzterwähnten Kranken trat eine Gewöhnung an das Contactglas nicht ein. Ich musste also die Versuche einstellen, an denen die Kranke ohnehin, wegen der leidlichen Sicht des linken Auges, kein rechtes Interesse hatte." (59)

Lohnstein recommended the use of his hydrodiascope for diagnostic purposes. Fick indicated that he was currently using his contact lenses for this and that they were probably better suited for this use than the hydrodiascope, because a single contact lens could be applied to all eyes, while the hydrodiascope had to be fitted to the profile of the face:

"Lohnstein recommends to ophthalmologists that they use the hydrodiascope for diagnostic purposes. In this regard, I have to comment that the contact glass is already being used for this purpose and that it is probably superior to the hydrodiascope. One and the same contact glass can be used in each patient, whereas with various facial configurations, quite a number of different hydrodiascopes would, after all, have to be available to have the best one available for a given patient."

"Lohnstein schlägt den Augenärzten vor, das Hydrodiaskop diagnostisch zu verwerthen. Dazu möchte ich bemerken, dass das Contactglas zu diesem Zwecke bereits benützt wird und in dieser Beziehung vielleicht dem Hydrodiaskop überlegen ist. Ein und dasselbe Contactglas lässt sich nämlich bei jedem Kranken anwenden, während bei dem verschiedenen Bau der Gesichter doch wohl ziemlich viele Hydrodiaskope zur Verfügung sein müssen, wenn man ein für den ersten besten Kranken passendes zur Hand haben will." (59)

None has actually worn Contact Lenses

Finally, Fick admitted that, to his knowledge, no patient had actually succeeded in wearing contact lenses. The experiments had to be continued because it did not seem impossible to him that a remedy for the epithelial clouding and ocular irritation would be found. One could, for example, coat the cornea with a protective fatty coating that would have, certainly, a refractive index different from that of the cornea but would not affect the propagation of light rays because of its infinitesimal thinness:

"Because Lohnstein seems to consider the matter decided that his hydrodiascope can be worn outside the house, it would seem to me perhaps worthwhile, after all, to continue the experiments with the contact glass, as it too, as far as I know, has never really been worn by any patient. Besides, it does not seem to me to be altogether impossible that some remedy will be found to reduce the epithelial clouding and most of the irritation."

Thus, one could even consider coating the cornea with a fatty layer. Although this would have a different refractive index from that of the cornea, it would not influence the passage of light rays because of its infinitesimal thinness.”

“Da Lohnstein es für ausgeschlossen zu halten scheint, dass sein Hydrodiaskop auch im Freien getragen werden kann, so ist es vielleicht doch der Mühe wert, die Versuche mit dem Contactglas fortzusetzen, wenn es auch bis jetzt, so viel mir bekannt, von keinem Kranken wirklich getragen wird. Denn es scheint mir durchaus nicht undenkbar, dass sich etwas finden liesse, was die Epitheltrübung und damit wohl auch das Wesentliche der Reizerscheinungen verhindere. So könnte man wohl an Ueberziehen der Hornhaut mit einer Fettschicht denken, die zwar einen anderen Brechungsexponenten hätte, wie die Hornhaut, aber gleichwohl, wegen ihrer unendlichen Dünne, den Gang der Lichtstrahlen nicht beeinflussen würde.”
(59)

This conclusion summarizes well the deadlock into which the application of contact lenses to the correction of keratoconus had fallen, as well as the pessimism of their inventor, barely ten years after their first utilization. I must also record that *Fick* had not obtained the support of the German manufacturing opticians and that, because of his pro-German nationalistic feelings, he was not willing to approach suppliers in France, although he recognized their knowledge and experience. (60)

Lohnstein’s Reply and the Choice of the best Liquid (1897)

The publisher of *Klinische Monatsblätter für Augenheilkunde* had submitted *Fick’s* comment to *Lohnstein*. His reply was then published following *Fick’s* letter, under the title **“Erwiderung auf die vorstehende Bemerkung des Herrn Dr. E.A. Fick in Zurich zu meinem Hydrodiaskop”** (*Reply to the Previous Comment Dr. E.A. Fick in Zurich on my Hydrodiascope*). This reply did not refer specifically to contact lenses but included an interesting comment on the observation of the visual blur resulting from corneal clouding, which *Fick* attributed to the prolonged submersion of the corneal epithelium in solution and *Lohnstein* to the incorrect concentration of the solution used for filling the space between contact lens and cornea:

“Mr. Dr. Fick seems to accept that clouding must necessarily occur after prolonged wetting of the cornea. According to my own experience with the hydrodiascope extending over almost nine months, I have to disagree with him. I now use the glass successively for two hours at a time on average; between these periods of use, there are often pauses of only ¼ to ½ an hour interspersed. As the result of cumulative exposure, if Fick’s assumption were correct, it might be that a harmful effect on the corneal epithelium could be produced in the course of using the glass for a total of eight hours per day. I place the main emphasis on the correct concentration of the solution used, i.e., 0.85 to 0.90% saline solution, which, according to the newest studies (by Hamburger, Koeppe and others), should be correctly designated ‘physiological’ saline solution because it is ‘isotonic’ with blood plasma.

When, mistakenly, on one occasion and on another for experimental reasons I used a saline solution of only 0.45%, I found no burning whatsoever but rather the feeling of a peculiar but unlocalized tension in the eye. When I removed the hydrodiascope after an hour, there was an unusual veil in front of the concerned eye. I was very readily able to distinguish this veil from the indistinctness of the outside world caused by my customary visual blur due to image dispersion. In any event, the phenomenon diminished within ten minutes. A flame that I was observing at the time showed poorly marked colored rings. This was therefore a true corneal clouding that could not, however, be detected by one of my brothers (a medical student) and was to all intents and purposes minimal. I drew

two conclusions from the experiment described above: 1.) I am in a position to recognize very mild diffuse corneal clouding through self-observation, 2.) this cloudiness resulted from water-intake by the corneal epithelium through osmosis that could, however, be readily avoided by the correct concentration of appropriate solution.”

“Herr Dr. Fick scheint anzunehmen, dass nach längerer Benetzung der Hornhaut nothwendig eine Trübung eintreten müsse. Nach meinen nunmehr über fast 9 Monate sich erstreckende Erfahrung mit dem Hydrodiaskop muss ich dem widersprechen. Ich benutze das Glas jetzt durchschnittlich schon zwei Stunden hintereinander; zwischen den einzelnen Malen sind oft nur Pausen von $\frac{1}{4}$ bis $\frac{1}{2}$ Stunde interponirt. Durch cumulative Wirkung hätte, wenn Fick's Annahme richtig wäre, bei im ganzen oft achtstündiger Benützung des Glases pro die, auf einem Auge doch wohl schon eine schädliche Beeinflussung der Hornhautepithels eintreten müssen. Ich lege den Hauptnachdruck auf die richtige Concentration der benutzten Lösung, also bei Kochsoltz 0,85 bis 0,90%, welche nach neueren Untersuchungen (von Hamburger, Koeppe u.A.) als eigentliche „physiologische“ Kochsoltzlösung bezeichnet werden muss, da sie dem Blutplasma „isotonisch“ ist.

Als ich einmal aus Versehen und ein anderes Mal experimenti causa, eine NaCl-Lösung von nur 0,45% benutzte, empfand ich zwar noch kein Brennen, aber das Gefühl einer eigenthümlichen nicht näher zu localisierenden Spannung vor dem Bulbus; als ich das Hydrodiaskop nach einer Stunde absetzte, hatte ich einen eigenthümlichen Schleier vor dem betreffenden Auge, den ich sehr wohl von der durch meine Zerstreuungsbildern bewirkten Undeutlichkeit der Aussenwelt zu unterscheiden vermochte, ein Phaenomen, das übrigens in etwa 10 Minuten abklang. Eine Flamme, die ich während der Zeit betrachtete, zeigte schwach angedeutete farbige Ringe.

Das war also eine wirkliche Trübung der Hornhaut, die übrigens objectiv von einem meiner Brüder, einem Mediziner, nicht festgestellt werden konnte, jedenfalls also minimal war. Ich schliesse aus dem beschriebenen Experiment zweierlei: 1) dass ich schon eine sehr geringe diffuse Trübung der Hornhaut durch Selbstbeobachtung zu entdecken im Stande wäre; 2) dass eine solche Trübung durch osmotische Wasseraufnahme seitens der Hornhautepithelien zu Stande kommt, demnach durch richtige Wahl der Concentration der betreffenden Lösung mit Leichtigkeit vermieden werden kann.” (61)

1.4 – Limited Interest in Contact Lenses (1892 – 1909)

Year	Publication
1892	De Haas - Snellen : "Contact-brillen" (Contact Spectacles) - Netherlands Society of Ophthalmology
1892	Fick: "Ueber das Photographieren des Augenhintergrundes" (Concerning Fundus Photography) -
1894	Michel: "Beitrag zur Frage der Akkommodation" (Contribution to the Accommodation)
1894	Bjerrum: "On Kontaktglas" (Concerning the Contact-glass)
1894	Fick: "Lehrbuch der Augenheilkunde" (Textbook of Ophthalmology)
1894	Panas: "Traité des Maladies des Yeux" (Treatise on Eye Diseases)
1894	Elschnig: "Ueber den Keratoconus" (Concerning Keratoconus)
1895	Spéville : "Un Fait Curieux observé avec le Verre de Sulzer" (An Unusual Observation with Sulzer's Glass)
1895	Parent: "Valeur Comparative des Divers Procédés Objectifs d'Optométrie" (Comparison of the Value of Different Objective Optometric Procedures) - Annual Report to the French Society of Ophthalmology
1901	Takahashi: "Three Cases of Keratoconus" (in Japanese)
1909	Antonelli: "Quelques Remarques sur le Traitement Optique du Kératocône" (Several Remarks on the Treatment of Keratoconus)

Table 13 - 6

Synopsis of the communications and publications related to the use of contact lenses between 1892 and 1909 (except Sulzer and Dor)

Contact lenses were recognized and made entry into the therapeutic and diagnostic arsenal, even if their practical use remained limited. Some rare pieces of evidence of

their utilization during this period are available to us. Contact lenses were regularly cited in treatises of ophthalmology, specialty review articles and congress reports.

1.4.1 - De Haas, Snellen (1892)

(Appendix 13-3)

Dating from 1892, there is evidence relating to the utilization of contact lenses in the Netherlands. A summary of a session of the Congress of the *Netherlands Ophthalmological Society* held in Amsterdam on December 18, 1892, indicates, in effect, that *De Haas*, an ophthalmologist in Rotterdam, expressed his disappointment following trials of *Sulzer's* contact lenses in a patient with cicatricial astigmatism, wherein the correction by cylindrical spectacle glasses had given better visual results. *Snellen* replied to him that patients with irregular astigmatism provided a better clinical indication for contact glasses than those with regular astigmatism:

“Mr. De Haas did not find the satisfaction he was hoping for in the use of contact glasses. In a patient with astigmatism following ocular trauma, visual acuity could be improved up to 1/3 with cylindrical spectacle glasses, whereas, with contact glasses, visual acuity reached only 1/4. Moreover, after having worn contact glasses for more than ten hours, patients had considerable pain and the corneal epithelium became opaque.

Mr. Snellen replied that it was not Dr. Sulzer's intention to compete with spherical or cylindrical spectacle glasses, but that he recommended contact glasses for patients with irregular astigmatism that one could not correct with conventional glasses.”

“M. De Haas n'a pas trouvé dans l'emploi des verres de contact la satisfaction qu'il en espérait. Dans un cas d'astigmatisme survenu à la suite d'un traumatisme, l'acuité visuelle pouvait être améliorée jusqu'à 1/3 avec des verres cylindriques, tandis qu'avec des verres de contact l'acuité visuelle n'atteignait que 1/4. De plus, après avoir supporté les verres pendant dix heures, les patients ressentaient de grandes douleurs et l'épithélium de la cornée devenait opaque.

M. Snellen répond à cela qu'il n'entrait pas dans l'intention du Dr Sulzer de faire concurrence aux verres sphériques ou cylindriques, mais qu'il recommandait les verres de contact pour les cas d'astigmatisme irrégulier, qu'on ne peut corriger avec des verres ordinaires.” (62)

1.4.2 - Fick's Procedure for Fundus Photography (1892)

In 1892, during the same year, *Fick* presented to the Annual Congress of the *Heidelberg Ophthalmological Society* a procedure for photographing the fundus through a “Contactbrille” comprised of a cylinder filled with liquid and covered with a slip of plate glass. This experiment was carried out only on rabbits and was not performed on humans. (63)

1.4.3 - Michel's Cylindrical Accommodation (1894)

In 1894, *Michel*, ophthalmologist at the *University Eye Clinic in Berne*, Switzerland, was publishing the results of his research on cylindrical accommodation. The literature of the time mentioned several experiments that involved research into physiological optics in order to determine whether accommodation by the crystalline lens was always spherical and whether cylindrical accommodation existed that could correct corneal astigmatism. In order to neutralize corneal refractive power, *Woinow* made use of a *Czermak* orthoscope. *Michel* repeated the experiments, but using a contact lens. This was, in

Michel's opinion, a procedure that was “not only more modern, but also pleasanter and easier”. As we have seen, he used the designation, “*Sulzer's* contact-glass”, thus provoking a protest by *Fick*. (64)

1.4.4 - Bjerrum's Publication (1894)

A first publication from Denmark, by *J. Bjerrum*, “***Om Kontaktglas***” (*Concerning the Contact-glass*), included a very accurate summary of the publications of *Fick*, *Sulzer*, *August Müller*, *Dor* and *de Haas* with citations, sometimes in the original language, of the most significant passages. The author did not include any personal experiments.

1.4.5 – The Treatises of Panas and Fick (1894)

Published treatises on ophthalmology did not fail to cite contact lenses. In 1894, the textbooks of both *Panas* and *Fick* appeared. Each author had been involved in the first experiments on contact glasses.

Panas' Treatise

The “***Traité des maladies des yeux***” (*Treatise on Eye Diseases*) by *Panas* (1894), after detailing the surgical and optical treatments of keratoconus (and these were generally rather unsatisfactory), devoted a page to contact lenses. In his text, he indicates that *Herschel's* proposal to apply “transparent cupules” was achieved in practical terms by *Fick* and *Kalt*. “Generally speaking, patients succeed in keeping the cupula in for a few hours”, and this is because of the irritation against the eyelids and the accumulation of cloudy fluid. For a time of short duration, the patients are able to see and, in addition, the “cupule” exercises an immediately beneficial and evenly distributed compression of the cornea. “Unfortunately, this desirable result has always been thwarted by the intolerance of the eye”. *Sulzer* has perfected “*Fick's* cupule”, which he called “approach glasses” (*verres d'approche*), and considers that these can be used like diaphragm lenses. It remains to be seen whether they would be better tolerated than others:

“John Herschel, with the aim of regularizing the abnormal curvature of the cornea, proposed to apply a transparent cupule to it directly. [...] Mackenzie, who quotes this passage in its entirety, adds that although such an application could be without danger for a few instants, the eye would not be able to tolerate it long enough to derive a true benefit from it.

In these last years, the ingenious method of the great English physicist has been adopted once again by Fick and Kalt. I am the more able to be the judge of that because the experiments have been carried out by the latter in my clinic.

Generally speaking, patients are able to keep the cupule in for several hours. Undoubtedly, tolerance is greater when the prosthetic device has a diameter not greater than the corneal diameter, but, in this case, it tends to fall out constantly in the course of knocking against the free border of the lower eyelid. Furthermore, behind the cupule, there accumulates a certain quantity of cloudy liquid, formed from tears and epithelial detritus, that does not cease to cloud the transparency of the shell.

For whatever reason, patients who were previously amblyopic succeeded, at least for a short time, to make out normal print from a short distance. They were also able to see distinctly from a distance by this method, provided that one corrected their myopia by concave spherical lenses.

By supposing that, with cocaine, similar cupules could be tolerated, a further benefit

would result, namely, immediate and even compression of the cornea. Unfortunately, this desirable outcome has been consistently thwarted because of ocular intolerance. Sulzer has taken up the challenge of perfecting the 'approach glasses' of Fick, to the effect that they are made from ground glass instead of from blown glass. He thinks that one could coat the inner surface of such a glass with a partial sphere of opaque enamel having the same color as the iris, taking care to arrange for an opening opposite those corneal areas that are the least defective. It remains to be seen whether these new cupules will be better tolerated than the others."

"John Herschel, en vue de régulariser la courbure anormale de la cornée, proposa d'y appliquer directement une cupule transparente. [...] Mackenzie, qui cite en entier ce passage, ajoute que bien qu'une telle application puisse être sans danger pendant quelques instants, l'œil ne saurait la supporter assez longtemps pour en retirer un réel bénéfice.

Dans ces dernières années, l'ingénieuse méthode du grand physicien anglais a été reprise par Fick et Kalt. Nous sommes d'autant plus à même de la juger que les essais ont été faits par ce dernier dans notre clinique.

En général, les malades arrivent à garder la cupule pendant quelques heures. Sans doute, la tolérance est plus grande lorsque la pièce prothétique ne dépasse pas le diamètre de la cornée, mais, dans ce cas, elle tend sans cesse à tomber, en venant buter contre le bord libre de la paupière inférieure. De plus, derrière la cupule il s'accumule une certaine quantité d'un liquide louche, formé de larmes et de détritux épithéliaux qui ne tarde pas à troubler la transparence de la coque.

Quoiqu'il en soit, au moyen de cette méthode, les malades, précédemment amblyopes, parviennent, du moins pour un temps de courte durée, à déchiffrer à la distance ordinaire l'impression courante et à distinguer nettement au loin, pourvu qu'on corrige leur myopie par des verres sphériques concaves.

En supposant que grâce à la cocaïne, de pareilles cupules puissent être supportées, il s'ensuivrait un autre avantage, celui de la compression immédiate et régulière de la cornée. Malheureusement, ce résultat désirable a toujours été contrarié par l'intolérance de l'œil.

Sulzer s'est attaqué à perfectionner les cupules ou verres d'approche de Fick, en ce sens qu'elles sont taillées au lieu d'être soufflées. Il pense qu'on pourrait les recouvrir à l'intérieur d'une calotte d'émail opaque de la couleur de l'iris, en ayant soin d'y ménager une ouverture vis-à-vis des parties cornéennes les moins défectueuses. Il reste à savoir si ces nouvelles cupules seraient mieux tolérées que les autres."

(65)

Fick's Textbook

The "*Lehrbuch der Augenheilkunde*" (Textbook of Ophthalmology) by Fick (1894) is notable for its restraint in contrast with the optimism revealed by Panas. Fick seemed to be distancing himself from contact lenses in that he "had never found a suitable case".

"I have proposed to treat keratoconus with my 'Kontaktbrille,' i.e., with a small ground glass that has the shape of a normally proportioned anterior ocular segment and is positioned on the affected eye. The space between the glass and the cornea is filled with a sterile solution of the same refractive power as the cornea. In this way, the influence of the cone-shaped cornea on the passage of the rays of light is eliminated. The improvement of visual acuity in appropriate cases of irregular astigmatism is quite astonishing. Unfortunately, I have not yet found any case suitable for the wearing of the Kontaktbrille."

"Ich habe vorgeschlagen, den Hornhautkegel mit « Kontaktbrille » zu behandeln, d.h. mit einem geschliffenen Gläschen, das die Form eines normal gebauten vorderen Augenabschnittes hat und auf das kranke Auge gelegt wird. Der Zwischenraum zwischen Glas und Hornhaut wird mit einer keimfreien Flüssigkeit vom Brechungsvermögen der Hornhaut gefüllt. Damit fällt jeder Einfluss der kegelförmigen Hornhaut auf dem Gang der Lichtstrahlen weg. Die Verbesserung der Sehschärfe in geeigneten Fällen von unregelmäßigem Hornhautastigmatismus ist geradezu überraschend. Leider habe ich noch keinen geeigneten Fall für die Benutzung der Kontaktbrille gefunden." (66)

1.4.6 - Elschmig's Qualified Opinion (1894)

It is very important to mention the contribution that the ophthalmologist *Elschnig* of Graz made in 1894, entitled "*Ueber den Keratoconus*" (*Concerning Keratoconus*), in which *Elschnig* makes a synthesis of pathogenic theories, methods of investigation, and different types of treatment of keratoconus during this era. He cites the available methods of treatment that had been tried out but were already in the process of being abandoned: iridectomy, paracentesis, general hormonal treatment, topical miotics, pressure dressings and contact lenses. The latter would be extremely difficult to manufacture and their elevated price a deterrent to their clinical use. Their application would be difficult and should be accompanied by precautions because of the mechanical irritation that they provoke. For *Elschnig*, early cauterization of the cone summit would seem to be the method best adapted to reduce the evolution of keratoconus. As far as the pressure bandage is concerned, *Elschnig* makes the following cautious assessment:

"According to Panas, what the pressure bandage should accomplish on a grand scale, the contact glass should achieve in miniature. Panas is proposing to reshape the corneal cone by means of placing a contact lens on it. The danger that such an initiative brings with it is evident. It could happen, even if very seldom, that the apex of the corneal cone becomes spontaneously ulcerated as a consequence of external damage. One would therefore have to be wary, and rightly so, of carrying out a procedure that is neither guaranteed to succeed but, when all is said and done, has considerable risk of producing uncontrollable inflammation on the most prominent part of the cone."

"Was der Druckverband im Grossen, sollte nach Panas das Contactglas im Kleinen bewirken; Panas schlägt vor, durch das Auflegen eines Contactglases den Hornhautkegel zu redressieren. Die Gefahr, welche ein solches Unternehmen mit sich bringt, ist evident ; wenn es, wenn auch sehr selten, sich ereignet, dass die Spitze des Hornhautkegels spontant exulcerirt, in Folge äusserer Insulte, so muss man mit Recht sich scheuen, ein Verfahren einzuschlagen, welches nicht nur keine sichere Erfolge verspricht, sondern bei aller Vorsicht doch einen nicht controlierbaren Reiz auf die prominenteste Partie des Hornhautkegels ausübt." (67)

Procedures leading to optical correction of keratoconus were only of theoretical interest to *Elschnig*:

"Panas's proposal gives us the opportunity to discuss experiments to remove disturbances of ocular function by correction of the optical error that keratoconus causes; one can summarize this briefly, as the endeavors remain, for now at least, of purely theoretical interest. However, close practical realization of this comes to the ideal management of keratoconus after it has become stationary. This applies as much to the use of hyperbolic glasses as to that of Fick's 'Contactbrille' [...]. The latter are so enormously difficult to manufacture that their elevated purchase price detracts from their practical use. They are, in addition, not only very difficult to insert into a patient's eye, but must also be used with caution because of the mechanical irritation that they entail."

"Panas' Vorschlag vermittelt uns den Uebergang zur Besprechung der Versuche, durch Correction des durch das Bestehen des Keratoconus bedingten optischen Fehlers die Störungen der Funktion des Auges zu beheben ; wir können uns hier um so kürzer fassen, als bis heute wenigstens die dahinzielenden Bestrebungen von rein theoretischem Interesse sind, so sehr auch die praktische Realisation derselben das Ideal der Behandlung des stationär gewordenen Keratoconus nahe rücken würde. Es gilt dies sowohl von der Anwendung hyperbolischen Gläser, als auch der Fick'schen Contactbrillen ; [...] letztere sind so

enorm schwer herzustellen, dass ihr hoher Preis schon der praktischen Anwendung entgegensteht, und sind überdies nicht nur sehr schwierig zu appliciren, sondern werden auch wegen des mechanischen Reizes, den sie bedingen, nur mit Vorsicht anzuwenden sein.” (68)

1.4.7 - Parent's Report (1895)

In 1895, the French Society of Ophthalmology charged *Parent*, an ophthalmologist established in Paris, with the annual report on the **“Valeurs Comparatives des divers Procédés Objectifs d’Optométrie”** (*Comparative Values of the Different Objective Optometric Procedures*). This report highlighted keratometric procedures of the time and described the difficulties encountered in the measurement and refractive correction of patients with keratoconus. In those patients in whom the corneas were very significantly abnormal, recourse to contact lenses as proposed by *Fick* and much improved by *Sulzer* was deemed necessary. These devices increased visual acuity and represented the sole means of fundus examination. Two diagrams taken from *Sulzer's* publication illustrate the text, but legends giving their source are missing:

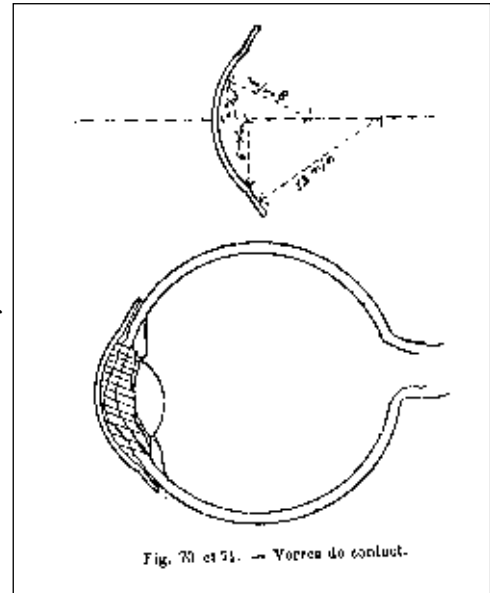


Figure 13-14
Presentation of Sulzer's contact lenses by Parent
In his 1895 "Annual Report" to the Congress of the
French Society of Ophthalmology, entitled "Valeur
Comparative des divers Procédés Objectifs
d'Optométrie" (Comparative Value of the Different
Objective Optometric Procedures), Parent presents
Sulzer's lenses

(PARENT H., "Valeur comparative des divers procédés objectifs
d'optométrie", Rapport annuel, Bulletins et Mémoires de la Société
Française d'Ophthalmologie, 13, 1895, 1-134 - Figure 70 and 71
page 114).

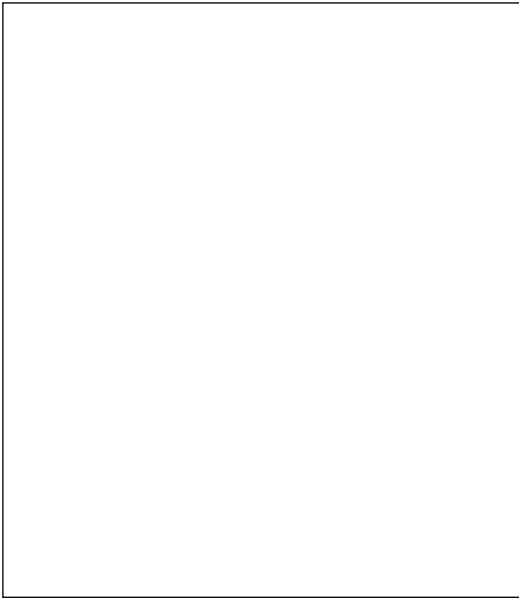
“Finally, when the cornea is much altered in shape, [...] you must have recourse to contact glasses. These were introduced in 1888 by E. Fick and were later very much improved by our colleague Sulzer; who was the first to surface them. Fick's contact glasses were blown and full of irregularities. These contact glasses have already produced a major benefit for many patients by providing considerable improvement in their visual acuity. In all situations where the cornea is very distorted, contact glasses constitute the sole means of obtaining satisfactory ophthalmoscopic visualization of the fundus.”

“Enfin, quand la cornée est très altérée dans sa forme, [...] il faut recourir aux verres de contact. Proposés par E. Fick, en 1888, ils furent ensuite très améliorés par notre collègue Sulzer qui, le premier, les a fait surfacer; ceux de Fick étaient soufflés et pleins d'irrégularités. Ces verres de contact ont déjà procuré un réel bénéfice à beaucoup de sujets en relevant considérablement leur acuité visuelle. Dans tous les cas où la cornée est très déformée, les verres de contact constituent le seul moyen d'avoir une image ophthalmoscopique assez nette du fond de l'œil.” (69)

1.4.8 - Spéville's Evidence (1895)

1895 was also the date of *Spéville's* communication to the *Paris Society of Ophthalmology*. This ophthalmologist in Paris described the success that he had observed with *Sulzer's* 'improved' contact lenses made by *Benoit-Berthiot*. (70)

1.4.9 - Takahashi's Communication (1901)



1901 is the date of the first Japanese communication to describe contact lenses. In a communication on three cases of keratoconus in brothers, *Koshun Takahashi*, ophthalmologist at Osaka, describes optical correction of keratoconus using “*Fick's contact-lenses*”. (71)

By the same token, we do not have any proof that *Takahashi* fitted the contact lenses, although he was familiar with glass prostheses, which he had developed after 1885 and of which he had even provided some models with transparent “corneal windows” for the management of corneal scars. This work was published in 1896. (72) *Takahashi* also expresses some reservations about the use of *Fick's* lenses:

“These are expensive items and the mechanical irritation prevents extended utilization.”

Figure 13-15
First page of Takahashi's communication. In this presentation, Takahashi describes, with reservations, the use of Fick's contact lenses in keratoconus. This document constitutes the first Japanese mention of any form of contact lenses. It is read from above down and from right to left.

(TAKAHASHI Koshun "Keratoconus in three Brothers" (in Japanese), *Nippon Ganka Gakkai Zasshi - Acta Societatis Ophthalmologicae Japonicae*, 5, 1901, 472- 481. - Excerpt page 472) (Document Prof. S. Mishima).

1.4.10 - Antonelli's Observation (1909)

The annual report of 1909 to the *French Society of Ophthalmology* was by *Parisotti* (Rome), and keratoconus was the chosen topic. This provided the opportunity for *Antonelli* (Naples) to give a communication with the title “*Quelques Remarques sur le Traitement optique du Kératocône*” (*Some Remarks on the Optical Treatment of Keratoconus*). *Antonelli* gave a detailed history of a female patient for whom he had provided ground contact lenses manufactured in 1906 by the opticians *Benoist et Berthiot*. She wore the lenses satisfactorily for the opera and for carriage drives in the afternoons, achieving an almost normal visual acuity:

“But she particularly used to enjoy attending the opera and therefore, in order to make her happy, I had Benoist et Berthiot make contact glasses for her. Once, while she was in her box at the opera, being a very intelligent person and also very dexterous, she slipped the small shells under her eyelids without even requiring

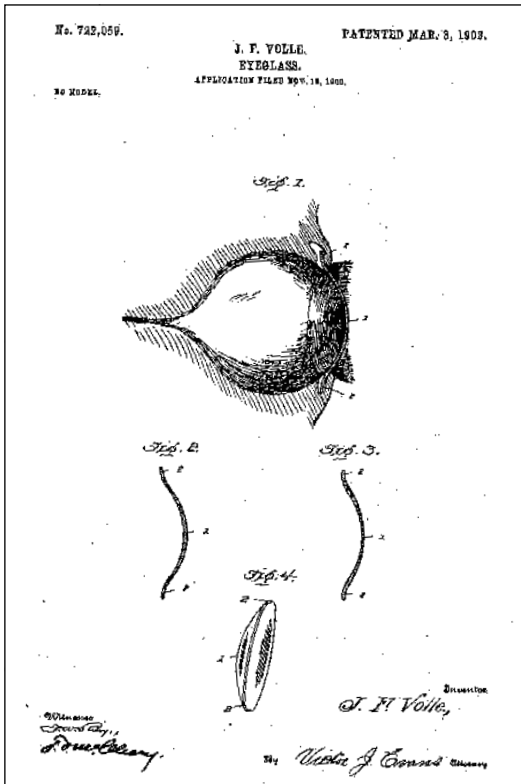


Figure 13-16
Volle's Frameless Eyeglasses. Johann F. Volle of Scranton (Mississippi) deposits on November 12, 1900 a patent under the title "Eyeglasses". The patent was assigned on March 3, 1903 (US Patent # 722,059).

to cocainize her eyes, after filling the shells with several drops of physiological saline. She tolerated these wonderfully well throughout the whole operatic performance and also inserted her lenses quite often for an afternoon drive by carriage. The left eye had pronounced ectasia and attained, with a contact glass, a visual acuity of 0.8, while the right eye, also with its contact glass, achieved 1.25 on the Snellen chart.”

“Mais, elle tenait beaucoup à jouir du spectacle à l’Opéra et, pour la contenter, je lui fis construire par Benoist et Berthiot des verres de contact. Une fois dans sa loge, étant très intelligente et très adroite, elle glissait, sans besoin même de cocaïner les yeux, les petites coques sous les paupières, après les avoir remplies de quelques gouttes de sérum physiologique. Elle les supportait à merveille, pendant toute la durée du spectacle, et elle les appliquait assez souvent également pour sortir l’après-midi se promener en voiture.

L’œil gauche, avec une ectasie prononcée, atteignait avec le verre de contact $V = 0,8$, tandis que l’œil droit atteignait, également avec le verre de contact, $V = 1,25$ Snellen.” (73)

From this, *Antonelli* concluded that, as the hydrodiascope had not been widely accepted, contact lenses represented an interesting alternative, although a temporary one and not for everyone:

“I have shown, in the course of the observation I just reported a moment ago, how useful contact glasses can be, in that they are perfectly well tolerated and give absolutely normal vision back to the patient. I could not say as much for Lohnstein’s hydrodiascope [...]. Only contact glasses can be claimed to have a truly practical application; such an application will, of course, be only a temporary and exceptional one.”

“J’ai montré, au cours de l’observation rapportée tout à l’heure, combien les verres de contact peuvent être utiles, étant parfaitement supportés et redonnant une vision absolument normale. Je ne saurai en dire autant de l’hydrodiascope de Lohnstein [...]. Seuls les verres de contact peuvent prétendre à une application vraiment pratique; elle ne sera, bien entendu, que temporaire et exceptionnelle.” (74)

1.4.11 – Volle’s Frameless Eyeglasses (1900-1903)

(Appendix 13-4)

It is also interesting to point out the U.S. patent, deposited on November 12, 1900, by *Johann F Volle* of Scranton (Mississippi), under the title “**Eyeglass**”. The patent was assigned on March 3, 1903, under # 722.059.

Volle asserts his claim as follows:

“My invention relates to frameless eye lenses or glasses, the object being to provide an eye lens or glass which will require no frame or attaching means, but will be supported in position upon the eyeball by the contact therewith of the eyelids.”

He also makes the following claim:

“An eyeglass comprising a lens constructed in a concavo-convex shape so as to conform to the configuration of the eyeball when resting thereon, and provided with a backwardly-curved surrounding edge portion to engage the inner surface of the eyelids of the eye, substantially as specified.”

The double plate shows:

A lateral view of an ocular globe fit with the eyeglass, two diagrams of the eyeglass in coronal section, the one biconvex and the other concavo-convex,

a diagram of the eyeglass in $\frac{3}{4}$ view.

The inventor specifies as follows for the corneal part: *“the specific form is immaterial and will vary with the requirements of the user; the glass will have more or less magnifying power or will be arranged to compensate for astigmatism, etc. The edges are slightly curved to adapt them to fit under the eyelids.”*

The drawing of the haptic portion is of very large scale. The inferior portion of the external border rests in the inferior cul-de-sac, while the superior part does not reach the superior fornix. The author anticipates placing *“the glass on the eyeball, allowing the eyelids to retain its position.”*

We are talking about an interesting report that describes, without giving details of it, a scleral shell of large dimension with a corneal portion of ground-in refraction and a haptic with a hooked extremity in order to hold it under the eyelids.

The author does not appear to have precise knowledge of ocular anatomy. The diagram shows a cornea that is not in proportion and a conjunctival sclera that is deficient. The conjunctival cul-de-sacs and the eyelids are miniaturized. As a result of this, the haptic zone of the ‘frameless eyeglass’ does not rest on the scleral conjunctiva but fits directly into the conjunctival sacs beyond the limbus.

2 - Discussion

2 1 - Terminology

In his initial publication, *Fick* proposed the designation of “contact-spectacle or contact-glass” (Contactbrille) for his device, which *May* translated for the English edition as “contact-lens”. *August Müller* invented the term “cornea-lens” (Hornhautlinse), whereas *Kalt* and *Panas* used the expression “glass shell” (coque de verre).

In 1892, *Sulzer* introduced the term “contact glass” (verre de contact). Since he was citing the biographical reference to *Fick*’s work in *May*’s English translation, it is possible that he was trying to adapt *May*’s expression “contact-lens”, which was, in any event, more suitable than *Fick*’s “contact-spectacles”. *Dor* went back to “contact glass” (verre de contact) in 1894 but credited *Fick* with its first use.

Subsequently, other expressions were used, including “cupola” or “bowl” (cupule), “artificial cornea” (cornée artificielle), “*Fick*’s approach glass” (verre d’approche de *Fick*) and “*Sulzer*’s glass” (verre de *Sulzer*). This last designation irritated *Fick* profoundly. However, the final choice for acceptance was “contact glass”, in French “verre de contact” and in German “Contactglas / Kontaktglas”. *Fick* even used this term, starting from 1897.

2 2 - Technical Aspects of Contact Lenses

The Contact Lens Manufacturers

Zeiss and Himmler

We are aware that *Zeiss*, who had delivered blown contact lenses to *Fick* in place of ground lenses without telling him, deceived him. Subsequently, *Fick* approached the Berlin optician *Himmler*, who had ground the lenses for *August Müller*, and obtained two ground contact lenses, each comprising two segments, a corneal segment adhered to a scleral segment.

Benzoni and Benoit-Berthiot

Fick sent one of *Himmler*’s ground two-piece contact lenses to *Sulzer*, who judged the latter completely unusable yet used it as a model for his own one-piece ground contact lenses manufactured by the optician *Benzoni* of Geneva. Subsequently, *Sulzer* pursued his trials with ground lenses manufactured by *Benoit-Berthiot*, whose engineer *Séguy* developed an original manufacturing process, necessary to fulfill *Sulzer*’s required specifications. *Antonelli* supplied testimony for the use of these “improved contact lenses” up to 1906.

Strübin and Verlin

In the course of the controversies between *Fick* and *Sulzer*, *Fick* says that for his physiological trials *Michel* used one-piece ground contact lenses manufactured by *Strübin* in Basel and that the second-generation of *Kalt* lenses were ground in Paris by *Verlin*. These second-generation *Kalt* contact lenses were single-curvature lenses without a scleral zone. The two contact lenses used by *Dor* were ground by *Benzoni* of Geneva. *Fick* used *Strübin*’s ground contact lenses occasionally in order to assess the best potential visual acuity in patients with deformed corneas. (75)

The Price of Contact Lenses

The manufacture of contact lenses seemed, however, to have been uncommon, and grinding of these was an exceptional event. According to observations made by *Elschnig* and *Takahashi*, the obstacle came from their difficult manufacturing process and the consequently high price. *Dor* paid 80 French francs per lens for *Benzoni* lenses, those of *Benoit* were sold for 30 francs per lens and, according to *Fick*, those of *Strübin* were cheaper. *Antonelli* reported in 1909 that it was “a wealthy Neapolitan women³ who used ground-glass contact lenses made in Paris by *Benoit-Berthiot*.”

Specifications of Contact Lenses

The *Sulzer* contact lenses were ground from one piece taken from a block of glass. They consisted essentially of an optic zone with a back radius of 8.00 mm and a diameter of 12.00 mm, and a scleral zone with a back radius of 13.00 mm and a total diameter of 17.00 mm. There are no records of their front radii and dioptric powers, although *Sulzer* mentions the possibility of an optical correction. The *Sulzer* lenses examined in 1937 by *Haas* had an optic zone radius of 7.70 mm and a total diameter of 17.00 mm.

In his memo to engineer *Séguy* in 1895, *Sulzer* insists on “total accuracy for the ground surfaces that have to allow clear vision, even if the radii of curvature are short” for the optic zone of the contact lens. This same memo demands making the external border less sharp and blending the transition between corneal zone and scleral zone, in addition to introducing grooves in the scleral part for the evacuation of tears and air bubbles.

Sulzer was thus the initiator, with the same entitlement as *August Müller*, of so-called “limbal blending” of the junction between scleral and corneal zones of a contact lens. *Sulzer* was also the inventor of scleral grooves ground into the back surface of the scleral zone in order to improve the circulation of tears.

Fick makes note of the presence of spherical aberration in the periphery of the optic zone of the lenses and considers that an ellipsoid grinding would solve this problem. Today this method of grinding is applied routinely for corneal contact lenses but was technically impracticable at the time. It is intriguing that *Sulzer*, in spite of having described the flattening of the optic zone periphery, did not also suggest the introduction of special grinding to produce peripheral flattening in the corneal zone of the contact lens in the specifications that he submitted to *Benoit-Berthiot*.

2.3 - Physiologic Aspects

Scleral Support

For *Sulzer*, contact lenses were held in position in the eye by the lids and had to pass over the cornea like a bridge, with a large corneal clearance. This essential design feature required that the lenses had to have a wide scleral support. *Sulzer*'s specification that he submitted to *Benoit-Berthiot* had asked the latter to “subordinate the curvature of the surfaces to the shape of the sclera of the specific patients” and to effect a surface processing at the zone of scleral support. *Sulzer* accorded enormous importance to the quality of the edge of the contact lens. He asked *Benoit-Berthiot* “to provide one or more grooves in the scleral band intended to facilitate the evacuation of tears or air bubbles”. For the “photographic Contactbrille”, *Fick* rested the glass tube directly on the rabbit's eye. It is true that it was a question of obtaining a liquid corneal neutralization bath and not an optical correction of a refractive error. The “cupulas” used by *Kalt* covered only the corneal part, where they were intended to stick by surface tension. This validates *Sulzer*'s observation that they were too poorly adherent to the eye to be useful.

The Intermediate Liquid

The indications referring to the liquid for filling the lenses are confusing and contradictory. In 1888 *Fick* had recommended a liquid of the same refractive index as that of the cornea and aqueous and had suggested a 2% glucose solution. The cornea tolerated this 2% glucose solution poorly because of its hypotonicity. *Sulzer* also recommended a glucose solution with refractive index equal to that of the cornea and aqueous, but his proposed 1/150 solution did not really match his requirements. *Dor* reported *Fick*'s use of a 1/50 glucose solution, which would have had the same refractive index as cornea and aqueous. He himself, however, used physiological saline solution, which was later adopted by the majority of authors.

Insertion of the Lenses

The difficulty with the insertion of contact lenses represented a considerable handicap in respect to their utilization. Several years after his first description, *Fick* simplified the insertion technique by positioning the lens horizontally after filling it with solution. This avoided the use of pipettes or droppers, as *Dor*, amongst others, pointed out. The female patient quoted by *Antonelli* inserted contact lenses in her eyes while she was in her box at the opera without using topical anesthesia.

Wearing Time and Tolerance of Contact Lenses

Authors were not slow to describe their patients' wearing times. *Fick* described the case of a patient affected by keratoconus who wore his contact lens for six hours a day. *Dor* reported another who achieved three hours and declared that they did not bother him. No publication by *Sulzer* gives any indication of wearing times. However, *de Spéville*, using a contact lens of *Sulzer*'s design, notes that a "a glass can only be tolerated for several minutes", but, with the 'improved' contact lenses of *Berthiot*, the wearing time increased to three or four hours, as least for one of his patients' eyes. *Panas* confirmed in his treatise that "generally, the patients succeed in wearing the cupula for several hours". The female patient fitted by *Antonelli* with *Berthiot* contact lenses in both eyes "tolerated them marvelously well throughout the whole operatic performance".

2.4 - Indications for Contact Lens Wear

The Optical Correction of Keratoconus

The correction of keratoconus was the principal indication for fitting contact lenses at the end of the 19th century. *Kalt* and *Panas* had envisaged "functional treatment" by compression of the cornea. *Panas* set out to achieve immediate and generalized compression of the cornea, but he admitted that this objective was thwarted by the intolerance of the patient's eye for the procedure. *Elschnig* drew attention to the risk of rupture of the cone by mechanical irritation under band compression, which would be an even greater under contact shells. This idea was, nevertheless, generally approved of and reiterated several times during this period.

The Correction of other Ametropias

As far as optical correction was concerned, all authors were agreed when they stated that contact lenses could constitute, at least theoretically, a better optical correction of keratoconus than spectacle glasses, including spectacles with hyperbolic, parabolic, stenopeic, or other glasses. *Fick*, *Sulzer* and *Dor* extended their indications to that of the various types of corneal astigmatism, both regular and irregular. *Dor* also cited the

results of correction of high myopia and hypermetropia.

The Enamel-Painted Contact Lens with Stenopeic Hole

Fick used a stenopeic opening in a contact lens covered by enamel paint as far back as 1888 in order to replace corneal tattooing. The painting of the shell using enamel lacquer was also referred to by *Sulzer* and *Panas* but was subsequently abandoned because of its ineffectiveness, its poor tolerance and the high cost of contact lenses.

Use of Contact Lenses for Diagnostic Purposes

Since this period, contact lenses were proposed for the determination of the best potential visual acuity. In 1892, *Fick* indicated that he was using them to differentiate low visual acuity of corneal origin from other causes. *Dor* did likewise.

Research on Astigmatism of the Crystalline Lens

The idea of studying the possible presence of astigmatism from the crystalline lens after neutralization of corneal astigmatism by a contact lens had been presented in 1892 by *Fick* and was quoted by *Dor*. The experiments of *Michel* were effectively carried out with glass contact lenses ground by *Stübin*, giving the same results as *Woinow* had obtained with the hydrodiascope.

Neutralization of Corneal Refractive Power for Fundus Photography

For photographing the fundus, *Fick* neutralized the refractive power of the cornea with a liquid “having the same refractive index as the cornea”, though he never specified the nature of the liquid. The liquid was poured into a glass cylinder 5.00 to 6.00 mm in length, cut from a test tube, over the end of which was sealed a microscope cover slip.

2.5 - Controversies over the Priorities

Herschel

Controversies regarding the priority of the invention of contact lenses have from time to time obscured debates on the difficulties of the use of these lenses. *Panas*, in order to cut off a priority debate between *Kalt* and *Sulzer*, recalled that “the astronomer *Herschel* had had the idea to apply glass shells to the ocular surface intended to correct the irregular curvature of the cornea” and that, because of this, the priority in contact lenses dated back to this scientist. *Sulzer* used this argument against *Fick* when the latter maintained, “the contact lenses are my intellectual property”. *Sulzer* did not take into account that, by referring to *Herschel*, he was contradicting himself, as he had claimed that “there is no question of grinding an irregular surface to correct the irregularities of the cornea, but simply applying to the cornea a regular surface or segment of a sphere”. Indeed, the proposal of *Herschel* was certainly to neutralize the corneal refractive power by “an irregular surface, a facsimile of the corneal irregularities”. (76)

Fick or Sulzer

Sulzer never denied that *Fick* had given him the idea of confirming his research data on the topography of corneal astigmatism by the neutralization of corneal power by means of contact lenses, a model of which had furthermore been forwarded to him by *Fick*. As *Fick* indicated, *Sulzer* owed his achievements to the expertise of the opticians, at first to *Benzoni* of Geneva but, above all, to *Benois-Berthiot* of Paris, who had faith in the future of this new mode of optical correction and invested their money, time and energy in

trying to achieve it. The memo read by *Sulzer* in 1895 to the Paris Society of Ophthalmology represented a list of specifications, anticipating most of the problems and suggesting solutions for overcoming these. The engineer *Séguy* had demonstrated an amazing facility for invention, but the poor quality of glass available at this time had not allowed achievement of his intended goals.

3 - A short History of Citations, Omissions and Misinterpretations

The participants in the development of contact lenses during the period following the invention of contact lenses by *Fick*, *Kalt* and *August Müller* are little known, rarely cited, or even concealed by contact lens historians. Most texts neglect this period, considering that not a single meritorious advance came to the fore during this decade. For certain authors, the period of silence extends even longer: “*In the two decades that followed the introduction of contact lenses by Fick, Kalt and Müller, there were few publications on contact lenses, although some recorded experimentation activity must have continued.*” (77) Others considered that the period of inactivity extended up to 1930: “*It seems, therefore, that from about 1895 until around 1930 an impasse was reached in terms of patient usage of contact lenses.*” (78)

Citations of Sulzer’s Work

If these existed at all, any references of the works of *Sulzer* are usually laconic or erroneous, as in the following three quotations: “*In 1892, Dr. Sulzer became interested in contact lenses; in fact, he too at this later date thought that he was the first to invent them. He had his lenses ground and recommended them in preference to the blown type.*” (79) or “*Sulzer made the diameter of the lenses smaller. His lenses were only from 11-mm to 13-mm in diameter. Their shape resembled today’s soft corneo-scleral shells. [...] The scleral shells were only much later [...] improved by cutting grooves in the scleral portions in order to improve the corneal metabolic exchange.*” (80) And: “*In 1882, B.E. Sulzer, a Geneva ophthalmologist, treated patients with scleral shells. At the beginning, he concerned himself with Fick-style blown shells.*” (81)

Citations of Dor

The Swiss author *Dor*, who, at that time, practiced in France at Lyon, is seldom quoted: “*Dor (1892) of Paris recommended the use of physiological saline solution as an insertion medium for contact lenses.*” (82)

Citations of the Manufacturing Opticians for Contact Lenses

Generally, historians forgot *Benzoni* of Geneva, *Strübin* of Basle, and *Benoit-Berthiot* of Paris, who provided the ground contact lenses of this period, in favor of *F.A. Müller* and of *Zeiss*: “*All historical contact lenses and shells are made from glass. They were manufactured either by Zeiss in Jena or by F. A. Müller in Wiesbaden.*” (83) In fact, the *Müller* of Wiesbaden furnished prosthesis-like protective shells that were not of optical quality. *Zeiss* employed ground contact lenses only for limited use from 1911 and did not supply them for the correction of keratoconus until the eve of World War I. (102) This misinterpretation was probably ‘inspired’ by a text of *Obrig*: “*While he (Sulzer) does not state exactly who ground his lenses for him, he does report that Berthiot of Paris and Benzoni of Geneva were then making ground contact lenses. He does not mention the claim of the Carl Zeiss Co. that they made their first ground lenses for Dr. Sulzer in 1892.*” (85) and later: “*The Carl Zeiss Co., of Jena, Germany made the first ground spherical contact lenses for Dr. Sulzer in 1892.*” (86)

Conclusion

One can therefore conclude this chapter with the observation that the years following the invention of contact lenses were marked by *Sulzer*’s contributions, supplemented by

Dor, Fick, Lohnstein, De Spéville, Antonelli and others, as well as by the controversies between certain of these authors. Their contributions are complementary and prepare the ground for the definition of an ideal contact lens.

After this era, it becomes evident that a contact lens with a good tolerance and a long wearing time must:

possess a ground surface that is polished and free of irregularities,
guarantee the optical correction by the dioptric power of the glass, rather than by means of the lacrimal meniscus,
match the shape of the eye with its scleral zone, accompanied possibly by the provision of grooves in order to obtain improved circulation of tears,
possess a rounded and smooth edge.

The unsuitability and bad quality of glass, the only material available at the time, and, above all, the absence of suitable manufacturing procedures, did not permit a satisfactory response to these requirements. This explains the frustrations and disappointments that became rapidly apparent.

Neither *Fick, Sulzer* nor *Dor* were able to achieve true contact lens wear in their patients. It is unlikely that the patients of *De Spéville* and *Antonelli* were able to tolerate the lenses outside of the short-term wear indicated by these authors.

In any event, there existed an undeniable interest in the optical correction of these patients by contact lenses. It is therefore not at all surprising that other devices for the neutralization of corneal dioptric power neutralization replaced contact lenses. Interest in contact lenses returned as soon as technical progress allowed and the interest of manufacturers provided new opportunities.

Notes

- 1 In this chapter, we use often the generic term “contact lens” (*ISO 8320: Contact lens: a generic term including any lens designed to be worn on the front surface of the eyeball. - A corneal contact lens is worn in its entirety on the cornea. - A scleral contact lens is worn on the cornea and the sclera*). (See Appendix 10-1).
The essential difference between a contact lens and a contact shell is that the former has a specified front or back vertex power. Although a rigid contact shell has no specified power, it does allow the formation of a *liquid lens* that will correct regular or irregular astigmatism and may also correct part of the spherical component of a refractive error. Thus, an afocal contact shell is capable of providing a reasonable visual acuity, especially in a condition such as keratoconus.
- 2 They were published in the *Archives d’Ophtalmologie* (Sulzer 1892/d & Sulzer 1893/e).
The proceedings of the session, with reference to the communication of May 6, 1891, and to the discussion of *Tscherning* were published in *Bulletins et Mémoires de la Société Française d’Ophtalmologie* (Sulzer 1891/a).
- 3 Sulzer 1891, p. 231-232.
- 4 Discussion *Tscherning* in Sulzer 1891, p. 233.
- 5 Sulzer’s name is followed by the clarification “from Geneva”, whereas the work of the previous year indicated “from Paris”. The publication of the communication in the *Bulletins et Mémoires de la Société Française d’Ophtalmologie* (Sulzer 1892/a) was to be followed during the same year by that of an identical text in the *Annales d’Oculistique* (Sulzer 1892/b).
- 6 Sulzer 1892/a, p. 116.
- 7 At the time under consideration, Sulzer was unaware that *J.F.W. Herschel* had already advocated this proposal to take an impression of the corneal irregularity. It was only in May 1893 (the following year) that *Panas* drew attention to the writings of *Herschel*. (See chapter VIII: *The Corneal Facsimiles of John Frederick William Herschel*).
- 8 Sulzer 1892/a, p. 117.
- The bibliographical reference on *Fick’s* paper presented by Sulzer is that of *May’s* English translation in the *Archives of Ophthalmology* (*Fick* 1888/b).
- Sulzer indicated in the *Bulletins et Mémoires de la Société française d’Ophtalmologie* publication that a 1/150th grape sugar solution interposed between the eye and the lens had to have the same refractive index as the cornea. In the *Annales d’Oculistique* publication (1892/b, p. 325) he indicates that this effect needs a 1/50th solution.
- 9 Sulzer 1892/a, p. 118.
- 10 Sulzer 1892/a, p. 119-120.
- 11 Sulzer 1892/a, p. 120.
- 12 *Javal* 1892, p. 673.
- 13 As Mrs. *Anne-Sylvie Guervern*, librarian for the Archives of the French Academy of Medicine, confirmed in her September 7, 1990, letter to me: “The report of Messrs. *Panas, Gariel and Javal* is not to be found in the archives of the Academy of Medicine and the same is true for ‘Dr Sulzer’s device, which it was supposed to document’ (*Le rapport de MM. Panas, Gariel et Javal ne figure pas dans les archives de l’Académie de médecine, pas plus que ‘l’appareil du Dr. Sulzer’ dont il devrait rendre compte*).
- 14 Because of its interest for the history of contact lenses, I am citing major extracts from this little known document.
- 15 Sulzer 1895, p. 15-16.
- 16 Sulzer 1895, p. 15-16.
- 17 Sulzer 1895, p.16-17.
- 18 Sulzer 1895, p. 17-18.
- 19 *Spéville* 1895, p. 106.
- 20 *Haas* 1937, p. LXXV (75).
- 21 I have researched, but unsuccessfully, the archives of *Benoit-Berthiot Company* for the years concerned. No catalogue or document is preserved in the registration of copyright at the *Bibliothèque Nationale de France* or at the *Bibliothèque Forney in Paris*, which has dedicated itself to collecting catalogues and documents concerning crafts since 1886.
- 22 *Siegrist* 1916, p. 407.
- 23 Communication to the *Société des Sciences Médicales de Lyon* (*Lyon Society of Medical Sciences*), published in *Lyon Médical* (*Dor* 1892/a). The same text is published in *Revue Générale d’Ophtalmologie*, the editor-in-chief of which was *Dor*, bearing the title “Communication à la Société des Sciences Médicales de Lyon, séance du 2 novembre 1892” (*Communication to the Lyon Society of Medical Sciences, Session of November 2, 1892*) (*Dor*, 1892/b).
- 24 *Dor* (1892/b, p.494). He also repeated *Fick’s* mistakes (1888), as Sulzer had already done in 1892, by assuming that a 1/50 (2%) glucose solution would have the same refractive index as the cornea. Such a refractive index would require a 1/5 (20%) dilution, which would be intolerable for the corneal epithelium. In fact, the recommended solution of 2% produces a refractive index (1.3358) that is close to that of tears (1.3370) but has an osmolarity of 115 mOsm/kg, which has a lower value than that of tears (310 mOsm/kg) and causes irritation.
- 25 *Fick A. E.* “Eine Contactbrille”, *Archiv für Augenheilkunde*, 18, 1888/a, 279-289.
- 26 *Dor* 1892/a, p. 494. He did not seem to have understood that *Abbe* of *Zeiss* had forwarded **four** shells to *Fick* (and not “one unique model”), which the latter believed to have been of ground-glass and which was in fact of blown-glass. (See chapter X: *Adolf Eugen Fick’s “Contactbrille”*)
- 27 *Dor* 1892/a, p. 494.
- 28 *Dor* 1892/a, p. 495.
- 29 *Dor* 1892/a, p. 496.
- 30 *Michel*, 1893, see chapter XVI: *Contact Lenses for Physiological Studies*.
- 31 Sulzer 1892/a, p. 117.
- 32 Sulzer 1892/a, p. 118.
- 33 *Fick* 1892/a, p. 306. In his letter of July 25, 1892, *Fick* was referring to Sulzer’s article in the *Annales d’Oculistique* (Sulzer, 1892/b), but he was also referring to the communication presented on May 2, 1892, to the French Society of Ophthalmology (Sulzer, 1892/a).
- 34 *Fick* 1892/a, p. 307.
- 35 Doctoral thesis defended by *August Müller* in Kiel on February 28, 1889. See chapter XII : *August Müller’s “Hornhautlinsen”*.
- 36 *Fick* 1892/a, p. 309-310.
- 37 Or “Warning”, or “Caution”.
- 38 Sulzer 1893/c, p. 122. Sulzer quotes the communication from *Dor* dated November 2, 1892, to the *Society for Medical Sciences of Lyon* (*Société des Sciences Médicales de Lyon*).
- 39 *Michel* 1894. See details later in text and in chapter XVI: *Contact Lenses for Physiological Studies*.
- 40 Letter dated November 5, 1893, in: *Fick* 1894/a, p. 128.
- 41 Sulzer 1894, p. 236.
- 42 See the detailed discussion on the priority of *Herschel* in chapter VIII: *The Corneal Facsimiles of John Frederick William Herschel*.
- 43 Sulzer 1894, p. 237.

- 44 *Panas's* communication was presented to the French Academy of Medicine on March 20, 1888, and not on March 13, as stated by *Sulzer*. Contrary to *Sulzer*, it does not concern “ground lenses without scleral edge” but blown contact shells. See chapter XI: *Eugène Kalt's “Optical Treatment” of Keratoconus*.
- 45 See chapter VIII: *The Corneal Facsimiles of John Frederick William Herschel*.
- 46 *Fick* 1894/b, p. 422-423.
- 47 *Fick* 1894/b, p. 423.
- 48 *Chevallereau* 1893/a & 1893/b, Session of May 3, 1893. The account of this differs somewhat depending on which of the usual sources is referred to (*Bulletin et Mémoires de la Société Française d'Ophtalmologie*, 1893/a, *Revue Générale d'Ophtalmologie*, 1893/b, *Annales d'oculistique*, 1893/c, or *Centralblatt für Augenheilkunde* 1893/d). I am relying on and have quoted the “official” version of the *Bulletins et Mémoires* of the French Society of Ophthalmology. The various versions are reproduced in *Appendix XI-2* of chapter XI: *Eugène Kalt's “Optical Treatment” of Keratoconus*.
- 49 *Abadie* in discussion of *Chevallereau* 1893/a, p. 391.
- 50 *Kalt* in discussion of *Chevallereau's* presentation, 1893/a, p. 391.
- 51 *Sulzer* in discussion of *Chevallereau's* presentation, 1893/a, p. 392.
- 52 *Sulzer* in discussion of *Chevallereau's* presentation, 1893/a, p. 392.
- 53 The attributions of priority to *Herschel* (1827) is analyzed in chapter VIII: *The Corneal Facsimiles of John Frederick William Herschel*.
- 54 *Panas* in discussion *Chevallereau* 1893/b, p. 308.
- 55 *Lohnstein*, 1896. The hydrodiascope refers to an optical device for the correction of refractive errors by a kind of watertight spectacle filled with water. See chapter XIV: *The Era of Hydrodiascopes*.
- 56 *Lohnstein* 1896/a, p. 417.
- 57 *Fick* 1897, p. 129. The references are: *Dor*, 1892/a & 1892/b, and *Sulzer*, 1892/a & 1892/b.
- 58 *Fick* 1897, p. 130.
- 59 *Fick* 1897, p. 131.
- 60 *Fick's* partisanship in favor of Germany explains also the vehemence of his controversy with *Sulzer* and his contempt for *Kalt* and *Panas*, whom he never cited.
- 61 *Lohnstein* 1897, p. 132-133.
- 62 *De Haas, Snellen*, 1893. Report in the *Annales d'Oculistique*, 53, 107-102, 1893 of the Second Congress of the Netherlands Ophthalmological Society, session of December 18, 1894. (Also, in *Nederlandsch Tijdschrift voor Geneskunde* 28, 2, 1892, p. 976 – see Appendix 13 – 3)).
- 63 *Fick's* procedure of using an intermediate device between the contact lens and the hydrodiascope is outlined in chapter XIV: *The Era of Hydrodiascopes*.
- 64 *Michel* 1893, p. 233. See details in chapter XVI: *Contact Lenses for Physiological Studies*.
- 65 *Panas* 1894, p. 294-295.
- 66 *Fick* 1894/c, p. 262.
- 67 *Elschnig* 1894, p. 52. This author read only summaries of the cited articles. His bibliographic references are: “*Panas, summary in Centralblatt, 1886, p. 139 - Desparagnet Treatment of keratoconus pellucidus, summary in Archiv für Augenheilkunde 1890, p. 155.*”
- 68 *Elschnig* 1894, p. 53.
- 69 *Parent* 1895, annual report p. 114.
- 70 The communication of *Spéville* (1895) has been analyzed above, as evidence of the use of *Sulzer's* “improved” contact lenses.
- 71 *Takahashi* 1901.
- 72 *Takahashi* 1896. This article was published by *Hirschberg* after his visit to Japan. The close resemblance of the two publications has been at the origin of assertions that *Takahashi* might have been the inventor of contact lenses in Japan. The literature provides no evidence to support this idea. I am indebted to Professor *Saïichi Mishima* of Tokyo for this information. Professor *Mishima* has kindly translated the text from which this passage is drawn and which has caused very detailed investigation of the “*Takahashi case*”, going right up to questioning the great grandchildren of *Takahashi*.
- 73 *Antonelli* 1909/b, p. 248.
- 74 *Antonelli* 1909/b, p. 251-252.
- 75 *Fick* send this *Strübin* lenses in 1930 to *von Mohr*. (Archives *Zeiss*, Jena # 1051).
- 76 *Herschel* 1845. See chapter VIII: *The Corneal Facsimiles of John Frederick William Herschel*.
- 77 *Mandell* 1988, p. 10.
- 78 *Sabell* 1976, p. 6. This viewpoint is also shared with *Albert* 1996, *Rubin & Hope* 1996 and others.
- 79 *Endore* 1948, p. 32.
- 80 “*Sulzer verkleinerte die Linsendurchmesser. Seine Linsen waren nur noch 11 bis 13 mm groß ; ihre Form glich der heutigen weichen Corneoskleralschalen. [...] Zur Verbesserung des Hornhautstoffwechsels wurden Skleralschalen erst viel später [...] Durch eingefräste Rillen im Skleralsegment verbessert.*” (*Roth* 1978, p. 26). This author apparently confuses *Sulzer* with *Kalt*, the latter having used lenses of the smallest diameter. He is also not aware that *Sulzer* had had grooves hollowed out in the scleral portions of the lenses after 1895.
- 81 “*1892 behandelte B.E. Sulzer, Ophthalmologe in Genf, Patienten mit Skleraschalen. Anfangs beschäftigte er sich mit den geblasenen Schalen nach Fick.*” (*Samland*, 1966).
- 82 *Sabell* 1972, p. 6. *Henri Dor* was of Swiss origin and he was first Professor of Ophthalmology at Berne (Switzerland). Subsequently, he opened a private clinic in Lyon, (France).
- 83 “*Alle historischen Kontaktlinsen und Schalen sind aus Glas. Hergestellt wurden sie entweder von Zeiss in Jena oder von F.A. Müller in Wiesbaden.*” (*Roth* 1978, p. 29).
- 84 The documents preserved in the *Zeiss* archives, in particular the letters exchanged in 1930 with *Fick* (# 1051), show without any doubt that before 1911 *Zeiss* was not interested in the field of ocular optics and manufactured neither spectacle lenses nor contact lenses. The archives preserve the correspondence with *Fick*, but there is no trace of an exchange with *Sulzer*.
- 85 *Obrig* 1942, p. 130.
- 86 *Obrig* 1942, p.137, *Obrig & Salvatori* 1957, p. 136.

Appendix 13 – 1

Transcription of

Bulletin et Mémoires de la Société française d’Ophtalmologie 10, 1892, 113-120

(Same text in : *Annales d’Oculistique* 57, 1892, 321-328)

**La correction optique du kératocône, de l’astigmatisme irrégulier
et de l’astigmatisme cicatriciel**

Par M. le Dr D.-E. SULZER (de Genève)

Lors de la dernière session annuelle de la Société française d’ophtalmologie, j’ai eu l’honneur de vous communiquer les résultats obtenus par la mensuration des rayons de courbure d’un grand nombre de point de la cornée, et les conclusions qui dérivent de ces mesures au sujet de la forme de cette membrane. [...] L’étude de la forme des cornées coniques et irrégulières m’avait montré u’il y avait peu d’espoir de corriger leur influence sur la vision par des verres coniques, comme l’avait essayé Galezowski, ou par des cylindres inclinés, comme me l’avait suggéré mon maître éminent, M. Javal. Pendant quelque temps, j’avais songé à utiliser l’image kératoscopique photographiée pour tailler des verres correcteurs de ces cornées irrégulières. L’image kératoscopique qui indique toutes les irrégularités de la cornée pourrait servir de guide pour tailler, à l’aide de la retouche locale, des lentilles correctrices. Une telle lentille devrait former, dans certaines circonstances, une image régulière des cercles déformés de la photographie de l’image kératoscopique. Ainsi l’image kératoscopique pouvait servir non seulement de guide pour la fabrication des lentilles, mais aussi comme moyen de contrôle.

La réalisation de cette idée rencontra deux difficultés : la difficulté technique de la taille de lentille, qui, pour certains cas, il est vrai, aurait été surmontable et l’impossibilité de maintenir la lentille correctrice dans une position telle que ses éléments différemment courbés restent en rapport avec les éléments cornéens qu’ils étaient destinés à corriger. Non seulement i est difficile de placer la lentille dans cette position, pour une direction déterminée du regard, mais le moindre mouvement oculaire doit dérange la disposition prise.

Il restait un seul moyen d’éviter cette difficulté : celui d’appliquer la lentille correctrice directement à la cornée. Le problème change alors complètement : en remplissant l’espace laissé entre la cornée et un ménisque concave-convexe, appliqué directement sur la cornée , par un liquide, ayant l’indice de réfraction de la cornée et de l’humeur aqueuse on peut substituer à la cornée une surface réfringente artificielle. Il ne s’agit plus de tailler une surface irrégulière, corrigeant les irrégularités de la cornée. Mais simplement d’appliquer sur la cornée une surface régulière, une calotte sphérique.

Grâce aux travaux de M. E. Fick (1), il est acquis qu’un ménisque concave-convexe appliqué sur la cornée et séparé d’elle par une couche d’une solution de sucre de raisin au 150°, solution dont l’indice de réfraction est égal à celui de la cornée et de l’humeur aqueuse, est toléré par l’œil humain.

Ces verres sont composés d’une calotte sphérique centrale dont le rayon est égal, pour la surface concave, au rayon de courbure moyenne de la surface antérieure de la cornée (mm). La base de cette calotte a un diamètre de 12 mm. Elle porte un bord de 2 à 2mm5 de largeur, découpé dans une sphère d 13 mm de rayon. La surface concave de ce bord, qui est dirigé du même côté que la surface concave de la calotte, s’applique sur la sclérotique. En haut et en bas, il est retenu par les paupières. Un verre de contact ainsi disposé, reste complètement en place, quels que soient les mouvements des yeux ou de la tête.

Les verres de contact employés par M. Fick étaient des verres soufflés. Quand on examine un verre soufflé à l’ophtalmomètre, on y découvre sans exception nombre d’irrégularités, quoiqu’il paraisse absolument régulier vu à travers une loupe. Ces irrégularités expliquent facilement les résultats peu satisfaisants obtenus par M. Fick. Après beaucoup de tâtonnements, je suis arrivé à faire tailler des verres de contact et les résultats obtenus avec ces verres sont, en somme, les suivants :

Un œil normal, armé d’un verre de contact, voit un peu moins que sans verre. L’acuit normale, par exemple, est abaissée à 5/6^e. Un œil à cornée irrégulière, qu’il s’agisse d’un astigmatisme irrégulier ou d’un kératocône, voit avec un verre de contact aussi bien qu’un œil normal armé du même verre. Je me permets de vous communiquer brièvement les observations de trois cas dans lesquels j’ai employé des verres de contact.

Dans le premier cas, il s’agit d’un peintre, âgé de vingt-six ans, qui n’a jamais bien vu, ni de loin ni de près, de son œil gauche. A l’ophtalmomètre, on constate un astigmatisme de 6,5 D, à axe oblique. Le meilleure correction subjective fut obtenue par le cylindre convexe 4,0 axe vertical. Tandis qu’à l’œil nu l’acuité visuelle était de 5/50^e, elle était avec ce verre 5/15^e. Les caractères n°3 de Sn furent déchiffrés difficilement avec ce verre. Avec le verre de contact, l’acuité visuelle était de 5/5^e et les caractères les plus fins furent lus facilement. Le méridien le plus réfringent de la cornée avait un rayon de 6mm 75 tandis que le moins réfringent avait un rayon de 7mm,75. Le rayon du verre de contact étant de 8 millimètres, l’œil ainsi corrigé présentait une hypermétropie de 4,0 D. Il est évident qu’en changeant la courbure de la surface antérieure du verre de contact selon le cas, on peut instituer l’emmétropie d’emblée.

Dans le second cas, il s’agit de l’œil gauche d’une dame âgée de vingt-deux ans. Cet œil a, sans verre, une acuité de 5/50^e ; la meilleure correction subjective est obtenue avec un cylindre convexe e 2,25 axe 30 degrés, qui améliore l’acuité à 5/30^e. L’ophtalmomètre indique un astigmatisme de 2,5 D, le méridien le plus réfringent étant à 20 degrés. Un verre de contact relève l’acuité visuelle à 5/6^e et permet de lire, en

combinaison avec le verre sphérique + 2,0, les plus fins caractères.

Le troisième malade, que je présenterai demain après-midi à quatre heures à ceux parmi vous, qui voudront bien me faire l'honneur de s'y rendre, au laboratoire ophthalmologique de la Sorbonne, est un artiste, atteint depuis six ans, d'un kératocône double, réfractaire depuis deux ans à toute correction cylindrique ou sphérique. L'acuité de son œil droit, qui compte les doigts à une distance de 3 mètres, est relevée à 4/5^e par l'application d'un verre de contact.

Pour les cas, où il y a à côté des irrégularités de forme de la cornée des opacités de cette membrane, on peut combiner la méthode sténopéique avec l'application des verres de contact. En couvrant la surface intérieure de la calotte centrale d'un émail opaque de la couleur de l'iris et en laissant une petite ouverture vis-à-vis des parties cornéennes les moins opaques, on obtiendra un résultat à la fois optique et esthétique. Je n'ai pas eu l'occasion, jusqu'ici, de faire cette application des verres de contact. Mais d'après ce que nous savons de la forme des parties périphériques de la cornée, on peut attendre un grand bénéfice des verres de contact diaphragmés dans les cas d'iridectomie optique, soit que l'iridectomie ait été faite à cause des opacités cornéennes, soit qu'elle ait dû remédier à une cataracte zonulaire.

Appendix 13 - 2

Transcription of:

Javal's presentation of Sulzer's contact lenses
(Bulletin de l'Académie de Médecine, 27, 1892, p. 673)

Présentation d'appareil

M. JAVAL : J'ai l'honneur de présenter à L'Académie un petit appareil de prothèse oculaire répondant à un desideratum depuis longtemps formulé par les ophtalmologistes

Il s'agit d'une capsule de verre ayant deux courbures successives de façon à pouvoir s'appliquer sur la cornée et sur la sclérotique en même temps.

M. le Dr Sulzer, qui a été l'instigateur de cet appareil, rapporte qu'un malade a pu le supporter pendant soixante-quatre heures sans aucune gêne. En tout cas, il est appelé à rendre de très grands services aux personnes à cornée irrégulières qui ne peuvent supporter les verres jusqu'ici en usage. Ceux qui s'en sont servi ont, en effet, éprouvé une satisfaction incomparable. – (*Renvoi à l'examen de MM. Panas, Gariel, Javal*)

Appendix 13 – 3

Transcription of
A / Nederlandsch Tijdschrift voor Geneeskunde Vol 28,2, p 974-979, 1892
 De Haas – 1892

Tweede Vergadering van het Nederlandsche Oogheekundig Gezelschap
 18 december 1892, Amsterdam

p. 976

Daarna verkrijgt Dr. De Haas het woord voor twee mededelingen.

In de eerste plaats spreekt hij over de **contact-brillen** van Fick en Sulzer. Twee van deze gewelfde glazen plaatjes demonstrerende, herinnert hij, dat zij zijn aanbevolen om aaneen slecht gevormde cornea haar invloed op den gang der lichtstralen te ontnemen. Zij worden op de cornea gelegd, nadat deze met physiologische keukenzout- of suiker – oplossing is bevochtigt en door de oogleden vast gehouden. Spreker zag van deze brillen in een geval een snel voorbijgaand succes; doch na enige uren was de visus weder gedaald, den volgenden dag zelfs door belediging van het hoornvlies zeer gering geworden. Prof. Snellen doet opmerken, dat deze glazen vooral zijn aanbevolen voor de correctie van het onregelmatige astigmatisme.

Dr. Snelles jr. heeft van Sulzer persoonlijk vernomen, dat deze de glazen niet op den duur wil laten dragen, doch den patient in staat wil stellen, dagelijks gedurende korten tijd, bijvoorbeeld een half uur, zijn visus te verhoogen.

B / Annales d'oculistique, 59, 106-108, 1893

Congrès de la Société Ophtalmologique Néerlandaise
 Séance du 18 décembre 1892 à Amsterdam
 Verres de contact.

p. 107-108:

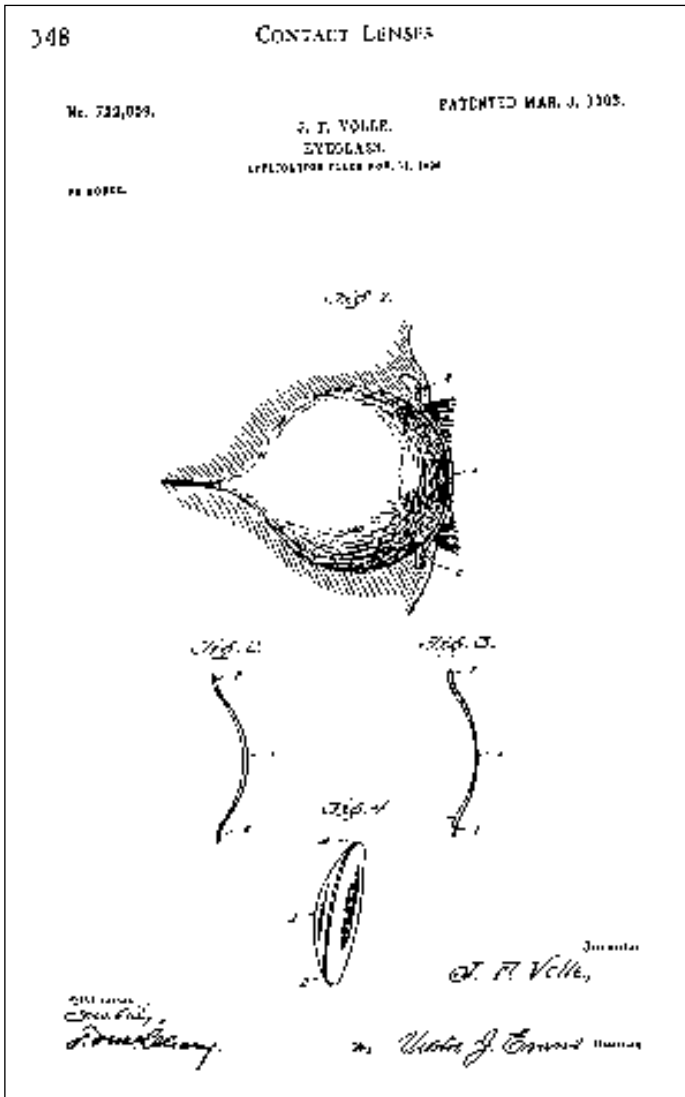
M. De Haas n'a pas trouvé dans l'emploi des verres de contact la satisfaction qu'il en espérait. Dans un cas d'astigmatisme survenu à la suite d'un traumatisme, l'acuité visuelle pouvait être améliorée jusqu'à 1/3 avec des verres cylindriques, tandis qu'avec des verres de contact l'acuité visuelle n'atteignait que 1/4. De plus, après avoir supporté les verres pendant dix heures, les patients ressentaient de grandes douleurs et l'épithélium de la cornée devenait opaque.

M. Snellen répond à cela qu'il n'entrait pas dans l'intention du Dr Sulzer de faire concurrence aux verres sphériques ou cylindriques, mais qu'il recommandait les verres de contact pour les cas d'astigmatisme irrégulier, qu'on ne peut corriger avec des verres ordinaires.

Appendix 13-4

Transcription of
UNITED STATES PATENT OFFICE
 JOHANN F. VOLLE, OF SCRANTON, MISSISSIPPI
EYEGLASS

SPECIFICATION forming part of Letters Patent No 722,059
 dated March 3, 1903.
 Application filed November 12, 1900. Serial No 36,239. (No model)



To all whom it may concern:

Be it known that I, JOHANN F. VOLLE, a citizen of the United States, residing at Scranton, in the county of Jackson, and State of Mississippi, have invented new and useful Improvements in Eyeglasses, of which the following is a specification.

My invention relates to frameless eye lenses or glasses, the object being to provide an eye lens or glass which will require no frame or attaching means, but will be supported in position upon the eyeball by the contact therewith of the eyelids.

The invention consists in the construction and arrangement of the device, as will be hereinafter described, and pointed out in the claim.

In the accompanying drawings, Figure 1 is a vertical section of a glass embodying the invention and shown in position in the eye, and Figs. 2 and 3 are vertical sections of different forms of the lens or glass. Fig. 4 is a perspective view of a lens or glass.

The reference-numeral 1 designates a glass or lens of concavo-convex form and having its edges 2 slightly curved to adapt them to fit under the eyelids.

The specific form of lens is of course immaterial and will vary with the requirements of the user – that is to say, the glass will have more or less magnifying power or will be arranged to compensate for astigmatism, &c., the same as the lenses of ordinary glasses.

The illustration in Fig. 1 shows the manner of applying the glass to the eye, it being only necessary to place the glass on the eyeball, allowing the eyelids to overlap the edges 2 of the glass to retain it in position.

The invention is adapted not only for use as an aid to the vision, but may be made in imitation of the eyeball and used as a substitute for the glass eyes in common use without the necessity of removing the eyeball, as is now necessary before the ordinary glass eye can be inserted.

It will be obvious that my improvement avoid the annoyance and inconvenience incident to the use of the usual spectacle-fastenings or the springs employed with what are termed “nose-glasses”.

I claim –

An eyeglass comprising a lens constructed in concavo-convex shape so as to conform to the configuration of the ball of the eye when resting thereon, and provided with a rearwardly-curved surrounding edge portion to engage the inner surface of the eyelids of the eye, substantially as specified.

In testimony whereof I affix my signature in presence of two witnesses.

JOHANN F. VOLLE.

Witnesses:
 A. L. MOORE,
 Z. L. MANSFIELD.

Figure 13 - 16