Chapter XXI

The Alternatives to Zeiss Contact Shells in German-speaking Europe

Introduction

The ground glass corneo-scleral contact lenses made by *Zeiss* and successively known as 'Adherent Shells' (Haftschalen) and then 'Overlay Glasses' (Auflagegläser) were rapidly challenged by alternatives. These derived from other initiatives originating in German-speaking Europe:

- First of all, the blown shells of *Müller Brothers* (Wiesbaden) were rapidly upgraded in order to be consistent with advancing knowledge.

- Secondly, those contact lenses originally manufactured by ocularists *Müller-Welt Brothers* (Stuttgart) using a blown glass technique in molds, were now complemented in their manufacture by an anterior optical grind.

- Then, and most importantly, the contact glasses resulting from the original work of *Joseph Dallos* (Budapest) became the first physiological contact glasses.

- Finally, the *Emerich Rakos* contact lens project.

1- The Blown Glass Contact Shells of Müller Brothers

The monopoly of contact lenses made by the ocularists *Müller Brothers* of Wiesbaden had been challenged in 1920 when the first clinical results obtained with ground contact glasses made by *Zeiss* for the optical correction of keratoconus were presented by *Stock* to the Annual Congress of the German Ophthalmological Society in Heidelberg. (1) However, in spite of the interest in a high quality optical product, the marketing of ground contact glasses by *Zeiss* did not signal the end of fittings of *Müller* blown glass shells. Actually, the politics of exclusive and restrictive distribution by *Zeiss* granted a respite of about ten years to the users of *Müller* contact lenses. According to contemporary publications, some physicians could not access *Zeiss* contact glasses, others considered their performance unsatisfactory, while others again made comparisons, sometimes very favorable to the *Zeiss* product, other times with reservations. The ophthalmologic literature of the era reflected these differing opinions.

Figure 21-1
Muller Brother's corneo-scleral blown shell. (Collection Victor Much)

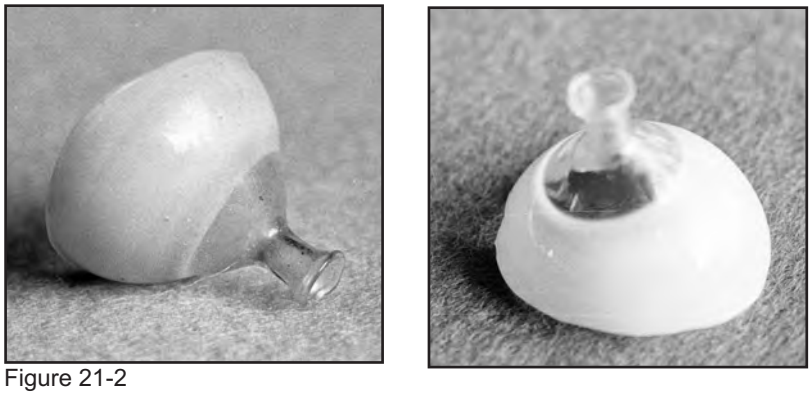


Figure 21-2
Müller Brother glass corneo-scleral shell for ocular instillations or perfusions.
Glass contact shell with a central hollow tube for the instillation or perfusion of therapeutic liquids. (Collection Victor Much)

1.1 - Ten Years of an Alternative to Ground Contact Shells for Keratoconus (1920 – 1930)

Between 1920 and 1930, notwithstanding the challenge to *Müller* contact shells by the first ground contact shells of *Zeiss*, many publications provided evidence of their utilization by practitioners who were regularly visited by *Müller Brothers* of Wiesbaden.

In 1920, *Wilhelm von Clausen* (Halle) presented a summation of the facts known about the etiology and the medical and surgical management of keratoconus. He made his presentation to the Congress of Ophthal-

Year	*Author*	*Title*
1920	Stock	Über Korrektion des Keratokonus durch verbesserte geschliffene Kontaktgläser (Correction of keratoconus through improved ground contact glasses)
1920	Clausen	Keratokonus und seine Behandlung (Keratoconus and its management)
1921	Hegner	Zur Frage der Brillenwirkung (Regarding the effectiveness of glasses)
1922	Schnaudiggel	Zur Therapie des Keratokonus (Treatment of keratoconus)
1923	Kraemer	Über die Massnahmen gegen Keratokonus mit besonderer Berücksichtigung der optischen Hilfsmittel, spez. der hyperbolischen Gläser (Measures for the management of keratoconus, notably visual aids, including hyperbolic glasses)
1924	Lauber	Kontaktgläser bei Keratokonus (Contact glasses in keratoconus)
1925	Siegrist	Zur optischen Behandlung der unregelmässigen Hornhautkrümmung, speziel des Keratokonus (The optical treatment of irregular astigmatism, with special reference to keratoconus)
1925	Scheffels	Beidseitiger Keratokonus (Bilateral keratoconus)
1925	Bohnenberger	Monokulare Diplopie (Monocular diplopia)
1926	Meyerbach	Pulsierende Descemetocoele als Endstadium von Gonoblenorrhoea adultorum und ihre Korrektion durch Müllersche Kontaktbrille (Pulsating descemetocele as a terminal stage of adult gonococcal blenorrhea and its correction by Müller contact glasses)
1927	Hessberg	Müllersche Kontaktschalen bei Keratoglobus (Müller's contact shells for keratoglobus)
1927	Quirin	Doppelseitiger Keratokonus korrigiert durch Müllersche Kontaktschalen (Bilateral keratoconus corrected by Müller contact shells)
1927	Sommer	Über Kontaktgläser zur Korrektion des Keratokonus (Contact glasses for the correction of keratoconus)
1927	Lauber	Kontaktglas bei Keratokonus (Contact glass in keratoconus)
1928	Weill	Correction du kératocône par les verres à contact (Contact glass correction for keratokonus)
1929	Goldschmidt	Keratokonus doppelseitig (Bilateral keratoconus)
1929	Deutsch	Über die Verwendung von Kontaktgläsern bei irregularem Astigmatismus und hoher Ametropie (Use of contact glasses in irregular astigmatism and high refractive error)
1929	Loewenstein	Zur Ätiologie des Keratokonus (Etiology of keratoconus)
1929	Clausen	Günstige Erfahrungen mit Müllerschen Kontaktschalen (Favorable results with Müller contact shells)
1929	Fésùs	Müllersche Kontaktgläser (Müller contact glasses)
1930	Lauber	Sechs Jahre getragene Kontaktgläser bei Keratokonus (Six years of wearing Müller contact glasses)

Table 21-1
Chronology of the principal publications between 1920 and 1930 describing the blown contact glasses of Müller Brothers (Wiesbaden).

mology held in Heidelberg and added two personal observations of correction of keratoconus by blown-glass *Müller* contact shells. He expressed the wish that the manufacturers would soon furnish shells with a ground optics and a haptics adapted to the scleral curvature:

"*The ideal would be a contact shell that would possess, apart from its supporting part, also a ground optical zone in its center*." [2]

In the following year, in a study on the optics of spectacle lenses and the use of prisms in eye glasses *C.A Hegner* of the Lucerne Ophthalmology Clinic in Switzerland also tackled the problem of contact lenses. Following a slightly inaccurate historical introduction, he reported the so-called current topics of the era, namely the sensitiveness of the eyes and their intolerance to foreign material [3]:

"*How sensitive the eyes are differs from one subject to another. However, in the majority of cases the contact glass provokes discomfort more or less rapidly. One has observed local irritations, conjunctival injection, foreign body sensations, photophobia, tearing and even epithelial lesions. (…). The patient should restrict himself to wearing the contact glass for only a short period of time, depending on his tolerance. Apparently blown-glass contact glasses have a less irritative effect than those that are ground*." [4]

In 1922 (the year following), *Otto Schnaudigel*, Professor at Frankfurt University Ophthalmology Clinic, told a light-hearted anecdote in a publication describing the management of keratoconus of a female patient who had obtained excellent improvement in her visua1 acuity at the time of her fittings with contact glasses, both blown and ground. Notwithstanding the good result, she had a very bad memory of the experience:"*She replied to me as follows: I have tried innumerable contact glasses; those of Müller and Zeiss definitely improved my vision; however, I would rather suffer the pains of labor a second time for each one of my seven children than wear a contact glass for only half a day*." [5]

In 1923, in a plea in favor of hyperbolic contact glasses, *Richard Krämer* emphasized the disadvantages of *Müller* contact glasses, of which the long-tern tolerance remained unproven. Without citing any personal experience and referring only to the opinions of *Lüdemann*, *Siegrist*, and *F.A. Müller*, he admitted that certain blown contact glasses could be worn for years, but the optical results were poor. The fittings were so stressful for both physician and patient that he could not imagine their extensive use. [6]
A year later, in 1924, *Lauber* (Vienna) presented the case of a student affected by bilateral keratoconus improved by *Müller* contact glasses that the student wore all day long and which allowed him to pursue his studies. When his eyes were examined at follow-up, the surface of the contact glass was found to be very irregular. This however did not seem to affect the visual result adversely. [7]

In 1925, *A. Siegrist* (Berne) undertook a new detailed compendium of the optical correction of irregular astigmatism. He made a historical review of the first contact glasses, various hydrodiascopes, *Müller* blown contact glasses and ground contact glasses of *Zeiss*. He explained why he now preferred the latter and how he had given up using blown shells "*of which the principal inconvenience (…) resides in the fact that these glasses possess practically no spherical curvature and that one does not have any idea about their refractive power, unless one has taken the trouble to measure it oneself*." [8]

In the same year *Scheffels* (Krefeld) presented the case of a patient affected by bilateral keratoconus, who wore contact glasses made by *Müller* every day for four years and was satisfied both from a functional and an esthetic point of view. He described that there had been a regression of the cone thanks to the pressure of the contact glass that would have a beneficial effect on the evolution of the condition. [9] In the same year (1925), *Bohnenberger* reported that he had corrected a patient with monocular diplopia due to a scar following a corneal ulcer by using a contact glass:"*By putting in place a contact glass, the applanation of the corneal vertex was eliminated and neutralisation of the ocular hypermetropic refractive error resulted from this. The latter now behaved like a myopic eye*." [10]

Rudolf Schneider filled the precorneal space under the *Müller* shells with tincture of iodine for the treatment of corneal infections, but he confirmed that this treatment was often poorly tolerated. [11]
A year latter, in 1926 *Fritz Meyerbach* (Frankfurt) reported the optical correction of a cornea markedly deformed due to descemetocele. He used *Müller* contact shells and observed visual improvement, good tolerance and regression of the corneal ectasia: "*This success is very satisfactory, the more so because the patient tolerates the shell all the time; he became accustomed to it so rapidly that he can no longer do without it*." [12]

In 1927, *Hessberg* presented a patient with bilateral keratoglobus who tolerated *Müller* contact shells and could still go to work. Also, *Quirin* (Wiesbaden) presented a patient with bilateral keratoconus corrected with *Müller* contact shells. These were well tolerated and improved his vision greatly, also arresting the progression of his condition:"*These Müller shells are generally well tolerated and it has even often been observed that the progression of the keratoconus has been arrested, which Dr. F. Müller interprets as an orthopedic bandage effect of the shell.*" (13)

In Vienna, *Lauber* reported his fourth success with *Müller* contact shells: "*Thanks to the shells, all four patients have returned to their trade or profession (teacher, seamstress, technician and civil servant) and were able to wear them throughout the whole working day*."

This communication was followed by discussions, in which *Fuchs* confirmed the favorable evolution of one of the cases, *Kestenbaum* reported favorable results in five cases, but *Lindner* was disappointed. *Krämer* found that the Zeiss contact glasses were better, but unfortunately more expensive. In his '*Manuel of Refraction*', *Hegner* described the relative success of contact shells, of which those of *Müller* could be worn for several hours a day with improvement in keratoglobus symptomatology. (14)

In her doctoral thesis (Inaugural Dissertation) at the Faculty of Medicine at the University of Freiburg i.Br. *Franziska Sommer* made an unusually objective summation of the situation during this era. This document differed from the communications usually presented at the congresses because it also documented the failures of contact lenses. (15) *Sommer* remarked that all of the publications on contact lenses were of German origin, which is explained by the fact that the only two manufacturers were from that country. After a fairly complete historical survey, *Sommer* reported clinical histories of 13 patients suffering from keratoconus in which the *Müller* contact shells were tried. These were collected from the records of six ophthalmologists between 1926 and 1927. Two patients were improved by ground contact glasses of *Zeiss* and another could not be fitted at all due to intolerance. *Sommer* concluded that, in spite of the difficulties of their fitting, "*Müller contact shells are more frequently tolerated by the eye without irritation*." (16)

The detailing of certain cases is particularly instructive and allows one to understand objectively the relatively limited success rate of the epoch:

"*Case 1 (Axenfeld) According to the history given by the patient in October 1926 she had herself fit right away in Wiesbaden with Müller contact shells. She wrote that these Müller contact glasses were worn continuously without any irritation and that her vision was significantly improved by them.*
Case 2 (Axenfeld) For six weeks the patient tried to wear three different pairs of Müller contact shells. The visual acuity would have been very good with the shells, but the two eyes were so severely irritated that he was only able to wear them for three short periods. Air bubbles always formed between the globe and the shell.
Case 3 (Heinersdorf) Although the contact shells of Müller allowed better distance vision, the patient declared that he could not wear them because of severe irritation of the eye. He could not tolerate them.
Case 10 (Stock) The patient still wears the old prosthesis of 1922, although it may no longer be beyond criticism and was probably the cause of recurrent irritation. These irritations progressively induced a protracted corneal lesion with a poor prognosis. However, even at Wiesbaden, they failed to prepare a shell that the patient could tolerate." (17)

In the first French language publication describing modern contact glasses, *Georges Weill* of Strasbourg recalled how in 1916, he had published in German his first successes with the blown-glass contact glasses of *Müller* at the Ophthalmology Clinic in Strasburg. He described the *Müller* contact glasses, but had abandoned these in favor of *Zeiss* contact glasses, of which the fitting was easier (18):

"*The Müller prosthesis (Wiesbaden) is of blown glass and resembles an ordinary simple shell prosthesis, but with a transparent cornea. These prostheses are often tolerated by the patients for the whole day and cause a really remarkable improvement in vision. Several of my patients have been wearing them for years and cannot do without them. Unfortunately, a sufficiently large choice of these prostheses is required before you can find the one that gives the maximum obtainable vision. This demands multiple examinations and much patience.*" (19)

In 1929, *Goldschmidt* (Leipzig) reported visual improvement in a patient with bilateral keratoconus. The patient had been wearing *Müller* shells all day for six months. During the discussion, *Fischer* reported that, when he was doing experiments on the ocular muscles, he had used ground *Zeiss* contact glasses and had measured the strength of their adherence to the ocular globe. (20)
Deutsch, an ophthalmologist from Vienna, reported a series of 49 patients (76 eyes) that were fit with ground *Zeiss* contact glasses of which he was a fervent fan. Two patients failed in the fitting, but these two were finally successfully fit with *Müller* contact shells. *Löwenstein*, in his publication on the etiology of keratoconus, stated that he obtained better results with the blown contact glasses of *Müller* than with the ground contact glasses of *Zeiss*. (21)

Also in 1929, *Clausen* (Halle) presented his excellent experience with *Müller* contact glasses because his patients were able to wear them for the whole day without interruption. However, in one of the patients he had been following, a persistent corneal infiltration occurred after a long period of wear. This episode reminded him of similar observations when he was fitting *Zeiss* experimental celluloid contact shells. According to the American ophthalmologist *Olga Sitchevska* (New York), *Clausen* had very considerable experience because he possessed about a hundred blown contact shells made by *Müller*. His reputation attracted patients from as far away as the USA. During the discussion, *Erggelet* (Jena) confirmed that some patients did not tolerate *Zeiss* contact glasses and required to be fit with the optically less-than-perfect *Müller* contact shells. At this point, *Fischer* (Leipzig) explained that tolerance depended in part on the maintenance of some lacrimal circulation between the eye and the contact glass. While instilling a drop of methylene blue into the eye, one could observe that this dye circulated freely under the the blown contact shells and yet it did not penetrate beneath the ground shells. This test provided evidence of good lacrimal circulation under the blown glass and explained why these contact glasses were better tolerated. (22)
In 1929, at the Congress of the Hungarian Ophthalmological Society, *A. Fésüs* reported the case of a female patient who suffered from bilateral keratoconus. The contact glasses of *Zeiss* were not tolerated and she was fit with *Müller* contact shells. This was in spite of the latter being of poorer optical quality that the Zeiss contact glasses. *Dallos* confirmed, in the course of the discussion, that the *Müller* shells were of a mediocre optical quality. (23)

The following year, in 1930, at the Viennese Society of Ophthalmology, *Lauber* referred again to his first patient with keratoconus who was fit in 1924 with blown *Müller* shells. These had been tolerated for six years. The keratoconus was hardly modified, except for a slight increase in the veil at the summit of the cone in the right eye: "*He is still wearing the same contact glasses that were prescribed six years ago. Müller had simply removed the incrustations that were adherent to them. (…) The patient wears the contact glasses for the whole day without difficulty. The keratoconus is little changed except for the veil being slightly more evident at the summit of the cone.*" (24)

1.2 - The Decline of Traditional Blown Contact Shells (1930-1939)

When *Zeiss* presented in 1930, with the support of Professor *Heine* of Kiel and with some aggressive advertising, their new ground contact glasses for the correction of all refractive errors, it became evident that the era of blown contact glasses was past. Several physicians still referred in public to their use of *Müller Brothers* blown contact glasses, essentially to compare them with *Zeiss* ground glasses, of which both the manufacture and the fitting were more rational, even if there existed sometimes a lesser tolerance. Soon the work of *Dallos* on molded shells was also well recognized and the ocularists *Müller-Welt* (Stuttgart) marketed lenses combining both grinding and molding. The traditional blown *Müller* contact glasses could no longer compete against the advances achieved by their competitors and their manufacturers had therefore to adapt to the new methods.

In 1930, at the time of *Hartinger*'s presentation of the new *Zeiss* ground contact glasses, *Erggelet* offered evidence from having repeated *Helmbold*'s experiment of sending blown *Müller* shells to *Zeiss* in order to have them optically ground. The process however, broke all these shells. *Erggelet* described how well blown

Year	Author	Title
1939	Erggelet	Discussion of Hartinger's communication: Zur Berichtigung der Fehlsichtigkeiten mittels der geschliffenen Zeissischen Haftgläser (The correction of refractive errors using ground Zeiss adherent glasses)
1930	Blatt	The correction of high myopia by Müller's contact glasses
1931	Stoewer jr.	Erfahrungen mit Müllerschen Kontaktschalen zur Korrektion hochgradigen Ametropien unter besondere Berücksictigung des Keratokonus (Results with Müller's contact shells in the correction of high refractive errors with particular reference to keratoconus)
1931	Wibaut	Müllers Kontaktgläser und Thyroidpräparate bei Keratokonus (Müllers' contact glasses and thyroid preparations in keratoconus)
1931	Baumgärtner	Discussion of Rall's communication: Versuche mit Zeissische Kontaktschalen (Fitting attempts with Zeiss contact shells)
1932	Holmström	Über Kontaktgläser bei Keratokonus mit ungleichmässigen Astigmatismus (Contact glasses in keratoconus with irregular astigmatism)
1934	Braun	Die Korrektion des Keratokonus durch Vorsatzschalen (The correction of keratoconus by contact shells)

Table 21-2
Several key publications dating from 1930 describing the use of blown Müller Brothers (Wiesbaden) contact shells in Continental Europe.

Müller shells were tolerated: "*It is clearly evident that personal sensitivity did not, at least not alone, determine how other wearers, including myself, were able to wear Müller contact shells for hours at a time and without discomfort. The shape of the shell also plays a very important role*." [25]

The same year (1930) the Rumanian ophthalmologist *Nicholas Blatt* (Targus-Mures) presented to the Rumanian Society of Ophthalmology extremely favorable results for the correction of 38 cases of myopia with blown contact shells of *Müller*. [26]

In 1931, *E. Stoewer jun*. of Witten, who had learned how to fit contact glasses at the Ophthalmological Clinic of Breslau, presented six cases of patients affected by keratoconus. During the discussion, *Stoewer* confirmed that the toleration of *Müller* contact shells was superior to that of the *Zeiss* ground contact glasses on condition that the patient devoted patience and time to their fitting. In order to demonstrate this good tolerance of contact glasses, *Stoewer* placed a contact glass in his own right eye. After the meeting, the participants could verify the absence of irritation: "*In order to demonstrate good tolerance, the speaker had placed a contact shell in his right eye about three hours before the start of the meeting. He used no cocaine. He wore it without difficulty for the major part of the session. After removal of the shell by one of the participants, the eye presented no evidence of irritation.*" [27]

The same year (1931), after a communication by *Rall* describing the new Zeiss contact glasses, *Baumgärtner* reported that he had successfully corrected a myopia of 12 diopters by means of *Müller* blown contact shells. However, a year later, he had observed intolerance, as shown by corneal edema and epithelial erosions. Professor *Stock*, who had just left Jena for the Chair at Tübingen, stated once again that, in his opinion, he himself tolerated the *Müller* shells better than those of *Zeiss*. [28]

Also, in 1931, at the Netherlands Society of Ophthalmology, *Wibaut* (Amsterdam) reported a case of improvement in the visual acuity of a patient with keratoconus. This was effected using blown contact glasses made by *Müller* ocularists when they passed through the Amsterdan area. *Holmström* (Sweden) had also had blown corrective shells for five patients with keratoconus at the time of the visit of the *Müller* to his clinic and, after a setback of two years, he reported favorable results, but deplored the difficulties of fitting. [29]

In 1934, *Max Braun* presented a doctoral thesis to the University of Würzburg in which he documented the case of a female patient suffering from keratoconus. She had failed to adapt to *Zeiss* contact shells, but she was successfully fit with blown *Müller* shells. According to the author, these shells filled the four criteria essential for success: good correction of the vision, prolonged wearing time without irritation, no adverse effect on patient's appearance and an orthokeratologic effect resulting in the arrest of keratoconus progression. (30)

In the course of the following years, several opinions regarding the value of blown-glass contact shells were declared or published in European countries other than the German- speaking ones. Their decline seemed irreversible, thus *Gallemaerts* reiterated the reproaches leveled at *Müller* contact glasses: "*Repeat fittings are often necessary for blown contact glasses. This requires a stay of one or two weeks in Wiesbaden under the supervision of a top-notch staff. Secondly, blown contact glasses cannot be polished on their anterior surface to obtain supplementary power*." (31)

In 1937, *Emile Haas* stated the general opinion:

"*To obtain useful results with Müller contact glasses, one has to send the patients to Wiesbaden or own a sufficiently large trial contact glass selection. That means two or three hundred trial contact shells. Add to that, the fitting can be very lengthy. (…) An attentive and ingenious observer will find the means of classifying his trial shells according to shape, weight and optical effect so that he will know how to recognize the type of asymmetry present in a given subject. (…) That is indeed the opinion of the oculists who have fit Müller contact glasses; it's also the opinion of most authors. However, once the contact glass has been selected, adaptation to wear is very rapid*." (32)

Then, in 1938 *Ida Mann* took up the story: "*Even in spite of the high degree of accuracy attained by skilled glassblowers, the optimum optical correction is seldom attained. Trial sets are not made for the surgeon's use, since at least 300 glasses would be required*." (33)

1.3 - Technical Improvements in Müller Brothers Contact Shells

The most important criticism of contact shells made by *Müller Brothers* concerned the imperfection of their optical zones. By contrast, good adaptation and fit of their scleral zones was generally reported. As a result, the firm sought out improvements by using research both into the quality of the glass and the blowing procedure. The original blown shells were manufactured in very soft glass as used for ocular prostheses. The optical zones were not flawless. However attempts to grind the optical zones failed because of internal stresses and poor glass quality.

At a later period in history, *Müller Brothers* tried to manufacture scleral contact shells composed of two qualities of glass. The first was soft glass, which they used for the haptic, the second was a denser crown glass used for the transparent portion. The denser glass was presented as 'flawless glass'. In 1920, *F. E. Müller* referred to this new method of manufacture. After other attempts, *Müller Brothers* also supplied scleral contact shells of which the corneal part was geometrically more perfect because it was partly manufactured by blowing glass in a spherical or asymmetric mold.
Such are still used as a last resource, above all in a case of failure of the *Zeiss* shells where some successes are still reported, e.g. by *Sattler*. (34) The experience acquired has allowed *Müller* of Wiesbaden rapidly to adapt their manufacturing processes to plastic materials and to deliver optically effective shells lighter than those glass shells made by *Zeiss*.

2 - The Dallos Alternative

See table 21-3 page 60

2.1 - Criticismes and Proposals of Dallos

2.1.1 - Dallos' Break-up with Zeiss

Dallos, became dissatisfied with his collaborative agreement with *Zeiss*, because the firm was ever eager to patent his suggestions but never followed his advice. Consequently he broke his connections with the company and pursued his own research projects in the clinical laboratory of the First Ophthalmological Clinic of the Royal Hungarian Péter Pázmány University of Budapest (Professor *Emil von Grosz*).

2.1.2 - The Tholometer

In the meeting of the Hungarian Society of Ophthalmology in June 1930 *Dallos* stated that there did not exist any procedure for measuring the radii of curvature of the haptic zone nor those of the optic zone, whereas the shells of *Zeiss* consist of combinations of these two curvatures. He proposed a device to measure these, which he named the '*Tholometer*'. This resembled the Schiøtz tonometer and it measured with a precision of 0.02 mm, like a spherometer, the height of the distance between the levels of the scleral base and the corneal limbus. During the same era, *Helmbold* had also described a similar device, the '*Sclerokeratometer*'. These instruments allowed an objective approach to measuring the corneal and scleral shapes and represented progress when compared to the subjective and empirical methods recommended by *Zeiss*. The tholometer was also adapted immediately to the measurement of the corneal arrow, then used for measurement of ocular molds and casts. [35]

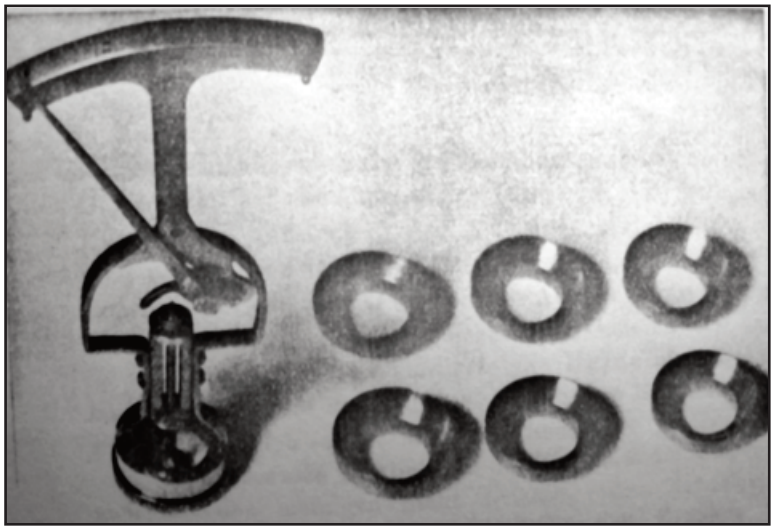


Figure 21-3
The Dallos's Tholometer.
Dallos had a 'tholometer' constructed according to the principle of the Schiotz tonometer:
The first version (shown in the picture) has supporting rings for placing on the base of the sclera and a probe equipped with corresponding rings for placing at the limbus. In this version, the 'tholometer' measures the height (the arrow) of the scleral curvature.
The second version measures the preeminence, the arrow, of the cornea with reference to the limbus. The non-movable calibrated ring is placed at the limbus and the probe touches the summit of the cornea. (Dallos J., 1933).

2.1.3 - The Dioptric Role of the Lachrymal Meniscus

Dallos, while pursuing his researches, was led, in the following year (1931), to criticize the very principle of the *Zeiss* contact shells, where the tear lens has to correct the refractive errors. In raising the height of the corneal part of the contact glass in order to avoid contact with the corneal apex, one introduces a large volume of liquid of which the maintenance requires, a powerful tightening of the scleral portion of the shell. This compresses the ocular globe like a band causing anoxia. It seemed to him absurd to require correction by the tears and not by an optic ground onto the anterior surface of the contact shell. From the experience that he had acquired during fitting of high myopes and aphakes with ground *Zeiss* contact glasses, he drew a double conclusion: first of all, good toleration requires optimum scleral support with a perfect spacing at the corneal level and secondly, the presence of the lachrymal meniscus between the cornea and the shell plays a refractive role, of which the effects are proportional to the difference between the curvature of the cornea and that of the posterior surface of the shell:

"*The series of Zeiss' adherent lenses indicated by Heine permits total correction, even of the highest refractive errors; unfortunately the practical application is not achievable because these adherent glasses differ too much from the ocular configuration and it is this fact that causes the irritations. The adherent glass is an optical prosthesis. One must ensure that it is well supported.*
It is necessary to have a large series of haptic shapes that takes account of the diverse possible shapes of the surface of the globe. On the best-tolerated sample shell thus found one must be able to grind at the center a glass cornea with an optical correction. A risk-free and lasting correction can only be obtained with such contact glasses." (36)

In the course of the following year (1932) *Dallos* deepened his study of the role of the liquid lens, the lachrymal meniscus embedded between the contact lens and the cornea. The liquid lens could be calculated, to a first approximation, starting with the radii of curvature of the corneal surface and the posterior surface of the contact glass. However, the thickness of this embedded liquid could not be predicted and errors of several diopters could result there from this cause. The thickness, a function of the globe and the contact glass, could, in fact, be measured with the tholometer if this were adapted to measure corneal curvatures, scleral curvatures and shells delivered by the manufacturer. However, as the globes are more or less aspherical and the contact glasses are subjected to pressures from the eyelids, numerous uncontrollable variables are introduced. An ideal contact glass should not touch the cornea in its optical part, it should correct the refractive error by the grinding on its anterior surface and not by the lachrymal meniscus. Its scleral part should be adapted to the geometry of the sclera and to the depth of the conjunctival fornices. For the achievement of the perfect shell it would be necessary to take inspiration from models conforming to the geometry of the globe, such as those that had just been achieved by the molding procedure of *Alphons Poller* to which he would return in two months' time.

With this conclusion, *Dallos* was condemning the standard ground contact shells according to *Heine* and he interrupted his collaboration with *Zeiss*. After this break, he engaged in an original path based on the construction of contact glasses of which the optic would be ground and the haptic would reproduce the topography of the ocular sclera obtained from a molding. (37)

2.2 - The Ocular Molding with Poller's Negocoll (1932)

When *Istvan von Csapody* gave an account of his experiments with ocular moldings of the preceding years, first in wax, then in Dentocoll, *Dallos* appeared to show an interest. He did not reveal the result of his researches until after his break with *Zeiss*. Thus it was in June 1932 that he described the procedure of ocular molding destined to procure the widest scleral support that was the most even and closest possible. (38)

Figure 21-4
Poller's Negocoll.
A 5 kg box and a 1 kg box of Negocoll. You see the small, mushy crumbs of the versed content of the box. Beside a small mass aggregative Negocoll, as obtained by the pressing with hand.
(Poller A., 1931)

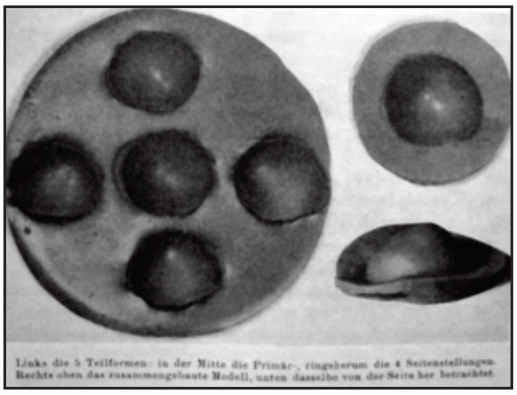


Figure 21-5
Ocular moldings of Dallos in five cardinal directions of gaze.
On the left, the synthetic mold in five cardinal directions of gaze: in the center, the direction of regard is in the primary position, surrounded by moldings in four cardinal directions of gaze. To the right and above: a plunging view of the model, beginning with and consisting of the preceding moldings, side view down below.
(Dallos J., 1933))

He recommended a reconstitution of the ocular topography by means of five moldings. These were to be obtained in the primary position and in four directions of gaze. He was to simplify his technique eventually by limiting it to one sole cast. The employment of Negocoll, as recommended by *Poller*, for taking casts of organic and inorganic objects was to give him the best results:

"*Adherent glasses, i.e. contact shells, must be positioned on the eye in an absolutely accurate fashion, in order for them to be well tolerated for a long period. For the preparation of contact glasses with individual shapes, it is necessary to have models of a large portion of the globe available. With Poller's procedure, Dallos was able to take a molding of the eye in the primary position and in four cardinal directions and, by re-uniting the different components, reconstitute the large surface model desired*". (39)

2.3 - The Synthesis Publication of Dallos (1933)

2.3.1 - The Principles of a Physiologic Contact Shell

All the elements necessary for changing the way of fitting contact glasses were brought together by *Dallos* and united in a synthesis. This was presented in July 1933 and then, a month later, published in German. The result was a seminal work, 18 pages long, that was to act as a reference for many a long year. (40)
Dallos rejected the *Zeiss* contact shells, even after these had been modified and improved according to his earlier proposals, because of their unphysiological behavior. This also applied to the new *Zeiss-Heine* contact glasses because of their inadequacy from the viewpoint of optics and physiology and of which the wearing time did not go beyond 3 or 4 hours. All eyes are different and it is therefore impossible to fit every eye by using stereotyped contact shells. These criticisms applied also to the recent *Müller-Welt* contact shells because they were only a poor imitation of the *Zeiss* ground contact glasses. He regretted that the optics of the blown and better-tolerated contact glasses of *Müller Brothers* did not produce significantly better vision.
Dallos stated two essential requirements for an ideal corneo-scleral contact shell: a broad scleral support and a thin and regular pre-corneal tear meniscus. In order to achieve this ideal, he recommended a contact shell in which the haptic part was molded and the corneal zone was ground.

2.3.2 - The Ocular Molding

The molding of the contact glass was done using a metal contratype; the method of its fabrication was not, however, divulged by *Dallos*. In his publication, he stated that *Csapody*'s procedure using paraffin wax for molding was unsuited to this purpose and therefore could not be used:

"*For the molding, I have not been able to use the interesting procedure of Csapody. This was because of the requirement not to deform the conjunctiva, either by changing the pressure (tube etc.) or pulling (lid retractor etc). It was necessary to find a substance that would produce the thinnest plastic layer possible against the conjunctiva and solidify quickly. Plaster and other derived substances cannot be used because of risk to the conjunctiva. Wax, paraffin and materials of that sort that only solidify at certain temperatures present thermal risks for the eye. I therefore addressed my attention to colloidal products.*" (41)

Dallos applied the recommendations of *Poller*, namely to use Negocoll for the mold and Hominit for the cast. Negocoll is a hydrocolloid that dissolves in boiling water to form a homogeneous mass of paste. When it cools to body temperature, it solidifies in 30 to 60 seconds into a mass that reproduces the smallest nuances, at the same time keeping an elastic consistency:

"*In order to take a mold of the ocular globe, I use a Müller shell of approximately the right size that I half fill with Negocoll paste which I knead with my finger all the time. Then I let it cool to ambient temperature. Next, I introduce the contact glass filled with Negocoll into the cocainized eye. One part of the Negocoll remains between the shell and the eye, the remainder runs out and is used as a reference mark. After the shell has been inserted, the patient is asked to look in the chosen direction until the moment when the Negocoll that has run out solidifies. After several seconds, the glass with the layer of Negocoll adherent to it is carefully*

removed and is immediately treated with the positive material 'Hominit'. The contact shell serves as a rigid support for the easily deformed lamella of Negocoll that otherwise would be rapidly dried out in the air and would lose its shape." (42)

2.3.3 - The Positive Cast

Starting with the mold, *Dallos* manufactured a positive cast, the surface of which reproduced exactly that of the ocular globe: "*I always place a marker on the exterior part of the positive. When the taking of the molding has been successful, the positive contratype presents a glistening cornea with well-defined borders and a smooth conjunctiva without folds. The transition between cornea and conjunctiva is continuous, the surface of the model has a particular curvature almost regular, but which differs according to the different meridians. The surface of the eye does not therefore consist of a surface that revolves; For that reason, it has nothing in common with the geometry of two spherical surfaces in which the one slides within the other*." (43)

In order to obtain a better impression and a true profile of the eyeball, *Dallos* completed his molding of the eye in the primary position with four other moldings in the cardinal directions of gaze: "*I noted that it is difficult to draw reliable conclusions starting with measurement of a unique central molding, comprising in his centre the cornea and 6 to 10 mm in width around a sclera, i.e. conjunctiva. For, from the beginning, I tried to obtain the largest possible molded model of the eyeball (the theory requires, in fact, that a regular distribution of the pressure be proportional to the surface of the haptic part of the glass). When I saw that a unique molding thus obtained is not sufficient to appreciate the distribution of the pressure of the internal surface of the glass on the surface of he eyeball, I decided to supplement my first molding. I had the patient look in different directions and I carried out a molding in each of these directions. On these moldings, the cornea is in an eccentric position (at the present time, I use contact shells constructed to allow for this) and a quadrant of the surface of the eyeball is very broadly visualized over a particular large surface*." (44)

Finally, he put together the four peripheral components around the central molding to produce a model that gave him an overall view of the ocular topography. He concluded: "*Even the scleral periphery is still covered by elastic, thickened, conjunctival tissue with folds*."

Dallos confirmed the reproducibility of his molding procedure by carrying out several casts on the same eye. The results of these were identical.

2.3.4 - Contact Lenses from Ocular Molds

The following procedural step led him to find a preparation procedure for contact lenses, starting with the casts. He did not consider using the *Zeiss* ground-glass procedure or blowing shells in a mold, as did *Müller-Welt*. He approached several glass-making establishments unsuccessfully before finally carrying out the experiments by himself with the assistance of several collaborators. (45)

2.3.5 - The Criticisms and the Eulogies

This publication by *Dallos* shocked the traditional fitters. His conclusions would be criticized by *Victor Much* who, referring to his experience of more than 500 fittings at *Heine*'s Clinic in Kiel emphasized the successes that he had obtained as far as visual comfort was concerned and in duration of wearing time. *Much* defended particularly the *Müller-Welt* contact shells of which the new models were superior to those of *Zeiss* and possessed an orthopedic effect in addition, that he attributed to the relative elasticity of the glass. He criticized *Dallos* for basing his criticisms on the first models of *Zeiss* and *Müller-Welt*, which were at the present time outdated. (46)
Another controversy with *Müller-Welt* was to cause several published letter exchanges in the journals.
Burned by his collaboration with *Zeiss*, who were eager to patent his suggestions, *Dallos* kept his technique of manufacturing molded contact glasses as a secret. He initiated several physicians including *Thier* (Utrecht) and *Sattler* (Königsberg) into the technique of molding, but required that the positive casts of these moldings be sent to him for the preparation of the contact glasses. This step was not without its problems because of the numerous returns necessary for touch-ups. Shortly after that, *Thier* developed his own tech-

nique for manufacturing contact glasses, while *Sattler* had a technician trained to carry out touch-ups. Then, shortly after, *Dallos* emigrated to London, where he found the necessary support to pursue his researches on moldings and the manufacture of contact lenses individualized for each patient.

2.3.6 - The Physiological Contact Shells

In the following year, (June 1934), *Dallos* refined his procedure for the preparation of physiological contact shells with ground optics. After numerous experiments, he concluded that scleral support obtained from accurate and reliable molding with Negocoll produced contact that was so intimate that it prevented lachrymal exchange. He recommended therefore to retouch the contact shells obtained by molding in order to permit the passage of tears towards the limbus by means of a breathing zone (zone of respiration) at the supero-temporal sector of each shell, while limiting the haptic support to the supero-medial and infero-lateral sectors. He confirmed his idea of almost perfect tolerance of the contact shells by perforating them at the level of the limbus and providing lachrymal circulation channels at their periphery. These modifications avoided the appearance of corneal edema and the syndrome of corneal anoxia with visual veil, described in the following year by *Sattler* [47]:

"*Moldings with Negocoll without compression of the living eye produce models which correspond exactly to the surface of the cornea and the scleral conjunctiva. Experiments have shown that the conditions for a non-irritative contact glass that does not cause irritation are the following: surfaces of support: 'above and in' and 'above and out'; contact surface: 'in and below'; zone of respiration at the limbus and 'above and out'. The center of the cornea generally tolerates light contact with the contact glass. If the pressure is thus divided in a regular manner between cornea and sclera, the wearing of the contact glass is not only not irritating, but also free of a veil*." [48]

2.3.7 - Shells for Special Indications

There remained need to adapt the contact shells for special indications, e.g. albinism and macular degeneration. For the first indication, *Dallos* had ground an optic in a blown glass shells for albinos of *Müller-Brothers* who had great experience of these indications. However, optical grinding of blown contact shells was considered unachievable at that epoch. *Zeiss* had always claimed that the attempts to grind and to polish blown shells had failed. For *Dallos*, these allegations were erroneous, "*for the two firms had at the time every interest in demonstrating the superiority of their own products*." [49] In order to obtain the enlargement of the retinal image of partially-sighted individuals, *Dallos* prescribed for each eye a concave contact lens with a convex spectacle lens, which was a more discrete solution and one which gave a field of vision that was more enlarged than telescopic glasses.

2.3.8 - Testimonies about Dallos' Efficiency

The fame of *Dallos* soon passed across the frontiers of Hungary as his method of producing molded sclero-corneal shells became more and more established. He collaborated with Ophthalmology Clinics in Vienna, Utrecht, London and Geneva as well as in North and South America. [50] The laboratory of *Dallos* at the University Ophthalmology Clinic in Budapest received numerous visiting ophthalmologists, of which *Carl H. Sattler* (Königsberg), *Andrew Rugg-Gunn*, *Frederick A. Williamson-Noble*, *Ida Mann* (of London) and *Theo E. Obrig* (of New-York) were the most noteworthy. Then, there were others like *P. F. X. Thier* (Utrecht) and others again who shared with *Dallos* the manufacture of contact shells following moldings that they had learned from him how to perform.

At the Vienna Ophthalmological Society, *F. Ramach* provided evidence that he had also visited *Dallos* in Budapest the year before and that he too used the *Dallos* procedure. However, he recommended recourse to the molded lenses only in the case of failure of the *Zeiss* contact shells, because the procedure of their manufacture was necessarily so fastidious and therefore expensive. During the discussion, *Proksch* announced good results with the new contact glasses of *Zeiss*, except in cases of aphakia. *Lindner* reported his failures with *Zeiss* contact glasses and then switched to the blown contact glasses of *Müller*. *Kafkas* was very

satisfied with *Zeiss* contact glasses. *Sachs* wondered why *Dallos* recommended a quasi-contact between the cornea and the contact glass. (51)

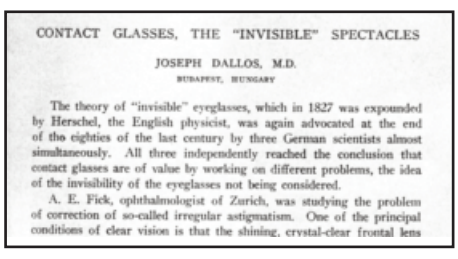
Other testimonies to the success and efficiency of the *Dallos* contact glasses as compared with those of *Zeiss* followed. Thus it was that the Polish ophthalmologist *Filip Wachtel* reported that only the *Dallos* contact lenses completely restored his vision and that they could be worn all day long. (52)

One of his visitors in Budapest was *Theodor Obrig* (New York). He left us a personal testimony of his visit to *Dallos* in July 1936:

"*He (Dallos) then proceeded to demonstrate the preparation of Negocoll and Hominit. Negocoll, which is a colloid kept moist and which resembles yellow milk chocolate in appearance is slowly heated over a Bunsen burner in a porcelain container until the bubbles are homogeneous and it becomes viscous.*
The patient lies on an operating table. Several drops of 1% or 5% cocaine are instilled several times. A large contact glass is filled with the Negocoll, which has been allowed to cool to room temperature, and worked up with the finger to an even consistency. One drop of cocaine is put in the other eye as it must fixate [a target] for 3 seconds when the cast is taken.
A contact glass is selected that approximates as closely as possible to the configuration of the eye. With the contact glass filled with the viscid, room-cooled Negocoll [and] held between the thumb, index and middle finger, the fourth finger pulls down the lower lid.
With the temporal side of the contact glass downwards, the patient looks down and the lens is then placed under the upper lid and the contact glass is turned 90° so that the temporal side of the glass is towards the external canthus.
These movements are continuous and almost simultaneous.
A firm cast of the cornea and of the sclera is then taken. As the eye is in primary [position], this is the negative mold. The Hominit for the positive mold resembles or is paraffin. It has been heated in a porcelain container. With a large bristle brush, it is placed, layer-by-layer, within the negative mold. To make the cast strong, it is built up with a thin layer of absorbent cotton covered over with Hominit, then another layer of cotton, then Hominit. The negative mold of Negocoll is separated from the large contact glass with a surgical curette or spoon. After the Hominit has been molded into the Negocoll cast, it is placed face downward in cold water to prevent distortion due to contraction and retraction.
When the Hominit is hardened, it is easily separated from the Negocoll cast. A plaster replica is fashioned for the manufacture of the contact glass." (53)

2.4 - Contact Glasses, the 'Invisible Spectacles'

In 1935, *Dallos* published in Hungarian a new paper on his researches under the title 'A làthatatlan contact szemüveg'. The English translation was published in the following year in Archives of Ophthalmology under the title '*Contact Glasses. The Invisible Spectacles*'. This was going to make his technique and his name known all over the world. (54)

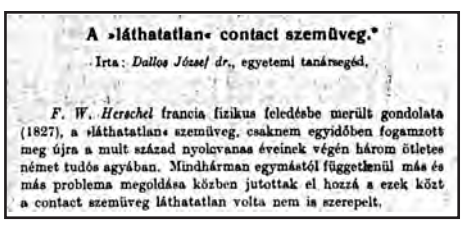


CONTACT GLASSES, THE "INVISIBLE" SPECTACLES

JOSEPH DALLOS, M.D.
BUDAPEST, HUNGARY

The theory of "invisible" eyeglasses, which in 1827 was expounded by Herschel, the English physicist, was again advocated at the end of the eighties of the last century by three German scientists almost simultaneously. All three independently reached the conclusion that contact glasses are of value by working on different problems, the idea of the invisibility of the eyeglasses not being considered.

A. E. Fick, ophthalmologist of Zurich, was studying the problem of correction of so-called irregular astigmatism. One of the principal conditions of clear vision is that the shining, crystal-clear frontal lens



A »láthatatlan« contact szemüveg.*

Irta: *Dallos József dr.*, egyetemi tanársegéd.

F. W. Herschel francia fizikus feledésbe merült gondolata (1827), a »láthatatlan« szemüveg, csaknem egyidőben fogamzott meg újra a mult század nyolcvanas éveinek végén három ötletes német tudós agyában. Mindhárman egymástól függetlenül más és más problema megoldása közben jutottak el hozzá a ezek közt a contact szemüveg láthatatlan volta nem is szerepelt.

Figure 21-6
'A làthalan Contact Szemüveg' & 'The Invisible Spectacles'.
The original version in Hungarian , 'A Làthatalan Contact Szemüveg', was published in 1935. Its English translation appeared in 1936 in Archives of Ophthalmology. It is to be noted that, in the original version, Dallos attributed French nationality to Herschel, but rectified his error in the English translation. (Dallos J., 1935, 1936)

In this remarkable publication, *Dallos* first presented a historical survey of the evolution of contact glasses, where he described the *Zeiss* contact shells intended for keratoconus, then the modifications following *Heine*:

"*But, in spite of the innumerable combinations of curvatures, sizes and sha-*

pes of these contact glasses, their use is satisfactory only in rare patients. At Kiel University Ophthalmological Clinic, where there is a series of over 300 different types of ground contact glasses (valued at $10,000), only a very small percentage of those who desire contact glasses can be satisfied."

Then *Dallos* described the causes of these failures:

"*On the surface of the eyeball, only the center of the cornea approaches the surface of a sphere and then it flattens out towards the limbus, while, on the boundary with the sclera, it continues evenly towards the gradually flattening curve of the protective bulbar conjunctiva. The ground spherical contact glasses do not and cannot satisfy these requirements, because the eyeball is not a sphere*."

These facts have become known, particularly since eyeball moldings had been done, notably his own moldings with *Poller*'s Negocoll:

"*In 1932, I succeeded in finding Poller's Negocoll, which is a material suitable for the purpose of making perfect casts. I also devised a method of making such casts. (…) The procedure is not any more unpleasant than the methods used in dentistry*."

At the bacteriology laboratory of the Budapest Ophthalmology Clinic and, with the aid of the Széchenyl Scientific Society and after many attempts, he was able to prepare glass shells that corresponded to ocular molds and were tolerated. This necessitated "*thousands of experiments through a systematic change in the shape of the shells*". Each shell is made on an individual basis and according to the mold and the desired refractive correction. *Dallos* concluded with the following words: "*A glass of this type can readily be worn continuously throughout the whole day*."

2.5 - Dallos in London

One of the most interested visitors to the Budapest Laboratory was *Ida Mann*, Professor of Ophthalmology in London. She too was dissatisfied with the fitting procedures recommended by *Zeiss* and it was she who persuaded *Dallos* to emigrate to Great Britain.
Concerned about the political evolution in Continental Europe, he established himself in London in 1937. His family and his technician and brother-in-law *George Nissel* accompanied him. He first worked in London with *Hamblin* opticians, then independently with *Nissel* and the support of the Ophthalmology Clinics of London. He brought the Hamblin Contact Lens Clinic to life, at the same time being appointed to the newly established Eye Department at Moorfields as a contact lens specialist.
In 1937, *Dallos* presented his first communication in Great Britain: *'The Individual Fitting of Contact Lenses*'. In this paper, he insisted that a well-tolerated contact shell had to correspond with the mold of the eye. He described all the details of this: start with a Negocoll mold, make a positive cast in Hominit and derive from the latter a model in metal on which the glass is molded. A glass that conforms hardly touches the corneal summit and rests on the sclera without pressing on it with its margin. The limbus and the contact glass margin require a reasonable clearance. The fitting procedure requires about 15 days along with more or less an hour of daily tries in order to avoid symptoms of irritation. Finally, the fitter marks the optical centre of the contact glass which is then given to the technician to make an exact copy in polished glass with the desired refractive correction. When the fitter receives the final contact glass, there follows a period of surveillance in which he checks for possible areas of corneal edema, patches of vascularization and symptoms and signs of irritation. During the discussion *Williamson-Noble*, *Ida Mann* and *Rugg-Gunn* congratulated *Dallos*. They wished to recognize his merit, his courage and his passion for making contact lenses usable in every day practice. [55]

In 1940, *Dallos* published with *Williamson-Noble* and *Ida Mann* a paper on correcting the refractive error in four patients using contact shells with an anterior sphero-cylindric optical grind. Correction of residual astigmatism had been imperfect or impossible using contact shells with a spherical surface. [56] It should be noted that *Dallos* was granted a conjoint medical qualification (MRCS & LRCP) with all the prerogative-

thereunto appertaining. At the request of *Mann*, he had also fit 84 patients, whose corneas had been burned by mustard gas during World War I. Almost all of these patients had been improved, according to their publication which appeared in 1944. (57)

After the utilization more or less generalized of plastic materials and in spite of the fact that he recognized in them certain advantages and also made use of them on occasions, *Dallos* continued to place his trust in glass. This contributed probably to his later separation from *Hamblin* Opticians and led to his installation independently in order to pursue his researches and the meticulous and fastidious manufacture of glass contact shells. (58)

2.6 - Sattler's Veil, Fenestration and Corneal Respiration

In 1946, *Dallos* drew attention to '*Sattler*'s Veil'. After referring back to his earlier publications, he insisted on the importance of the lachrymal layer in his experience of 2.000 fittings. (59) He recalled the description in 1935 by *C.H. Sattler* (Königsberg) of a 'veil', which often appeared after two hours of wear of a contact shell and then disappeared 20 minutes after its removal. He was witnessing what he described as 'internal suffocation', due to blockage of nutrition by the tears. Indeed, the veil did not occur when the eye was bandaged, or when the eyelids were closed during sleep. Certainly, there were individual variations, but well-fitted contact glasses provoked veils to a lesser extent. Aside from individual fitting, *Dallos* recommended, the placement of perforations and channels to counteract anoxia: "*I am confident that ways will be found, perhaps through a combination of air pockets, channels and holes (…) to overcome this last minor trouble with contact glasses*."

It was reported that, at the time of doing a final polishing, *Dallos*' technician accidentally drilled an orifice in the contact shell of a patient affected by keratoconus. *Dallos* polished the edges of the hole and returned it to the patient with his apologies, while waiting for an urgent replacement. When that patient came back only after several months and *Dallos* did not observe any signs of local irritation, he deduced that his theory was correct, likewise his understanding that corneal edema and the visual veil were due to defective lachrymal circulation. From that time on, he frequently placed a ventilation orifice in the form of a "*limbal hole in the superior flange*". (60)

It is noteworthy that, since 1934, *Dallos* was convinced of the importance of the circulation of tears. He had already described the regression of corneal edema under shells provided with ventilation orifices and channels. (61) When, at a later date, the idea became more widely known and disseminated, particularly by *Bier*, namely, that the systematic positioning of perforations could prolong the tolerance of contact glasses and eliminate the corneal edema (62), *Dallos* recalled that the ventilation of contact shells was only a 'better than nothing' or 'make-do' solution. It was more worthwhile to avoid bad fittings than remedy the consequences of these. Individual fittings were, in fact, later accompanied by moderate and rational usage of perforations and canals. (63)

When corneal contact lenses had made their triumphant entrance, *Dallos* stated in 1964 that their "*great advantage over haptic lenses is the potential total non-interference with the bulbar conjunctiva*".

Nevertheless:

"*Corneal consequences, both epithelial in various stages and clinical appearances (from veiling to erosion) and interstitial (keratoxys, warping) are frequent and much more difficult to avoid than with haptic lenses. (…) Corneal fitting has today reached a stage analogous to Heine's multi-curve combination in the Zeiss type of spherical sclero-corneal contact lenses. They are a marked improvement on single curve variations, but suffer from a basic anatomical inaccuracy, inherent in the geometrical conception of their design.*" (64)

Dallos proposed that the corneal lenses be equally in conformity, physiologically speaking, with the corneal

profile. As he stated, "*any deviation from uniform anatomical co-adaptation (flush-fitting) inhibits fluid exchange*." Taking corneal molds was the only way of reaching this objective. *Dallos* was, however, not to become adept with corneal lenses nor with polymethyl methacrylate (pmma) and would remain faithful to his belief in glass corneo-scleral shells. This was because they responded best to the needs of his clientele, which consisted mainly of patients with pathological conditions.

In 1967, he described a suction holder with an illuminated component for the insertion and removal of corneal lenses of small diameter. Then, in 1969, *Dallos* presented a historical retrospective giving his thoughts on the achievements of his career and the evolution of sclero-corneal shells. He delivered a very critical assessment regarding the evolution of contact glasses, because these had been taken over by commercial interests and were now so easy, cheap and effortless to manufacture from the new plastic materials. This was against a background of proclamations that intolerance could be resolved by using solutions. (65) This document of 13 pages represented a true synthesis of *Dallos*'s work and a plea for glass contact lenses:

"*With good ventilation, tolerance depends on the precision of the fittings. Inadequately or approximately fitted ventilated lenses are not comfortable, whereas precision fitting invariably results in uneventful tolerance. Precision fitting can only be achieved with glass, not with plastic material*."

The advent of hydrophilic contact lenses gave *Dallos* a new opportunity to emphasize the basics of contact lens fitting. Because of the infection risk, he recommended heat sterilization. He described his conception of an automatic asepticizer that he named '*pasteurizer*' because it did not heat the lenses beyond 72° C. He confirmed his statements by tests on contaminated lenses. (66) In 1979, several weeks before his death, *Dallos* gave his last lecture. In this, he railed against the idea, currently expressed, that the cornea breathed oxygen from the air. (67) Everybody knew, however, that an eye could remain hermetically sealed by a tight bandage during days or weeks without there being any evidence of signs of anoxia. This was because the cornea receives its nutrition and eliminates its waste products starting with tears at the limbus and via the conjunctival vascular network and lymphatics. The corneal epithelium has no relationship, whatsoever, with pulmonary alveoli. On the other hand after a few hours, every interruption of the lachrymal circulation isolates the cornea and interferes with energy transport and waste elimination, causing local physico-chemical disturbances with their familiar symptomatology. Replacing a contact lens by another of identical geometry, but gas-permeable, is the same as placing a uremic patient in an oxygen tent instead of connecting that patient to an artificial kidney. *Dallos* illustrated his remarks in a very realistic manner: on his right eye, he placed a non-ventilated corneo-scleral shell and, simultaneously, occluded his left eye with a hermetically sealed dressing for 24 hours. After the session he removed both and had his audience observe that the cornea of his right eye was edematous, whereas the fellow eye, although hermetically sealed for 24 hours, showed no sign of pathological disturbance. Thus it was, with a true spiritual testament, that *Dallos* addressed his audience, inviting its members not to renounce scientific reasoning and distance themselves from all kinds of anecdotal treatments. These only covered up ignorance and served commercial interests. (68) Until the last days of his life, *Dallos* maintained his trust in glass, which he considered it to be the most perfect of materials. It should therefore not be replaced by alternatives from the 'new materials'.

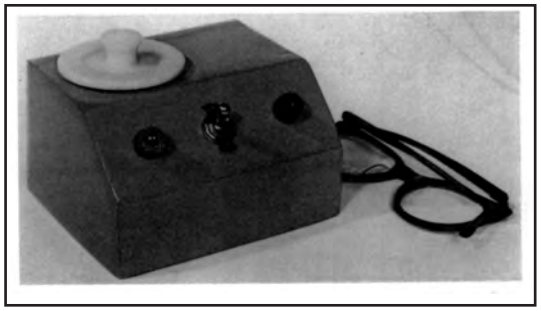


Figure 21-7
Dallos's 'Pasteurizer'.
In 1972, Dallos described a 'pasteurizer' for the routine overnight sterilization of hydrophilic lenses. He preferred this to chemical methods of disinfection.
(Dallos J., Hughes W.H., 1972)

3 - The Müller-Welt Glass Scleral Contact Lenses

3.1 - The First Patents

Figure 21-8
Müller-Welt 'Corneo-Scleralschalen'
Müller-Welt (Stuttgart) corneo-scleral shells. Radius of the scleral part: 11.5 mm; radius of the posterior corneal part: 43 mm; radius of the anterior corneal part: between 41 and 42 mm
(Collection Victor Much)

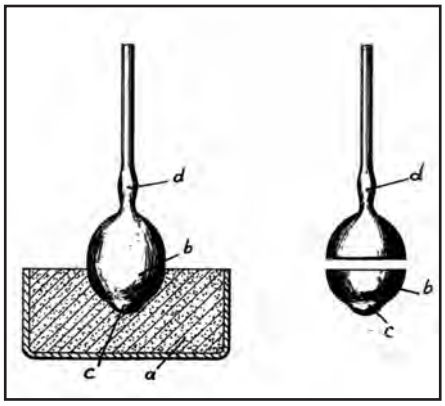


Figure 21-9
Extract of the Müller-Welt patent for the manufacture of blown contact glasses in a mold.
This patent, registered in 1930, covers the principle of the manufacture of glass corneo-scleral shells by blowing glass in a mold. The mold is of metal, porcelain or other material. The lateral view of the mold corresponds with the lateral view of the human eyeball and has a fitted scleral part and a spherical corneal part. The molding is performed following traditional glass-blowing techniques.
(Mueller-Welt Gebr., 1930)

The *Müller-Welt Brothers*, who were descendants of the glass-blowers *Müller* of Lauscha too, had moved from their native Thuringia to Wiesbaden before establishing themselves in Stuttgart, where they created a manufacturing facility for the production of ocular prostheses. Being of an inventive disposition, they had been introduced to and were on good terms with the German ophthalmological clinics. Notably, they had registered in 1925 a patent for and then marketed contact shells for ptosis equipped with two spurs or a prong for retaining the margin of a paralyzed lid. In addition, they had blown glass shells that were equipped with a hollow tube in their centre that was suitable for the ocular perfusion of therapeutic agents. [69]

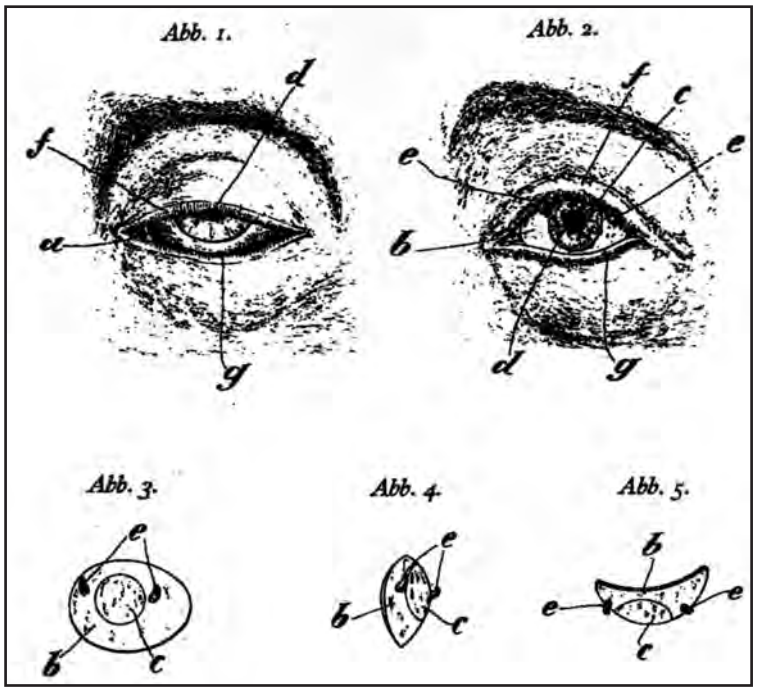


Figure 21-10
Müller-Welt patent: contact shell with 'crutches' (prongs) for blepharoptosis.
This patent, registered in 1925, deals with the principle of supporting the upper eyelid in a patient with blepharoptosis due to paralysis of the levator palpebrae superioris, by using two or more 'crutches' (prongs) fixed to the corneo-scleral shell.
(Mueller-Welt Gebr., 1925)

From 1930, one of the brothers, *Adolph Müller-Welt*, also manufactured scleral glass contact shells. With the aim of rationalizing production, improving optical quality and reproducibility, and anticipating future mass production, *Adolph Müller-Welt* invested large sums of money into his research. This pioneer skimped neither on the expenditure of his own financial resources nor on the amount of his personal time given to research. His efforts culminated in the registration of an application for a patent for manufacturing contact lenses. [70] The patent protected the manufacturing process and the devices for the carrying out of that process. The process consisted of blowing the melted glass bubbles into a calibrated mold, the geometric parameters of which were transmitted to the anterior surface of the glass bubble.

Cutting the glass bubble off and polishing its edge was to give the geometrical specifications of the contact lens without further modification:

"*The basic material for the manufacture of the shells consists of acid-resistant rock-crystal glass, which, in the form of a heated glass tube, (…) is blown in a mold or matrix corresponding with the desired shape of the adherent glass (Haftglas).*" (71)

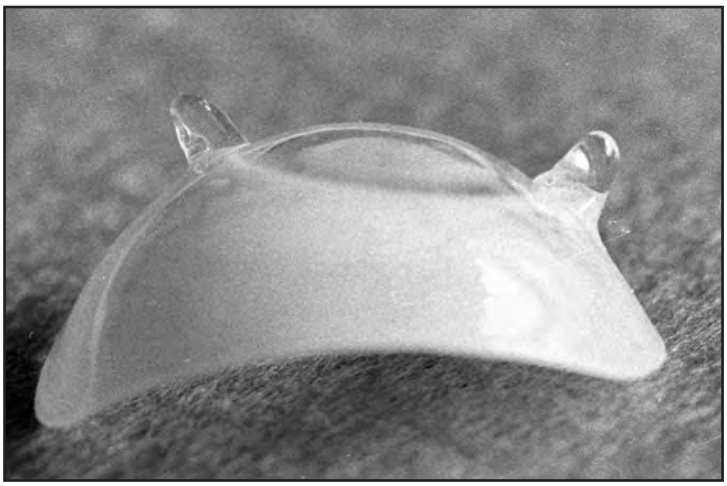


Figure 21-11
Müller-Welt glass corneo-scleral shell for blepharoptosis.
This glass shell has two prongs (crutches) in the upper third of the anterior surface in order to support the upper eyelid in a patient with paralytic blepharoptosis. (Collection Victor Much)

The authors expected significant advantages from this:

"*The most significant advantage of the process that has been presented is based on the fact that it is possible to prepare blown adherent glasses (Haftgläser) with these molds that possess an optical precision such as is usual for spectacle glasses. The same glass can be manufactured in large numbers in a precisely corresponding manner. In the event of an order for replacement, the physician will always receive the same contact glass, identified by precise numbering of the corneal and scleral size that will be placed permanently on the lenses*." (72)

It is to be noted that *Zeiss* had obtained in the same era a patent for an almost identical procedure for the manufacture of a contact shell by blowing a bubble of glass against a molding of the anterior segment of the eyeball. (73) As a result, a lawsuit was launched by *Zeiss* that obliged *Müller-Welt* to modify their procedures several times in regard to the manufacture and geometry of their contact shells.

3.2 - The First Generation of Müller-Welt Contact Shells (1932-1934)

A first generation of these scleral contact shells blown onto a molding cup was marketed with three anterior scleral radii, namely 11.00 mm, 12.00 mm and 13.00 mm as well as a large range of anterior optic zone radii. As for the *Müller-Wiesbaden* and the *Zeiss* contact glasses of this era, the 'fluid lens' made the optical correction. In 1932, *J. Strebel* (Lucerne), in his study of anterior scleral asymmetry declared that he had recently and successfully been using "*adherent glasses with an exactly spherical center but an asymmetrical periphery of Müller-Welt Brothers of Stuttgart. These were extremely light, were blown in molds and could be inserted in good position by light massage on the eyelids*." (74)

The pieces of evidence available in the literature regarding this first generation of *Müller-Welt* contact shells are relatively limited. In 1934, *Müller-Welt* presented a demonstration for ophthalmologists of the 'new corneo-scleral shells':

"*These items represent an innovation in the field of adherent glasses because the advantage of an optically defect-free corneal curvature of ground adherent glasses is combined with the irregular scleral curvature of blown contact shells. The ordering process is thereby simplified, in that it is referred to according to the refractive power of the corneal curvature in diopters and only three different scleral sizes, a small, a middle-sized and a large are differentiated. With the data on corneal curvature read in diopters from the Javal ophthalmometer and the specification of the subjective or objective correction plus the size of the globe as determined, a choice of corneo-scleral shell is available from the manufacturing firm for ordering without further information. The price for one shell is RM 25-.*" (75)

Presentation	*Publication*	*Title*
08.03.1929	1929	Discussion in Fésüs (Müllersche Kontaktgläser) (Discussion in Fésüs regarding Müller's contact glasses)
29.11.1929	1930 a, b	Über die Kontaktschalen (About contact shells)
28.06.1930	1931 a	Korrektion hochgradiger Myopie durch Haftgläser mit drei Flächen (Correction of high-grade myopia by adherent glasses with three surfaces)
28.06.1930	1931 b, c	Das Tholometer, ein Apparat zur Messung der relativen Wölbung der Hornhaut (The tholometer, an instrument for measuring the relative vault of the cornea)
07.06.1931	1931d	Haftglaskorrektion von Ametropien (Correction of ametropias by adherent glasses)
19.03.1932	1932a	Über den Einfluss der Form der Haftgläser auf ihren Korrektionswert (About the effect of the shape of the adherent glasses on their refractive correction)
10.05.1932	1932b	Bulbusmodelle (Models of the eyeball)
19.07.1933	1933a	Neue Kontaktgläser (New contact glasses)
	1933 b	Über Haftgläser und Kontaktschalen (Adherent glasses and contact shells)
02.06.1934	1934a	Versuche über Haptik der gebogenen Kontaktschalen (Experiments on the haptics of curved contact shells)
02.06.1934	1934 b	Müllersche Lichtschutzschalen für Albinotiker mit geschliffener Optik (Müller's light-protecting shells with ground optics for albinos)
02.06.1934	1934c	Halbstare afokale Systeme (Half-rigid afocal systems)
	1934 d	Entgegnung (zur Firma Müller-Welt) (Reply to Müller-Welt Company)
	1935	A 'lathalan' contact szemüveg (An invisible contact spectacle)
	1936	Contact Glasses. The invisible Spectacles
08.06.1937	1938	The Individual Fitting of Contact Glasses
	1940	Spherocylindrical Contact Lens (with Williamson-Noble and Ida Mann)
	1946	Sattler's Veil
	1954	Ventilated Glass Contact Lenses
	1956	Dallos's Contact Lens
	1964	Individually fitted Contact Lenses made by means of Corneal Molds
	1967	Suction Holder for Insertion and Removal of Contact Lenses
	1969	Über Hornhaut-Linsen und Kontaktgläser (Corneal lenses and contact glasses)
	1972	Sterilization of Hydrophilic Contact Lenses using Hughes Asepticizer
	1979	The Myth of Oxygen Permeability

Table 21-3
Synopsis of the fundamental publications of Joseph Dallos.

In the same year, a controversy developed between *Dallos* and *Müller-Welt*. In a publication describing the technique he had invented for the manufacture of molded contact lenses, *Dallos* published a virulent criticism of *Müller-Welt* contact shells:

"*For this reason, the description of the corneo-scleral shell of Müller-Welt is also false as it describes a 'round, oval or kidney-shaped curvature', although we are concerned with, in fact, only lenses with round, oval or kidney-shaped edges and a spherical curvature. (…) The imperfection of the corneo-scleral shells is the result of the technique used for their manufacture: the front surface of the glass is made according to the negative model. The back haptic surface bears no resemblance to the front surface and it cannot be measured, as the thickness of the glass diminishes progressively from the periphery towards the center at the time of blowing, this being truer the thicker the lens becomes. For this reason, all these lenses have a negative refractive power,*

depending on their thicknesses.„ [76]
Müller-Welt presented their viewpoint under the title 'Rectification' (Richtigstellung). Firstly, they described numerous geometrical possibilities for their scleral contact shells:

"*The shell lives up to expectations in every degree. It combines the advantages of two manufacturing procedures: the absolutely spherical corneal curvature of ground contact glasses and the aspheric scleral curvature of blown 'adherent glasses'. Thanks to the possibility of modification of its negative, the scleral curvature can be curved in all of the meridians as required by the respective eyeball shapes, i.e. the outer curvature can be brought to correspond with one meridian, two opposite meridians, several different meridians, or with all meridians and, at the same time, to correspond with all of the actions of the extrinsic ocular muscles, depending on need and tolerance*." [77]

Secondly, they insisted on innovation regarding optical properties and the absence of internal tension, hence the risk of breakage:

"*As far as the optical part is concerned, the corneal portion of the corneo-scleral shell is absolutely spherical far outside the pupillary area. No greater risk of breakage results from it; on the contrary, we improve the resistance to breakage, which lies solely in the difference of tension inside the glass after the manufacturing procedure. We achieve this by submitting each shell to a second process that rids it of internal tension*." [78]

Finally, they justified the geometry of the edge and the design:

"*The shape of the edge of the corneo-scleral shell is determined either by the line of section of a plane perpendicular to the axis of the scleral curvature, or it is chosen according to the shape of the edge of the ocular prosthesis. But the edge is always made smoothed and rounded.*" [79]

Dallos replied that, as far as the scleral zone of these corneo-scleral shells was concerned, his measurements failed to confirm the curvatures stated by the manufacturers [80]:

"*The haptic: In the series at my disposal, the scleral part is spherical, as is the case with the Zeiss adherent glasses; likewise, the description indicates the variations in the scleral zone in units of spherical radii and does not describe an asphericity generated according to requirements and need. The finish of the edge leaves a lot to be desired. The transition between the corneal and scleral parts is an annular impression and so it presses at the level of the limbus, where the majority of eyes are the most sensitive*." [81]

Then *Dallos* goes on to criticize the fact that the optic zone is referred to by the radius of curvature of the front surface and not by the radius of the back surface, which touches the cornea. It is evident that blowing of glass in a concave mold could only produce a convex copy of the curvature of the anterior optical and haptic lens surfaces:

"*Optical Aspects: The indication of the front radius of curvature is insufficient. The optical effects of the glass are determined in part by the characteristics that are indicated in the Zeiss adherent lenses, i.e 1) the back corneal radius, 2) the refractive power of the lens in air and, partially, 3) by the height of the 'arrow' (the thickness of the tear lens). (...) For this reason, the spherical correction must always be ground on the outer surface of a contact glass that has been exactly modeled on the inside haptic*." [82]

3.3 - The Renewal of Müller-Welt Contact Shells (1935)

Müller-Welt Brothers registered new patents shortly afterwards. The first patent was registered in 1935 and dealt with contact glasses having two perforations in the lateral side in order to avoid their usual excessive adherence. In the following year, another patent addressed the principle of an optical part of the contact shell in quasi-contact with the cornea, but which possessed a significant perilimbal space and irrigation channels directed towards the periphery. [83]

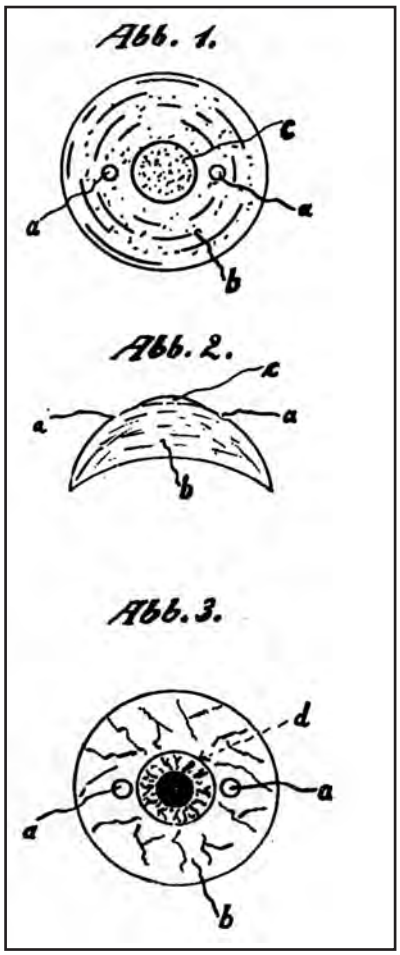


Figure 21-12
Extract of the Müller-Welt patent on contact glass with perforations.
This patent, registered in 1935, covers the principle and production of perforations in the scleral part of contact glasses intended to favor circulation and exchange of tears and avoid excessive adhesion of the glass. The orifices can be placed at a greater or lesser distance from the limbus, but always in the horizontal axis of the glass.
(Mueller-Welt Gebr., 1935a)

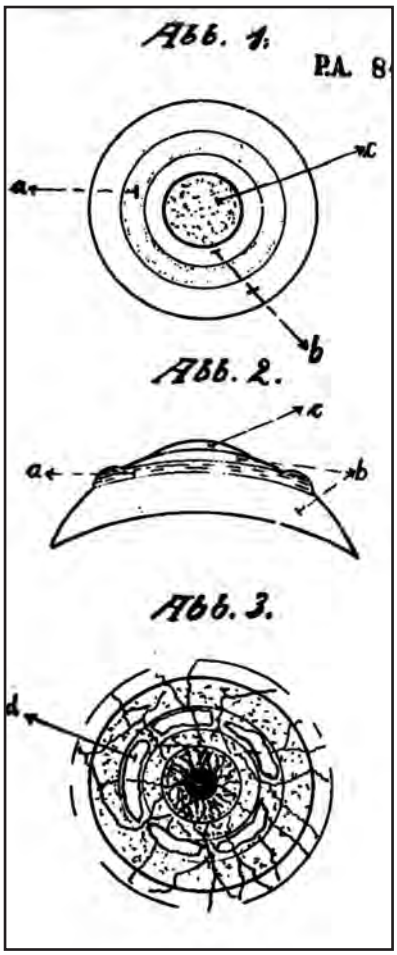


Figure 21-13
Extract of the Müller-Welt patent on contact glasses with perilimbal clearance and canals towards the periphery.
This patent, registered in 1936, covers the principle and the production of a clearance on the posterior surface of the peri-limbal zone of the scleral part in order to favor the circulation of tears and air. Canals at the periphery of the shell may link these spaces. The patent mentions that the shells are inserted without the adjunct of liquid.
(Mueller-Welt Gebr., 1936)

Notwithstanding the many criticisms, the '*Müller-Welt* molded and blown scleral contact shells' were produced in large numbers including export to the United States of America, whence *Nelson*'s evidence has come to us. [(84)] His criticism echoed that of *Dallos*:

"*Formerly Müller-Welt Brothers manufactured blown lenses, which more or less resembled the ground Zeiss lenses in size and shape. The optic part of these lenses had no refractive power of its own, the additional refraction being produced by the 'fluid lens' formed between the anterior surface of the patient's cornea and the posterior surface of the glass cornea. The scleral parts were also spherical and were manufactured in three different curves of 11-, 12-, and 13-mm radius. Those blown lenses gave a fairly good result in most of the cases, and I used them for different types of cases, especially refractive errors, for a number of years. However, the Müller-Welt lenses had the same disadvantages as have the Zeiss lenses, so well known to every oculist who has to supply patients with them. The lenses of patients, particularly those with less excluding air bubbles in the pupillary region, since the lenses filled with normal salt solution or Ringer solution, had to be applied in a nearly horizontal position with the head bent forward. The edge of the spheric scleral part of the lens, resting upon the anterior section of the usually aspheric sclera, exerted an uncomfortable local pressure on areas where the scleral radius was smaller than in adjacent areas, causing local pinching of conjunctival and episcleral blood vessels, and probably nutritional disturbances of the corneal tissue.*"

In his 1937 report to the Paris Society of Ophthalmology, *Emile Haas* described the *Müller-Welt* contact glasses that he was using. Their optical prescription was simple, it was only necessary to provide the manufacturers with the measurement of the corneal radius of curvature and indicate to them the contact glass giving the best visual acuity. For the scleral part, according to *Haas*:

"*It presents an established one shape for all scleral shapes and it is available in different sizes. This shape*

is lightly milled ('godronné') in such a way as to create three resting points for the contact glass on the globe of the eye. The first of these is superior and medial, the second is inferior and medial and the third is lateral. The scleral portion is more or less extended and its inferior edge rests generally in the sulcus. The contact glasses of Müller-Welt have only 6 scleral sizes, for each of which there are four different corneal projections of the corneal part i.e 24 variants altogether. The contact glass that is found during the trial fit can be reproduced with the optic for the desired refractive correction." (85)

A doctoral thesis, defended by *Bernard Reichman* reported in 1938 that the majority of 55 patients affected by keratoconus had been successfully fit in the Tübingen Ophthalmology Clinic with *Müller-Welt* contact shells. In the opinion of the author, the principle of their fitting was simpler than that for the contact shells of other suppliers. It should be noted that *Müller-Welt* was on very good terms with most of the University clinics to which he rendered numerous services. These included contact shells with supporting crutches or prongs for blepharoptosis, contact shells for ocular perfusion, prostheses and contact shells to prevent and manage symblepharon. (86)

It is necessary to pay tribute to *Albert Alvin Müller-Welt* for his perseverance in the research by which, using a complex procedure, he succeeded in manufacturing contact lenses free of internal strain, as *Obrig* describes:

"*The glass from which these lenses were manufactured was superior to that from which the earliest type of blown lenses was made. It was more resistant to the chemical action of the lachrymal fluids and was annealed by a special patented process by which the internal stress in the glass was eliminated. They were so resistant to destruction by chemical changes that they could be transferred from ice water to boiling water without danger of breakage. The two principal disadvantages of the Müller-Welt lens are the capillary separation of the corneal portion of the lens from the cornea, (...) and the difficulty in fitting an irregular scleral portion with a limited variety of scleral toric curves*." (87)

On the basis of these developments, a new generation of contact glasses evolved in the years that followed. In these, the absence of internal stresses allowed the grinding of both anterior and posterior corneal surfaces. These new *Müller-Welt* contact glasses finally permitted a parallel fit with a reduced and nearly 'fluidless' tear film plus an anterior surface provided with a ground refractive correction as required. This evolution towards the '*new Müller-Welt fluidless contact lenses*' represented enormous technical progress and, at the same time, a definitive change in the philosophy of optical correction by tear meniscus that was traditional at the time.

This evolution will be confirmed when glass is abandoned in favor of plastic materials. *Müller-Welt* was to achieve great success with these, first in Germany then in the USA, thanks to the experience the firm acquired in the course of the preceding years with fluidless shells as an alternative to *Zeiss* contact shells.

4 - The Rakos 'Individually Fitted' Glass Contact Shell (1935)

In December 1935, *Emerich Rakos*, an Austrian ophthalmologist based in Vienna, had applied to register a patent for a '*Vaulted glass contact shells, individually fitted to the eye, with a ground optic intended to correct the refractive errors*' The patent was accepted and registered in October 1936. (88)

In the preamble to this document, *Rakos* listed four types of *'adherent or contact glasses*' (Haft- oder Kontaktgläser) in existence, with advantages and, especially, disadvantages:

"*The four best-known types of this contact glasses for vision correction are, in the first instance, those that are blown in the manner of artificial eyes. The pain-free wearing of these glasses and the duration of wear depend on various uncertain situations.„*

ÖSTERREICHISCHES PATENTAMT.

PATENTSCHRIFT Nº 147366.

Figure 21-14
Title page of the patent delivered in 1936 to Emerich Rakos.
The patent delivered to Emerich Rakos by the Austrian Patent Office on 26th October 1936 with application March 15, 1936, registered December 10, 1935, described 'Vaulted glass contact shells, individually fitted to the eye, with a ground optic intended to correct the refractive error'. (Gebogene, dem Auge individuel angepasste Glasschalen mit eingeschliffener Optik für Sehkorrekturen). (Rakos E., 1935)

Another type consists of round glass shells, spherically ground, which, after being filled with saline, adhere to the eye by suction. The wearing-time for these glasses is usually very short, because of their strong adherence to the eye, which produces severe pains.
A third type is conceived in such a way that the glass corresponds exactly to the shape of the eye, but the posterior surface of the glass does not take into account the very sensitive parts of the eyeball, with result that this lens also causes a significant limitation of wearing time.
A fourth type consists of a lens-holder designed like an anchor that is modeled in glass or rubber, in the shape of the eyeball. An optical portion of sufficient refractive power is wedged into this support. With this type of glasses, the main purpose of a contact glass is absent, the correction by a so-called liquid lens." (89)

According to the patent, *Rakos*'s corneo-scleral contact glass has the following characteristics with advantages as described:

- The glass shell is manufactured individually from an ocular mold. It follows the eye movements and is invisible because it covers the entire eyeball;
- The posterior surface is designed in such a way as not to touch the limbus, but has light secondary contact with the corneal apex: this prevents foggy vision and veiling;
- Construction of the shell prevents interruption of the lachrymal circulation under the glass. To achieve this, the posterior surface of the shell contains depressions in the form of invisible channels to the bare eye,
- In order for the contact shell not to touch the rectus muscles, which would provoke significant pains, it is modified in these areas so that they are covered, but do not serve as supports;
- The contact glass is provided with supporting areas in the supero-nasal and infero-temporal regions, which guarantees that it has good followability of the eye movements.

There follows a summary of the claims described in the patent:

"*Vaulted glass shells, individually fitted, with ground optic for visual correction, characterized by the fact that the glass shell should touch the eye at the central point of the cornea but that, in the limbal region, its posterior surface is designed so as not to result in any contact in this zone between eyeball and glass shell. - Glass shell (...), the posterior surface of which is provided with ground depressed zones in the form of channels in order to promote tear circulation. - Glass shell (...), the posterior surface of which is shaped so that the rectus muscles are covered, but ensuring that there are not in contact with the shell. - Glass shell (...), the posterior surface of which is provided with resting surfaces lying directly on less sensitive parts of the eye thereby permitting glass to follow the eye in different directions of gaze.*" (90)

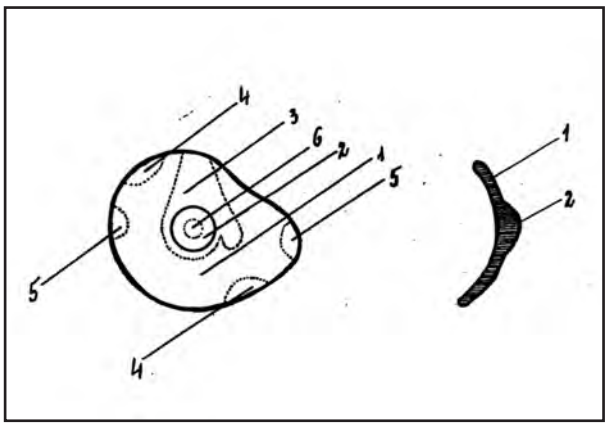


Figure 21-15
Diagram of the claims stated in the patent of Emmerich Rakos.
1. Scleral Part (Sklerateil); 2. Optical part of contact glass; 3. Depression planned for lachrymal circulation (die vorgesehene Ausnehmung für den Tränenkreislauf); 4. Points of support (Stützpunkte); 5. Depressions for ocular rectus muscles (die Ausnehmungen für die geraden Augenmuskeln); 6. The corneal contact of the glass (die Hornhautberührung des Glases). (Rakos E., 1935)

Rakos provides us with an accurate assessment of the defects of the two most widely used types of corneo-scleral shells of his era. The blown contact glasses of *Müller Brothers* have, in fact, very approximate scleral and corneal parts, whilst the ground *Zeiss* contact shells have an almost perfect sphericity, but one that does not correspond with the irregular profile of the eye. Besides, *Rakos* is critical of the *Dallos* contact shells, because they rest on sensitive areas of the eye while others have support limited to the sclera, as

imagined by *Feinbloom*, *Wilhelm*, and others, but have poor optical qualities.
The structures imagined by *Rakos* closely resembled *Dallos*'s contact shells and consisted of an almost exact copy of these. On the other hand, *Rakos* adopted the principle of avoiding support for the shells in the zone of the extra-ocular muscles. It must be noted that some of the features, e.g. depressions, channels and support zones were not easy to grind in glass, but were ulteriorly executed in pmma contact shells. It is more than likely that the *Rakos* contact shells of this era did not go past the stage of principle and prototype. Their development was interrupted by the '*Anschluss*' [91] and the emigration of *Rakos* to the United States, where he subsequently and successfully pursued his research activity on pmma contact lenses, both scleral and corneal.

Notes in Chapter XXI

1. See volume II, chapter 18, pp. 287-289: Stock's Communication on Ground Contact Lenses for Keratoconus (1920).
2. Clausen W.v., 1920. “Ideal wäre eine Schale, die außer einer sogenannten Trägerschicht im Zentrum eine geschliffene optische Zone besitzt.”
3. Hegner C.A., 1921. He confuses the works of Kalt and Sulzer by maintaining that the latter discovered contact lenses without having had knowledge of the works of Fick.
4. “Die Empfindlichkeit der Augen ist verschieden, aber in den meisten Fällen verursacht der Kontaktglas nach kürzerer oder längerer Zeit Beschwerden. Es können locale Reizerscheinungen, konjunktivale Injektionen, Fremdkörpergefühl, Lichtscheu, Tränenfluß, auch sogar Epithelläsionen auftreten. (…) Aber auch hier muß sich der Patient darauf beschränken, das Kontaktglas nur während kurzer Zeit zu tragen , je nachdem er dasselbe verträgt. Es scheint, daß geblasene Gläser von geringerer Reizwirkung auf das Auge sind als die geschliffenen.”
5. Schnaudigel O. 1922. “Sie antwortete mir: ich habe eine Unzahl probiert, Müllersche und Zeiss’sche, sie haben auch das Sehen ganz erheblich verbessert; aber ich will lieber noch einmal meine sieben Kinder kriegen, als nur einen halben Tag so ein Ding tragen.”
6. Krämer R., 1923. Communication to the Viennese Ophthalmological Society (Wiener ophthalmologischen Gesellschaft), 18th June 1923.
7. Lauber H., 1924. Presentation before the Viennese Ophthalmological Society (Wiener ophthalmologischen Gesellschaft), 18th February 1924.
8. Siegrist A., 1925a, b. “Der Hauptnachteil (…) ist darin zu suchen, dass die Gläser so gut wie niemals sphärische Krümmungen aufweisen, und dass man, wenn man nicht eigene Messungsmethoden anwendet, keine Ahnung hat, wie stark ihre Refraktion ist.”
9. Scheffels, 1925. Presentation on 8th March 1925 to the Ophthalmology Society of Rhine-Westphalia (Verein Rheinisch-Westfälischer Augenärzte).
10. Bohnenberger F., 1925, 1926. Presentation on 17th May 1925 to the meeting of Central German Ophthalmologists (Tagung mitteldeutscher Augenärzte) at Jena: “Durch Aufstecken eines Kontaktglases wurder die Applanation des Hornhautscheitels ausgeschaltet, und der Effekt war: Auslöschung der hyperopischen Refraktion des Auges, das sich im wesentlichen nun wie ein myopisches verhielt.”
11. Schneider R., 1925. Presentation on 17th May 1925 to the Meeting of the Central German Ophthalmologists (Tagung mitteldeutscher Augenärzte).
12. Meyerbach F., 1926: “Dieser Erfolg ist sehr befriedigend, zumal Patient die Schale dauernd gut verträgt, sich sogar binnen kurzer Zeit so daran gewöhnt hat, dass er sie gar nicht mehr missen will.„
13. Hessberg, 1927: Communication presented on 23rd October 1927 to the Meeting of the Hessen and Hessen-Nassau Ophthalmologists (Vereinigung hessischer und hessen-nassauer Augenärzte) in Wiesbaden. "Diese Müllerschen Kontaktschalen werden in allgemeinen gut vertragen und es ist auch häufig Stillstand der Progression des Keratokonus beobachtet, den Dr. F. Müller im Sinne einer Wirkung der Schale als orthopädische Bandage auffast.„
14. Lauber H., 1927. Communication on 21st November 1927 to the Ophthalmological Society in Vienna (Ophthalmologische Gesellschaft in Wien), followed by discussions by Fuchs, Sachs, Meller, Kestenbaum, Lindner and Krämer. "Alle 4 Kranke sind mit den Gläsern arbeitsfähig und können sie während der ganzen Arbeitszeit tragen (Lehrerin, Näherin, Techniker, Beamter).„ Hegner C.A., 1927: 'Das Kontaktglass' in Hegner: 'Grundriss der Refraktion und Brillenlehre' (Manuel of Refraction and Theory of Glasses).
15. Sommer F., 1927. The Inaugural Dissertation of Franziska Sommer was defended on 12th November 1927 at the faculty of Medicine of Freiburg i.B. under the direction of Professor Axenfeld. The clinical histories were supplied by Axenfeld (Freiburg) (2 cases), Heinersdorf (Elberfeld) (1 case), by Asmus (Düsseldorf) (2 cases), by Stock (Tübingen) (6 cases) and by Siegrist (Berne) (2 cases).
16. “Die Müllerschen Schalen werden offenbar häufiger ohne Reizung des Auges vertragen.”
17. “Fall 1 [Axenfeld] Nach einem Bericht von der Patientin selbst im Oktober 1926, ließ sie dann in Wiesbaden Müller’sche Kontaktschalen anfertigen. Patientin schreibt, dass diese Müllersch Gläser von ihr ohne jede Reizung ständig getragen würden, und dass sich das Sehvermögen damit bedeutend gebessert hätte. Fall 2 [Axenfeld] Er hat drei Paare verschiedene Schalen sechs Wochen lang immer wieder zu tragen versucht. Das Sehvermögen wäre mit Schalen sehr gut gewesen, aber beide Augen wären so stark gereizt

worden, dass Patient die Schalen immer nur ganz kurze Zeit hätte tragen können. Auch hätten sich immer Luftblasen zwischen Bulbus und Schale gebildet. Fall 3 [Heinersdorf] Obwohl mit der Kontaktschale ein etwas besseres Sehen in der Ferne erreicht wird, erklärt Patient sie nicht tragen zu können, da sie das Auge so stark reizen, dass er es nicht erhalten könne. Fall 10. [Stock] Patient trägt immer noch die alte Prothese von 1922, obgleich sie nicht mehr ganz tadellos und wohl mit an den sich immer wiederholende Reizungen ist. Diese haben allmählich zu einer sich langsam ausdehnenden Schädigung der Hornhaut geführt und lassen die Prognose nicht sehr günstig erscheinen. Doch ist es trotz zahlreicher Versuche auch in Wiesbaden selbst nicht wieder gelungen, eine Schale anfertigen, die der Patient verträgt."

18. Weill G., 1916, 1928. Communication to the Ophthalmological Society of Eastern France (Société d'Ophtalmologie de l'Est de la France) on the 1st July 1928 at Nancy. See volume II, chapter 18, § 1.2.4: Three Strasbourg Keratoconus Cases fitted by Weill (1916) and in this volume, chapter 23, § 4.4.1.

19. "La prothèse de Müller (Wiesbaden) est soufflée et ressemble à une prothèse ordinaire à simple coque, mais avec une cornée transparente. Ces prothèses sont souvent supportées par les malades pendant toute la journée et donnent une augmentation de la vision vraiement remarquable. Plusieurs de mes malades les portent depuis des années et ne sauraient plus s'en passer. Malheureusement, il faut un assez grand choix de ces prothèses avant de trouver celle qui donne le maximum de vision, ce qui exige des examens multiples et beaucoup de patience."

20. Goldschmidt 1929; Fischer F.P. 1929b. Communication at the 30th meeting of the Central Germany Ophthalmologists (Vereinigung mitteldeutscher Augenärzte), in Leipzig on 8th and 9th December 1928.

21. Deutsch A. 1929b; Loewenstein A. 1929.

22. Clausen W.v.1929. Communication to the 30th meeting of the Central Germany Ophthalmologists (Vereinigung mitteldeutscher Augenärzte) in Leipzig on 8th and 9th December 1928, followed by discussions of Erggelet, Fischer and Hartinger, Sitchevska O. 1931, Erggelet H. 1929, Fischer F.F. 1929a.

23. Fésüs A. 1929, Dallos J. 1929. Communication to the Hungarian Society of Ophthalmology, in Budapest on 8th March 1929.

24. Lauber H., 1930a, b. Presentation on the 17th February 1930 to the Viennese Ophthalmological Society (Wiener Ophthalmologischen Gesellschaft). The case has been presented at the same Society on February 18, 1924 (Lauber H., 1924a, b). "Es sind das dieselben Gläser, die er vor sechs Jahren bekommen hat. Müller hat sie lediglich von anhaftenden Inkrustationen befreit (...). Der Patient trägt die Gläser den ganzen Tag ohne Beschwerden. Der Keratokonus selbst hat sich kaum verändert, lediglich die Trübung an der Spitze des Keratokonus am rechten Auge ist etwas stärker geworden.„

25. Erggelet H., 1930a in discussion with Hartinger H., 1930. Meeting of the German Ophthalmological Society (Deutsche Opthalmologische Gesellschaft) in Heidelberg. Same texts in Erggelet H., 1930b: "Das aber nicht persönliche Empfindlichkeit, mindestens nicht allein, sonder die Form der Schale eine sehr wichtige Rolle spielte, ergab sich klar daraus dass, wie andere Träger, auch ich Müllersche geblasene Schalen ohne Störung stundenlang tragen konnte.„

26. Blatt N., 1930. Presentation on the 10th December 1930 to the Rumanian Society of Ophthalmology in Bucarest. The article was to be published in English in the Archives of Ophthalmology in 1932.

27. Stoewer E. 1931. Communication of the 26th July 1930 at Witten, before the Society for Science and Life in the Industrial area of Rhine-Westphalia. "Um die gute Verträglichkeit zu demonstrieren, hat Vortr. sich etwa drei Stunden vor Beging der Tagung ohne Kokain eine Kontaktschale in das rechte Auge setzen lassen und sie während des größeren Teiles der Sitzung getragen, ohne Beschwerden zu haben. Nach Herausnahme der Schale durch einen Teilnehmer in der Sitzung zeigt der Augapfel keine Reizung.„

28. Rall, 1931; Baumgärtner, 1931; Stock W. 1931. Presentation of Rall followed by discussions at the reunion of the Würtenburg Ophthalmological Society (Würtenbergische Augenärztliche Vereinigung) on 28th June 1931, held in Tübingen. Stock suffered from a mild degree of myopia, but did not have keratoconus as numerous authors have erroneously repeated.

29. Wibaut F. 1931. Communication at the Meeting of the Netherlands Ophthalmological Society on 13th and 14th December 1930 in Amsterdam. Holmström M. 1932.

30. Braun M., 1934. Inaugural Dissertation under the direction of Professor F. Schieck.

31. Gallemaerts E., 1933: "Pour les verres soufflés, il faut souvent des essais répétés qui nécessitent un séjour de une à deux semaines à Wiesbaden, sous la surveillance d'un personel d'élite; d'autre part, les verres soufflés ne peuvent être polis à la face antérieure pour une correction supplémentaire."

32. Haas E., 1937: "Pour obtenir des résultats utiles avec les verres de Müller, il faut envoyer les malades

à Wiesbaden ou posséder soi-même une collection d'essai suffisante, c'est à dire de 200 ou plutôt 300 pièces. De plus, l'essai risque d'être très long. (…) Un observateur attentif et ingénieux saura trouver moyen de classer ses pièces selon leur forme, leur grosseur et leur action optique et qu'il saura reconnaître chez le sujet le type d'asymétrie dont il s'agit. (…) Telle est du moins l'opinion des oculistes qui ont pratiqué les verres de Müller; c'est aussi l'opinion de la majorité des auteurs. Toutefois une fois le verre choisi, l'accoutumance est très rapide.„

33. Mann I., 1938.

34. Sattler C.H., 1938a.

35. Dallos J., 1931b, c. Presentation at the meeting from 28th to 29th June 1930 to the Hungarian Society of Ophthalmology at Debrecen. - Helmbold H.L.v., 1931, see chapter 29, § 1.3.

36. Dallos J., 1932 a, d. Presentation to the Annual Congress of the Hungarian Society of Ophthalmology on 6th June 1931: "Die von Heine angegebene Serie der Zeißschen geschliffeen Haftgläsern ermöglicht die Vollkorrektion selbst der höchstgradigen Ametropien; doch kann letzteres in die Praxis nicht übertragen werden, da diese Haftgläser von der Konfiguration des Auges stark abweichen und daher das Auge reizen. Das Haftglas ist eine optische Prothese, es ist eine unerlässliche Forderung, daß sie gut ertragen werde. Es ist eine reichhaltige haptische Serie notwendig, die die physiologische schwankenden Maßverhältnisse der Bulbusoberfläche berücksichtigt. Auf das unter diesen gefundene besterträgliche Exemplar soll die im Einzelfall notwendige Korrektion im Zentrum der Glashornhaut aufgeschliffen werden. Eine sichere, ungefährliche und dauernde Korrektion kann nur mit solchen Gläsern erreicht werden." (Dallos J., 1933).

37. Dallos J., 1932 a. Presentation to the Hungarian Society of Ophthalmology in Budapest on 19th March 1932.

38. Csapody I.v. 1929 a, b. Presentation to the Hungarian Society of Ophthalmology in Budapest on 10-12 June 1932. Dallos J., 1932b; Poller A., 1931.

39. "Haftgläser bzw. Kontaktschalen müssen dem Auge auf eine ganz bestimmte Weise anliegen, um dauernd gut vertragen zu werden. Zur Herstellung von individuell geformten Gläsern sind Modelle von einem großen Teile der Oberfläche des Bulbus notwendig. Mittels des Pollerschen Verfahrens konnte er das Auge in der Primärstellung sowie in 4 Seitenstellugen abformen und durch Zusammenbauen der Teilformen das gewünschte große Oberflächenmodel rekonstruieren.„ (Dallos J., 1932b).

40. Dallos J., 1933a, b. Presentation to the Hungarian Society of Ophthalmology in Budapest on 9-11 July 1933.

41. "Zum Abformen konnte die sinnreiche Methodik von Csapody nicht gebraucht werden, da es eine Bedingung war, die Bindehaut nicht zu deformieren, weder durch umschreibenden Druck (Tubus usw.) noch Zug (Lidhalter usw.). Es sollte eine möglichst dünne Schicht einer plastischen Substanz an der Bindehaut möglichst rasch erstarren. Nachdem Gips und Gipsartige Substanzen an der Bindehaut ohne Gefahr nicht anwendbar sind, weiterhin Wachs, Paraffin und derartige Stoffe nur bei solchen Temperaturen ihre Konsistenz gehörig und schnell genug ändern (beim einlegen fast flüssig, beim abnehmen unbiegsam), die dem Auge ebenfalls schädlich sein können, wandte ich mich zu den leimartigen Substanzen.„ (Dallos J.,1933b).

42. "Um den Bulbus (…) abformen zu können, verfuhr ich so, das ich ungefähr passende Müllersche Schale mit dem breiartige Negokoll halb fülle, dann mit einem Finger knettend auf Zimmertemperatur abkühlte und das mit Negokoll-Brei dick bestrickene Glas in das kokainisierte Auge einsetze. Es bleibt dabei eine Schicht Negokoll zwischen Schale und Auge, das übrige läuft aus und wird beobachtet. Nach dem Einsetzen des Glases läßt man den Patienten in der entsprechenden Richtung fixieren, solange, bis das ausgelaufene Negokoll erstarrt ist. Nach einigen Sekunden wird nun das Glas samt dem Positivmaterial 'Hominit' weiterbehandelt. Die Glasschale dient als starre Stütze der sonst leicht deformierbaren Negokoll-Lamelle, die an der Luft durch Eintrocken bald ihre Form einbüssen würde.„

43. "Am Positiv signiere ich immer die Richtung 'aussen'. Das so erhaltene Positiv weist bei guter Technik eine spiegelnde Hornhaut mit scharfen Rande und runzelfrei, glatte Bindehaut auf. Der Uebergang zwischen Hornhaut und Bindehaut ist stetig, die Oberfläche des Modells hat eine eigenartige fast einheitliche Krümmung, die jedoch in den einzelnen Meridianen verschieden ist. Die Augenoberfläche bildet demnach keine Rotationsfläche; um so weniger hat dieselbe mit zwei ineinander geschobene Kugelflächen etwas gemein.„ (Dallos J., 1933b).

44. "Aus den Messungen einer einzigen zentralen Abform mit der Hornhaut in der Mitte und einer 6-10 mm breiten Sklera bzw. Bindehaut-Umgebung diese Schlusse zu ziehen, wäre allerdings bedenklich. Ich war aber von Anfang an bestrebt ein möglichst großes Model vom Bulbus Abzuformen – aus der Theorie

folgt nämlich, daß die gleichmässige Druckverteilung mit der Oberfläche der Glassklera proportional ist – und als ich sah, daß eine auf diese Weise gewonnene Abform allein zur Beurteilung des Verhältnisses zwischen Augenoberfläche und Glasinnenfläche nicht hinreichend ist, ging ich ein Schritt weiter. Ich ließ den Patienten nach verschiedenen Richtungen blicken, und nahm in jeder Blickrichtung je eine Abform. An diesen abformen ist die Hornhaut excentrische gelegen (ich benütze jetzt zu diesen Modellen entsprechend geformte Kontaktschalen), dazu gesellt sich je ein Quadrant der Bulbusoberfläche in einer besonders großen Ausdehnung.„ (Dallos J., 1933b).

45. Dallos cited the glassmaker Stefan Komçromy, the clinical assistant at the polyclinic Dr. Zoltan Veress and the two denturists Stefan Ràkos and Joseph Simonots.

46. Much V., 1934. This polemic publication 8 pages long criticizes Dallos violently. In an interview that he granted me in 1981, Much expressed his regret in regard to his aggressive behavior when he was a young man. Dallos J., 1934d, Müller-Welt, 1934.

47. Dallos J., 1934a. Presentation to the Hungarian Society of Ophthalmology on the 2nd June 1934. – Sattler C.H., 1935.

48. "Die druckfreie Abformung des lebenden Auges mittels Negocoll ergib Modele, die der Oberfläche der Hornhaut und der Bindehautdecke der Sklera genau entsprechen. Die Versuche zeigten, dass die Bedingungen des reizloses Sitzes folgende sind: Stützflächen oben-innen und oben aussen. Haftflächen innen und unten, Atmungsgebiet am Limbus und oben-aussen. Die Hornhautmitte verträgt zumeist ein mittelbares Aufliegen des Glases: ist dadurch der Druck auf Hornhaut und Lederhaut gleichmäßig verteilt, so ist das Tragen des Glases nicht nur reizlos, sondern auch schleierfrei.„ (Dallos J., 1934c).

49. Dallos J., 1934b, c. Presentation to the Hungarian Society of Ophthalmology on 2nd June 1934. „Um die Überlegenheit ihrer eigenen Fabrikate zu beweisen" (Dallos J., 1969). The failure of optical grinding of blown contact glasses had been reported by Hembold in 1913 (see volume II, chapter 15, p. 210-211) and by Erggelet 1930b.

50. According to Dallos J., 1964.

51. Ramach F., 1935. Presentation to the Ophthalmological Society in Vienna (Ophthalmologische Gesellschaft in Wien) on the 21st October 1935. – Proksch M., 1935; Lindner K., 1935; Kafkas P., 1935; Sachs, 1935.

52. Wachtel F., 1938a, b.

53. Obrig T.E., 1942, p.204-206.

54. Dallos J., 1935, 1936.

55. Dallos J., 1938. Presentation to the Oxford Medical Congress 8-10 July 1937, followed by discussions by Williamson-Noble, Mann and Rugg-Gunn.

56. Williamson-Noble F.A., et all., 1940.

57. Mann I., 1944.

58. Dallos leaves Theodore Hamblin's in 1964 and sets up independently at 17 Devonshire Place, London.

59. Dallos J., 1946.

60. Reported by Bowden T., 2009, p. 84 (no date given).

61. Dallos J., 1934 c.

62. Choyce D.F., 1954. Dallos challenges the priority of Bier in a letter to the editors, based on patent # 592.055, applied in 1945, but not published before 1947.

63. Dallos J., 1954.

64. Dallos J., 1964.

65. Dallos J., 1967, 1969.

66. Dallos J., 1972.

67. Dallos J., 1979. Presentation to the Annual Congress of the British Contact Lens Association.

68. Heitz R.F., 1980; Much V., 1980.

69. Müller-Welt, 1925.

70. Müller-Welt, 1930.

71. " Als Grundmaterial für die Herstellung dieser Schalen dient säurebeständiges Kristallglas, das in Gestalt eines erhitzten Glasrohr (…) in eine dem zu erzeugenden Haftglase entsprechende Form oder Matrize geblasen wird."

72. "Der überaus bedeutsame Vorteil des vorliegenden Verfahrens besteht darin, daß es möglich ist, bei den in entsprechende Formen geblasenen Haftgläsern eine optische Genauigkeit durchzuführen, wie sie

bei der Verwendung von Brillen üblich ist. Dasselbe Glas kann in genau übereinstimmender Ausführung in größerer Stückzahl hergestellt werden. Bei Nachbestellung kann der Arzt stets wieder dasselbe Glas erhalten, zumal auch eine genaue Numerierung in Cornea- und Skleralgrössen für die Gläser festgelegt werden kann."

73. Zeiss, 1933.

74. Strebel J., 1932: Note p. 639: "zentral-exactsphärischen, peripher-asymetrischen, dünnleichten, formgeblasenen Stuttgarter Haftgläser der Gebrüder Müller-Welt die durch leichte überlidstrichmassage in die passende Stellung gebracht werden."

75. Müller-Welt, 1935a. Presentation on 28th October 1934 at the 30th Meeting of the Würtenberg Ophthalmological Society (Würtenbergischen augenärztlichen Vereinigung) held in Stuttgart. "Letztere stellen eine Neuerung auf dem Gebiet der Haftgläser insofern dar, als sie die Vorzüge der optisch einwandfreie sphärischen Kornealteilwölbung geschliffener Haftgläser mit der unregelmässigeren geblasener Kontaktschalen in sich vereinigen. Ihre Verordnung ist dadurch erleichert, dass sie nach dem Brechwert ihrer Kornealwölbung, also in Dioptrien bezeichnet sind und dass nur drei verschiedene Skleralgrössen, eine kleinere, eine mittlere und eine größere unterschieden werden. Mit den Angaben der Hornhautwölbung wie sie am Javalschen Ophthalmometer in Dioptrien abzulesen ist, der subjektiv oder objectiv bestimmten Fehlsichtigkeit und der abgeschätzten Bulbusgrösse ist ohne weiteres eine Auswahl Korneal-Skleralschalen bei der Herstellerfirma zu bestellen. Der Preis für die Schale beträgt RM. 25-.„

76. Dallos J., 1936 b. p.659, note 1: "Deshalb ist auch die Beschreibung der Müller-Weltschen Kornea-Skleralschalen irrig, indem dieselbe „runde, ovale oder nierenförmige Wölbung" angibt, obwohl es sich dabei nur um eine runde, ovale bzw. nierenförmige Randform sphärisch gewölbter Gläser handelt. (...) Die Unfollkommenheit der Kornea-Skleralschalen ergibt sich aus ihrer Herstellungstechnik: dem negativen Modell wird immer die Aussenfläche des Glases anpassen. Die haptische Innenfläche ist der Aussenfläche nicht ähnlich, auch kann sie nicht berechnet werden, da die Dicke des Glases beim Blasen von der Peripherie nach dem Zentrum hin stetig abnimmt, um so mehr, je dicker es gewesen. Deshalb haben auch diese Gläser all eine von der Dicke afhängigen negative Brechkraft.„

77. Müller-Welt, 1934: "Die Schale hält vollkommen, was sie verspricht. Sie vereinigt die Vorzüge zweier Herstellungsverfahren: die der absolut sphärischen Kornealwölbung der geschliffenen und die asphärischen Skleralwölbung der geblasenen Haftgläser. Die Skleralwölbung kann dank der Modifizierungs möglichkeiten seines Negativs in allen Meridianen den jeweiligen Bulbusformen, entsprechend ausgebogen werden, d.h. die Auswölbung kann in den Meridianen entsprechend eines zweier entgegengesetzter, mehrere verschiedener oder auch aller Augenmuskeln je nach Bedarf und Verträglichkeit angebracht werden.„

78. "Was die Optik anbehangt, so ist die Kornea-Skleralschale im Kornealteil weit über den Pupillenbereich absolut sphärisch. Eine erhöhe Bruchgefahr besteht deshalb keinesfalls, im Gegenteil, wir vervollkommneten die Bruchsicherkeit, die aber nur in Spannungdifferenzen innerhalb des Glases selbst nach Ablauf des Herstellverfahrens liegen, dadurch, das wir, jede Schale einem zweiten Prozess unterwerfen, der sie spannungsfrei macht.„

79. "Die Forme des Randes der Korneo-Skleralschale wird entweder durch die Schnittlinies einer Ebener Senkrecht zum der Achse der skleralwölbung bestimmt, oder sie wird nach Art der Randform der Schalenaugenprothesen gewählt, ist aber stets glatt und abgerundet gearbeitet.„

80. Dallos J., 1934 d. It is probable that Dallos had only a first series available to him, or that Müller-Welt had not yet introduced asphericity to the haptic portion.

81. "Haptik. In der uns zur Verfügung gestellten Serie war der Sklerateil sphärisch, wie in den Zeissschen Hafgläsern, auch gibt die Beschreibung die Variation des Sklerateils einfach in Kugelradien an und erwähnt nichts von einer nach Wunsch und Bedarf genau hergestellten Asphärität. Die Bearbeitung des Randes lässt viel zu Wunschen übrig. Der Übergang zwischen Hornhautteil in den Sklerateil ist ringförmig eingedrückt und drückt somit gerade am Limbus wo die meisten Augen am empfindlichsten sind. "

82. "Optik. Die Angaben des äußeren Krümmungsradius ist unzulänglich. Die optische Beschaffenheit des Glases ist teils durch die bei den Zeissschen Haftgläsern angegeben Daten d.h. 1) von dem inneren Kornealradius und 2) von Brechkraft des Glases in Luft, teils 3) durch die Scheiteltiefe (Dicke der Flüssigkeitlinse) bedingt. (...) Die sphärische Korrektion muss daher immer auf das innen haptisch genau modellierte Glass außen angeschliffen werden, wie das bei den neuen gebogenen Gläsern verwirklicht wird.„

83. Müller-Welt, 1935, 1936.

84. Nelson F., 1938. Presentation on November 20, 1937 at the Colorado Ophthalmological Society.

85. Haas E., 1937, 1938. "Elle présente une forme établie une fois pour toutes et qui existe en différentes

dimensions. Cette forme est légèrement godronnée de façon à prendre sur le globe trois appuis: le premier en haut et en dedans, le second en bas et en dedans, le troisième en dehors. La partie sclérale est plus ou moins étendue et son bord inférieur repose le plus souvent dans le cul de sac. Les verres de Müller-Welt n'ont que 6 grandeurs sclérales, à chacune desquelles correspondent quatre saillies différentes de la partie cornéenne, soit 24 formes en tout. La verre qui convient au moment de l'essai est susceptible d'être reproduit avec l'optique que l'on desire.„

86. Reichman B., 1938. The doctoral thesis of Bernhard Reichman defended in 1938 was inspired by Professor W. Stock, Director of the Ophthalmological Clinic in Tübingen. It was completed with 28 essential bibliographical references from the era.

87. Obrig T.E., 1942, p.162-164. In this era, Obrig had not yet adopted the principle of the fluidless contact lens of Dallos and popularized by Müller-Welt.

88. Rakos E., 1936. 'Gebogene, dem Auge individuel angepasste Glasschalen mit eingeschliffener Optik für Sehkorrekturen'. The Austrian Patent Office delivered the patent on 26th October 1936, with effect starting from 15th March 1936. Patent # 147,366.

89. "Die vier bekanntesten Typen dieser zur Korrektur der Sehschärfe angewendeten Gläser sind erstens jene, die nach Arte künstlicher Augen geblasen werden. Das schmerzlose Tragen und die Tragedauer dieser Gläser hängt von verschiedenen zufälligen Momenten ab. Eine weitere Form bilden runde, sphärisch geschliffene Glaschalen, die mit Salzwasser gefüllt, sich an den Augapfel ansaugen. Die Tragedauer dieser Gläser ist in der Regel sehr beschränkt, da infolge des festen Anhaften nicht unbeträchliche Schmerzen verursacht werden. Eine dritte Form ist derart ausgebildet, dass das Glas wohl der jeweiligen Augenform entspricht, jedoch nimmt die Innenform des Glases keinerlei Rücksicht auf die höchst empfindlichen Teile des Augapfels, so dass auch bei dieser Ausbildung eine mehr oder minder beschränkte Benutzungsmöglichkeit besteht. Eine vierte Form ist ein greiferartig ausgebildeter Linsenträger, welcher aus Glas oder Gummi dem Augapfel nachgebildet wird. In diesem Träger wird die notwendige Optik eingesprengt. Bei solcher Art von Gläsern fällt der Hauptzweck aller Kontaktgläser weg, nämlich die Korrektion mit der sogenannten Wasserlinse."

90. "Gebogene, dem Auge individuel angepasste Glasschalen mit eingeschliffene Optik für Sehkorrekturen, dadurch gekennzeichnet, dass die Glasschale die Mitte der Hornhaut zwar berührt, aber an der Innenfläche in der Limbuslinie derart ausgebildet ist, dass in dieser Zone keine Berührung des Augapfels mit der Glasschale erfolgt.. Glasschale (...), dass an ihrer Innenfläche für den Tränenkreislauf kanalartige Vertiefungen eingeschliffen sind. Glasschale (...), dass ihrer Innenfläche derart ausgebildet ist, das die geraden Augenmuskeln wohl von der Glasschale bedeckt, aber nicht berührt werden. Glasschale (...), dass an ihrer Innenfläche Auflageflächen vorgesehen sind, die unmittelbar an weniger empfindlichen Teilen des Auges aufliegen und das Mitgehen des Glases mit dem Auge bei verschiedenen Blickrichtungen ermöglichen."

91. The historians of World War II described by the word "Anschluss" the invasion of Austria followed by its annexation by Germany.