Chapter XX

The Zeiss Corneo-scleral Shells in German-speaking Europe (1920-1944)

Introduction

At the beginning of the 20th Century, the quality of glass and the manufacturing methods did not allow the realization of the concept of contact shells, such as their pioneers had imagined. The hopes placed in this mode of correction were quickly disappointed. The double-curve grinding from a block of glass presented very significant technical difficulties.

In a preceding chapter, we described the chronology of development and the use, between 1914 and 1920, of prototypes of scleral contact lenses, which had been specifically ground for the correction of keratoconus.[1] The experience gained during this period allowed *Zeiss* to test the market and refine the manufacturing. These first trials with ground contact lenses were somewhat confidential and the results were disappointing. *Zeiss* profited from the respite granted by the First World War and the immediate post-war period in order to seek a solution to these problems.

The official birth of the *Zeiss* ground glass contact shells for the correction of keratoconus coincides with their presentation by *Wolfgang Stock* of Jena in 1920. However, for his trial fittings, *Stock* had available only one model of ground-glass shell without refractive power. It was exclusively planned for the correction of keratoconus and was imagined to have 'an orthopedic' effect. [2]

In the course of the following five years, of 1920 to 1925, the *Zeiss* ground-glass contact lenses were available exclusively in German-speaking Europe and bordering regions. In the second half of the decade, the *Zeiss* Company more widely diffused the contact lenses ground for keratoconus, in particular towards Central Europe and America. *Zeiss* at that time held a quasi-monopoly on the ground contact lenses.

1 - The Zeiss Contact Shells for Keratoconus (1920 – 1929)

1.1 - In Germany and Switzerland

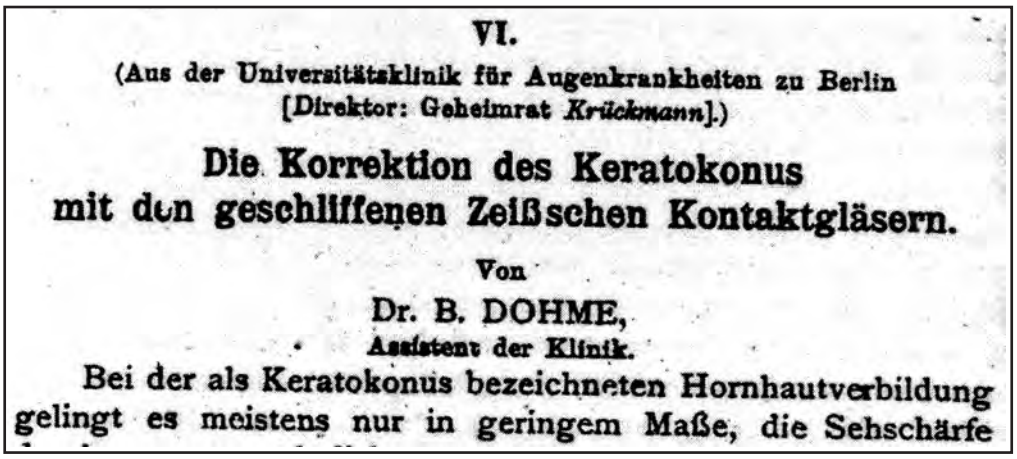
Year	*Author* (town)	*Publication*
1920	*Stock* (Jena)	*Über Korrektion des Keratokonus durch verbesserte geschliffene Kontaktgläser* (The correction of keratoconus by improved ground contact glasses).
1922	*Dohme* (Berlin)	*Die Korrektion des Keratoconus mit den geschliffenen Zeiss'schen Kontaktgläser* (The correction of keratoconus by the ground Zeiss contact glasses).
1925	*Siegrist* (Bern)	*Zur optischen Behandlung der unregelmässigen Hornhautkrümmung, speziell des Keratokonus* (The optical treatment of irregular astigmatism, especially of keratoconus).
1927	*Sommer* (Freiburg iB)	*Über Kontaktgläser zur Korrektion des Keratokonus* (Contact glasses for the correction of keratoconus).
1927	*Hegner* (Lucerne)	*Das Kontaktglas* (The contact glass).
1928	*Clausen* (Halle)	Discussion: *Contact glasses compress the limbal conjunctiva*.
1928	*Erggelet* (Jena)	Discussion: *Contact glasses compress the limbal vessels*.
1928	*Fischer* (Leipzig)	Discussion: *Ground contact glasses adhere too strongly*.
1928	*Hartinger* (Zeiss)	Discussion: *Ground contact glasses are more spherical than the sclera.*

Table 20–1
Chronology of the principal publications in Germany and Switzerland on ground contact glasses for the correction of keratoconus (1920-1928)

1.1.1 - The Three Trial Contact Glasses of Zeiss and their Use by Dohme (1922)

From 1920 and after the presentation by *Stock*, *Zeiss* proposed the sale of a set of three trial contact glasses to physicians. These were afocal ground trial lenses, with corneal radii of curvature of 7.50, 8.10 and 9.00 mm, a scleral radius of 12.00 mm, and a total diameter of 20.00 mm. Soon after that, *Zeiss* added a fourth model with a corneal radius of 6.50 mm (model # 4).

It was recommended to have the patient wear each model successively for a day, then to select the one that was the best fit and the best tolerated. The physician should perform refraction on each eye with the selected model of trial contact glass inserted in order to measure the residual spherical refractive error. With this date as starting point, *Zeiss* manufactured and delivered a definitive contact glass. This was provided with a posterior radius of curvature for the optic zone that was perceived to provide an optimal refractive correction for the patient by means of the lachrymal tear film meniscus.



VI.

(Aus der Universitätsklinik für Augenkrankheiten zu Berlin
[Direktor: Geheimrat *Krücknann*].)

Die Korrektion des Keratokonus mit den geschliffenen Zeißschen Kontaktgläsern.

Von

Dr. B. DOHME,
Assistent der Klinik.

Bei der als Keratokonus bezeichneten Hornhautverbildung gelingt es meistens nur in geringem Maße, die Sehschärfe

Figure 20 -1
Publication by Dohme on Zeiss ground contact glasses.
In 1922 Bruno Dohme (Berlin) published his observations on fittings of Zeiss ground contact glasses in keratoconus patients under the title: 'Die Korrektion des Keratoconus mit den geschliffenen Zeiss'schen Kontaktgläser' (Correction of keratoconus by Zeiss ground contact glasses). The article is to serve as a reference article for many years to come.

(Dohme B., 1922c)

In March of 1922, *Bruno Dohme*, assistant physician at the University Ophthalmological Clinic of Berlin, presented to the Ophthalmological Society of this city the first fit of a patient with keratoconus with the new *Zeiss* ground contact glasses:

"*Dohme presented a patient with keratoconus, wearing the new Zeiss contact glasses. Visual without glasses: 4/50, with glasses: 5/6. The glasses can be inserted and removed by the patient himself and are very well supported. (Price 500 Marks)*." [(3)]

Dohme added that he had also fit six other patients, making use only of the three trial glasses. The #3 contact glass, of 7.50 mm radius of curvature, seemed to him the most useable. He proposed to *Zeiss* to add a trial contact glass with a 6.50 mm radius, to which the manufacturer complied, soon after, in the form of model #4:

"*The Zeiss contact glasses are, moreover simpler to fit than the Müller glasses. From the trial set of three contact glasses with zero refractive correction, one chooses that which rests best on the eye concerned. Then one determines the correction necessary by spherical lenses, retinoscopy and subjective examination. This correction is ground by Zeiss in the corresponding contact glass. Since, on the 12 eyes thus corrected, 11 were corrected better by the trial glass with the smallest radius of curvature (Zeiss # 3), Dohme proposed to add a fourth trial contact glass with an even a smaller radius*." [(4)]

The same year 1922, *Dohme* published his observations under the title 'The correction of Keratoconus by ground Zeiss contact glasses' (*Die Korrektion des Keratokonus mit den geschliffenen Zeiss'schen Kontaktgläser*). He listed the requirements, which the ideal contact glasses for the correction of keratoconus should fill. The new Zeiss ground contact glasses would fill these requirements [(5)]:

"*To the ideal contact glass (…) able to satisfy a patient afflicted with keratoconus, one should establish the following requirements: The contact glass must have an absolutely spherical corneal surface. The glass should not irritate the eye, it must be able to be tolerated without pain for a prolonged duration, and it must be able to be inserted and removed easily by the patient himself. The supporting and corneal parts of the glass must correspond exactly to the ocular geometry to avoid the entrapment of air bubbles between the shell and the eye. The glass must adhere strongly to the eye, so as not to fall out or be ejected by blinking. The glass should not disfigure the patient. Tears must not attack the glass. Moreover, the corneal portion of the ideal contact lens must have a corrective power suited to all corrections and, in particular, it must be able to neutralize the myopia produced by the lengthening of the optical system secondary to the apposition of the contact glass and to compensate for other residual ametropias. The trial contact glasses must be identified according to certain*

criteria to facilitate the selection and the renewal of the most suitable glass." (6)

And he concludes:

"*A contact glass which fills all of these requirements could be manufactured by the Zeiss Company. Such a glass was presented for the first time by Stock in 1920 in Heidelberg. The Zeiss contact glass consists of a thin round shell of ground glass, of which the peripheral part rests on the sclera and is used as the supporting part, while the central part of the shell, the corneal part, is more strongly curved and provides the necessary compensation for any corneal deformation. By appropriate grinding, one can give to this corneal part a suitable refractive correction*." (7)

The results presented were undoubtely extremely favourable in the six fittings. *Dohme*'s article gives, however, only details of one case and he admits that the patients must be endowed with great patience in order to withstand the trial and fitting procedures and to learn the required manipulations:

"*The patient must possess great patience in order to undergo the procedure of repeated trials for the choice of the appropriate contact glass. Besides, the patient needs a certain confidence in order to learn the manipulations which, at the outset, appear to him or her impossible to achieve.*" (8)

Dohme had, in fact, two sets of trial contact glasses, each with three lenses:

"*Zeiss has sent us two identical trial sets, each with three different contact shells, designated as #1, #2 and #3. Among these three models we find the contact glass that best suits the patient by trial and error, i.e. the glass that is best positioned and does not permit the formation of air bubbles, without preoccupying ourselves at this initial stage with any subjective examination. Then, we determine by skiascopy and subjective examination the additional necessary spherical glass. The optical effect is the same for the three models after correction by spherical lenses, provided that the contact glasses are fitted without air bubbles. At the time of the trial fitting, it is therefore necessary for the fitter to be compelled to achieve a good fit for the contact glass. According to information on the designated trial lens and the refraction thus found, the Zeiss Company grinds the definitive contact glass of which the shape and the refractive power correspond with those that were determined*." (9)

In his publication, *Dohme* described the characteristics of the trial contact glasses placed at his disposal: total diameter of 20.00 mm; diameter of the corneal portion: 13.00 mm for model #1, 12.50 mm for # 2 and 12.00 mm for model #3. The arrow, i.e. the height between the corneal apex and the scleral plane is 4.00 mm for model #1, approximately 4.50 mm for model #2 and approximately 3.00 mm for model # 3. This description does not correspond exactly with those supplied by *Zeiss*. (10)

1. 1. 2 - The Publications of Siegrist (1925)

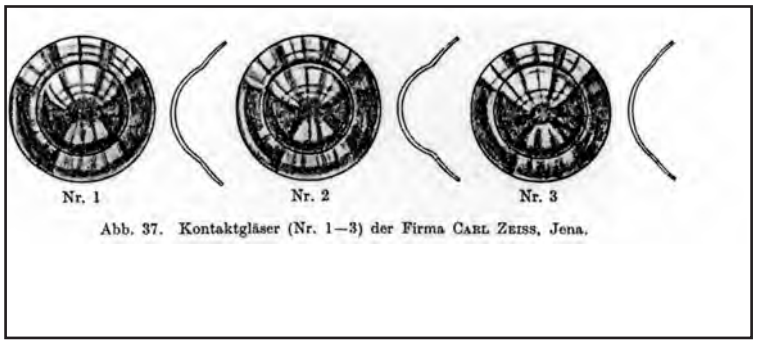


Figure 20-2
The three models of Zeiss ground contact glasses used by Siegrist between 1920 and 1925.
Illustration by Siegrist of the three models of Zeiss ground contact glasses for trial fittings for keratoconus correction. Contact glass #1 has a curvature of 8.00 mm, #2 of 9.00 mm and #3 of 7.00 mm, or a refraction of 45 diopters for #1, of 50 diopters for #2 and of 40 diopters for #3. (Siegrist A., 1925a, figure 37)

In his successive publications on the optical correction of keratoconus between 1920 and 1925, *August Siegrist* of Berne reported excellent results with ground contact shells, both from the point of view of their tolerance as well as in the optical correction of the keratoconus.
In 1925, *Siegrist* published the first synthesis of his publications on the optical correction of keratoconus and irregular astigmatism based on his experience at the Berne Ophthalmological Clinic. A new supplementary publication with a historical retrospective appeared the same year in his treatise on refraction. (11)
In these publications, he reported that the patients were hospitalized for 5 to 6 days

at the Berne Ophthalmological Clinic for the contact lens trial and fitting. Without giving details, *Siegrist* announced excellent results, both from the point of view of tolerance and optical correction. He evoked the possibility of the correction of high myopias and hyperopias, and also attributed the three trial contact glasses of *Zeiss* to his own initiative:

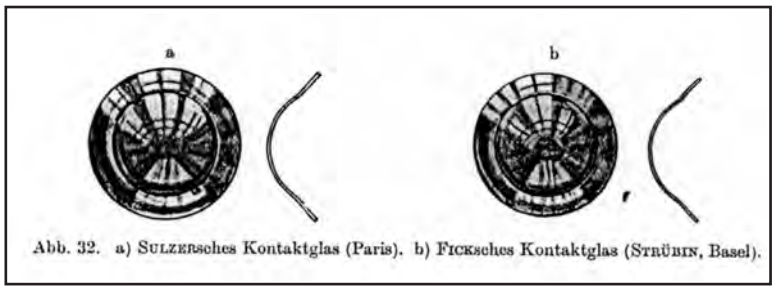


Abb. 32. a) Sulzersches Kontaktglas (Paris). b) Fickssches Kontaktglas (Strübin, Basel).

Figure 20-3
The two models of ground-glass sclero-corneal shells used by Siegrist between 1920 and 1925.
Illustration by Siegrist of the two models of ground contact shells for his trial fittings for the correction of keratoconus: on the left, the so-called 'Sulzer lens' ground in Paris by Benoit-Berthiot; on the right, the so-called 'Fick lens' ground in Basle by Strübin.

(Siegrist A., 1925a, figure 32)

"*Thereafter, Zeiss followed my requirements by manufacturing, as I asked them, new ground contact glasses. The new Zeiss contact glasses are made in three varieties. They carry the numbers 1 to 3. They resemble absolutely the contact glasses of Strübin and also have a strong resemblance to those that Sulzer had had manufactured at the same epoch in Paris. They differed only from one another by higher or lower refractive power (…).*
Glass # 1 has a depth, respectively a curvature of 8 mm,
Glass # 2 has a depth, respectively a curvature of 9 mm,
Glass # 3 has a depth, respectively a curvature of 7 mm.
According of these differences of curvature:
Contact glass # 1 had a refractive power of 45.0 diopters.
Contact glass # 2 had a refractive power of 50.0 diopters.
Contact glass # 3 had a refractive power of 40.0 diopters." (12)

Siegrist recommended the use of a suction cup for the manipulation of the shells and he mentioned that he also used the ground shells of *Strübin*, optician in Basle, of which the radii of curvature of the corneal zone are 5.50 mm and 6.00 mm:"*Unlike the Zeiss contact glasses, the Strübin contact lens has a depth of 5.5 and 6 mm and a corresponding power of 43.0 and 44.0 diopters respectively*". (13)

He illustrated his historical description with some drawings of various contact devices that had been or are still used at the Berne Clinic: various models of hydrodiascopes, *Sulzer* contact glasses, *Strübin* contact glasses, and the three *Zeiss* trial contact glasses. According to *Friede*, who was himself inventor of a 'sclerometer', *Siegrist* would have had several prototypes of instruments for measuring the ocular parameters: diameters, curvatures and height of the arrow. (14)

1.1.3 - Sommer's Doctoral Thesis (1927)

In her doctoral thesis ('Inaugural Dissertation') on the use of contact glasses in the correction of keratoconus that she presented in 1927 to the Faculty of Medicine of Freiburg im Breisgau, *Franziska Sommer* reported that *Stock* and *Siegrist* used the ground *Zeiss* lenses.(15) Contrary to *Stock*, whose two patients did not tolerate contact lenses, *Siegrist* obtained a very satisfactory success in one of his patients and a good result in the other. *Stock*'s actual results were as follows:

"*Four trials with Zeiss contact glasses were undertaken. In spite of significant improvements of visual acuity, two subjects suffered such severe irritation, that the contact glasses could not be tolerated.*" (16)

By way of contrast, *Siegrist* preferred the *Zeiss* contact glasses at this time and abandoned the blown-glass contact shells of Müller:

"*Case 12 of Siegrist (…). The patient tolerated the Müller contact shells well. When the Zeiss contact glasses appeared, the patient received contact glass # 3, with a +2.0 diopter sphere in each eye. The vision was thus: OD = 1.0, OG = 1.0.*
The patient wears his contact glasses for the whole day without the least trouble. At the outset, he used the rubber suction cup, as proposed by Siegrist. Nowadays he removes them just by hand.

Case 13 (Siegrist) (…) Typical keratoconus in the right eye, left eye is still emmetropic. With a Zeiss contact glass # 1, vision is OD = 0,75.
While in the clinic, the patient learned how to insert and remove the contact glass himself and without the aid of another person. He wears them several hours a day for work and has binocularity." [17]

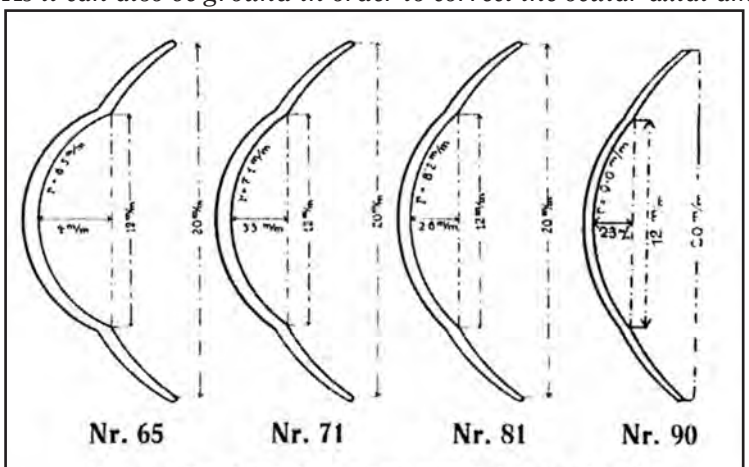
1.1.4 - Hegner (1927)

In 1927, *C.A. Hegner* of Lucerne devotes a chapter to contact glasses in his '*Manual of Refraction and Prescribing and Dispensing of Glasses*'. In his book, *Hegner* described not only the great theoretical optical benefits of contact lenses, but also their limitations of indication in keratoconus, because of their poor tolerance, both subjective and objective. [18]

1.1.5 - Presentation of the Four Zeiss Trial Overlay-Glasses (1927)

In October 1927, the Company Magazine '*Zeiss-Notizen*' (Zeiss Notices) announced under the title '*Auflagegläser/Kontaktgläser*' (Overlay glasses/Contact glasses) that, henceforth, four trial contact shells would be available, each with an optical zone diameter of 12.00 mm and a total diameter of 20.00 mm. [19] For the first time *Zeiss* indicated both the height of the arrow and the radius of curvature of the optical zone. The shells were designated as a function of the posterior central radius of curvature, e.g. shell # 65 had a posterior radius of curvature of the optical zone of 6.50 mm. The innovation comprised the manufacture of afocal trial lenses, but with the possibility of grinding the anterior surface of the optical zone of the definitive lens in order to give it a concave or convex refractive power of up to + or -6.00 diopters:

"*The thin glass shell positioned under the eyelid follows the eye movements and is absolutely unnoticeable. As it can also be ground in order to correct the ocular axial ametropia up to approximately + or -6 diopters, we can state that the contact lenses are ideal visual aids, since they can be worn continuously without producing ocular irritation.*" [20]



Die vier Probier-Auflagegläser von 0 dptr im Schnitt
(doppelte natürliche Größe)

Bezeichnung	Krümmungsradius der Innenfläche etwa	Scheitel-tiefe	Durchmesser des Hornhaut-teils	Durchmesser des Sklerateils
Nr. 65	6,5 mm	4,0 mm	12 mm	20 mm
Nr. 71	7,1 mm	3,3 mm		
Nr. 81	8,2 mm	2,6 mm		
Nr. 90	9,0 mm	2,3 mm		

Figure 20-4
Extract with description of the four 'Probier-Auflagegläser' (trial over-lay glasses) manufactured by Zeiss in 1927.
The early Zeiss trial contact lenses are afocal, their total diameter is 20.00 mm and the diameter of the optical part 12.00 mm. The table indicates the posterior radius of curvature and the height of the arrow for each of the four models.
(Zeiss Carl, 1927a)

The description emphasizes meticulous polishing, thinness and a perfectly spherical surface: "*They are finely polished and all the angles are painstakingly rounded off (...). The surface in contact with the cornea is ground in such a way that it is completely spherical.*" [21] The lens is chosen subjectively from among the afocal trial lenses and is ordered by indicating the best tolerated lens and the additional refraction:

"*To order or renew an 'overlay glass' (Auflageglas), please indicate the number to be found on the trial contact glass and the frontal power corresponding with the axial refractive error. The definitive contact glass has to have the same curvature on its inner surface as the trial overlay-glass (Probier-Auglageglas) in order for it to be compatible with the cornea. With a sufficient curvature of the external surface, the definitive overlay-glass obtains the power necessary for correction of the axial ametropia.*" [22]

These documents will serve in the course of the following years as a model for several publications worldwide. [23]

1.1.6 - Von Clausen and Discussions of Erggelet, Fischer and Hartinger (1928)

In December 1928, *Wilhelm von Clausen*, Professor at the Eye Clinic of Halle an der Saale presented favourable results that he had obtained with the *Müller* blown glass contact shells and was critical of the ground *Zeiss* contact glasses because of their tendency to strangle the paralimbal conjunctiva, thus potentially creating extensive corneal erosions. He had observed this same strangulation of paralimbal blood vessels several years ago at the time of his fittings of celluloid contact lenses. [24]
His communication was followed by an interesting discussion during which *Erggelet* (Jena) confirmed that insufficient attenuation of the ridge between the corneal and the scleral parts of the contact glass could be the cause of the vascular compressions [25]:

"*Certain persons tolerate well the Zeiss ground adherent glasses. These ground glasses have the advantage that their corneal part consists of an optically perfect segment of a sphere of which the curvature can be produced on demand. Certain persons do not tolerate these ground adherent glasses, but do tolerate contact glasses blown by Müller in Wiesbaden. But even in such cases where the Zeiss adherent glass is not tolerated for a prolonged period, I nevertheless use it for examination in order to check the usefulness of pursuing the trials. In fact, if the corneal cone presents opacities, one cannot always verify if the fall in vision is attributable to the opacity or if the surface of the blown contact glass might be partially flawed.*
As far as the cause of those difficulties that are often provoked by ground contact glasses is concerned, one can frequently observe that the sharp ridge between the corneal and the scleral parts compresses para-limbal vessels. In one case, I observed a sickle-shaped white sector that was totally anaemic and traversed only by some empty large vessels. This area of sclera was almost totally compromised and presented a dark red band in the vicinity of the corneal border. In this medial region, one saw a quantity of fine vessels filled to the extreme (…). After elimination of the ridge, the patient was able to tolerate the contact glass without difficulty" [26]

In the course of the discussions, *F.P. Fischer* of Leipzig stated that he had used *Zeiss* contact glasses in the course of experiments on ocular physiology. [27] He had observed that these scleral glasses adhered so strongly to the globe that a tractional force of more than 100 grammes was necessary to detach them from the eyeball. Methylene blue instilled into the conjunctival cul-de-sac did not penetrate under the ground contact lenses, whereas it penetrated always under the blown glasses, thus explaining the good tolerance of the latter:

"*During experiments on the force of traction of the ocular muscles, I used Zeiss contact glasses and I measured the force with which they adhered to the eyeball. The Zeiss contact shells adhered extremely strongly and a force of traction of at least 100 grams was necessary to detach them. If one instils methylene blue into the conjunctival sac after having inserted the Zeiss contact shells, one notes that the methylene blue does not penetrate under the shells, and, after having removed the excess methylene blue, one sees that the sector of conjunctiva on which the contact glass was fixed remains colorless, therefore blocking circulation. With the Müller shells, the methylene blue penetrates immediately under the shell. The Müller shell is never placed in the conjunctical sac as strongly and exactly as the Zeiss shells, which is so essential for the precision of their optical effect*." [28]

The *Zeiss* Company engineer, *Hans Hartinger*, without contesting these observations, attributed them to geometric anomalies of the ocular globes, of which the sclera has not always sphericity as perfect as the contact glasses. [29] He announced that, in the future, the transition between the corneal and the scleral parts of the *Zeiss* contact shells would be more rounded and better attenuated, which would avoid strangulations of surface blood vessels and excessive adherences by the shells to the eyeball:

"*It is not excluded that the cause of the difficulties that appeared sometimes at the time of wearing the adherent glasses of Zeiss may be looked for in the fact that the shape of the ocular globes is not that of a perfect sphere. Of course, it could also be that the angle of the ridge at the transition between the scleral part and the corneal part of the glass could have an unpleasant consequence; particularly if the glass is too strongly adherent due to excess suction. In any event we are going to pursue our attempts to improve the smoothing of this ridge.*" [30]
As it turned out, *Zeiss* immediately issued two patents. The one addressed a corneal zone rendered cupuliform by the grinding of a flatter radius of curvature in its periphery. The other patent addressed the grinding of a corneo-scleral transition at the level of the corneo-scleral junction of the shell. [31]

1.1.7 - Non-optical Use of Zeiss Contact Shells

In the following year (1929) and after a communication from *Goldschmidt* of Leipzig, the physiologist *F.P. Fischer* stated once again that he had used some *Zeiss* ground shells in his experimental studies on the ocular muscles and had noticed their extreme adherence to the eyeball. Furthermore, the methylene blue instilled in the eye did not penetrate under the shells, which is not the case with the blown-glass shells of Müller thus explaining why the latter were better tolerated. (32)

1.2 - In Austria

These first successes in Germany, sustained by massive advertising, encouraged the dissemination of the ground *Zeiss* contact shells to neighboring countries. It was from Austria that the most interesting reverberations were heard. The Viennese clinicians had, in fact, taken the initiative of extending, in the course of the years 1928 to 1930 the indication for contact lenses intended for the correction of keratoconus to that of other ametropias.

1.2.1 - Lauber and Discussions of Sachs, Meller, Kestenbaum and Krämer

In 1927 and in the course of a discussion of a communication by *H. Lauber* at the Ophthalmological Society in Vienna on several clinical cases in which *Müller*'s blown contact lenses were fit, the participants *Sachs*, *Meller*, *Kestenbaum* and *Krämer* did not present clinical examples, but confirmed their interest in contact lenses and their belief in the superiority of the *Zeiss* ground contact glasses. The choice of these required, however, repeated trial fittings: (33)

"*Sachs, Meller, Kestenbaum and Krämer confirmed the advantage, sometimes excellent, of contact lenses and emphasized the outstanding superiority of Zeiss contact glasses compared with Müller's. Kestenbaum stated that repeated trials are sometimes necessary to reach a good toleration of the contact glass.*
Sachs had successfully treated numerous patients with contact glasses, including a pharmacist and a physician. He used none other than Zeiss contact lenses.
According to Krämer, progress was due to the fact that the weight of the contact glass is not supported by the cornea, but by the sclera. The Zeiss contact glasses were better, but also more expensive. The patient, who had been presented several years earlier with hyperbolic spectacle glasses, is now completely satisfied with the Zeiss contact glasses." (34)

1.2.2 - Procksch (1928)

At the meeting in January 1928 of the Viennese Ophthalmological Society, *Maria Procksch* (35), assistant physician and surgeon in Professor *Sachs*'s Unit at Vienna's Wiedener Hospital, reported that she had successfully used ground *Zeiss* contact lenses for the correction of cases of cicatricial astigmatism, congenital and acquired corneal degenerations, corneal nebulae and complications of interstitial keratitis as well as one case of high myopia:

"*Contact glasses can also be advantageously used for various other corneal diseases, quite apart from their use in keratoconus,. Thus, patients affected by an old eczematous pannus and raised degenerative nodules of the cornea were treated by contact lenses after all other methods had failed. (…) In one patient affected by this disease, the visual acuity improved with the contact glass from 1/24 to 6/30 and the patient was also able to read with it. At the present time, he wears the contact glass for eight hours a day and tolerates it very well. In a second and similar case, the acuity improved from 6/36 to 6/8, in a third, who only saw hand movements or, at best, only counted fingers, it improved to 6/60. In a case of primary corneal degeneration, the contact glass improved the visual acuity from 3/60 to 6/24. Also, in the presence of old eczematous corneal cicatrisation, it often happens that the contact glass also improves the acuity by one or two lines on the Snellen chart. Occasionally, the visual acuity is improved to six times its initial level. Particularly gratifying successes were obtained with cases of corneal cicatrisation associated with iris inclusion. In one patient with persistent descemetocele, the acuity improved from 3/36 to 6/15.*" (36)

Even corneal deformations caused by interstitial keratitis benefited from treatment by contact lenses:

Year	*Author*,	*Publication*
1927	*Lauber*,	discussions in Sachs, Meller, Kestenbaum, Krämer.
1928	*Procksch*:	Die Verwendung von Kontaktgläsern bei Hornhautnarben (The use of contact glasses in cases of corneal scars).
1929	*Aust*:	Ueber einige weitere Arten der Verwendung der Kontaktgläser. (About any other utilizations of the contact glasses) - Photography of the fundus in astigmatism.
	Lauber,	discussion: correction of astigmatism and myopia.
	Sachs,	discussion: Procksch corrects too astigmatism and myopia.
	Lindner,	discussion: contact glasses cause corneal lesions.
1929	*Deutsch*:	Praktische Durchführung von Myopiekorrektion mit Kontaktgläsern (Practical apply of myopia correction by contact glasses).
	Lauber,	discussion: contact lenses cause corneal neovascularisation.
	Krämer,	discussion: often ground contact lenses are poorly tolerated.
1929	*Deutsch*:	Über die Verwendung von Kontaktgläsern bei irregulärem Astigmatismus und hoher Ametropie (The use of contact glasses in irregular astigmatism and high ametropia).
1929	*Procksch*:	Berichtigung zu der Arbeit von A.Deutsch: 'Über die Verwendung von Kontaktgläsern bei irregulärem Astigmatismus und hoher Ametropie'. (Rectification in regard to the paper of *A.Deutsch* 'The use of contact glasses in irregular astigmatism and high ametropia').
1929	*Lindner*:	Bemerkungen zu der Arbeit von Frau Dr. Deutsch 'Über Verwendung von Kontaktgläsern usw' und zu der 'Berichtigung' von Frau Dr. Procksch. - Offene Korrespondenz (Remarks on the paper of Ms Dr. Deutsch: 'The use of contact glasses etc.' and about the 'rectification' by Ms Dr. Procksch. - A Public correspondence).

Table 20-2
Chronology of the principal publications on the extension of the indications for contact lenses by physicians in Vienna in the course of the years 1927 to 1929.

"*In a case of interstitial keratitis, the visual acuity of one eye was improved from 6/36 to 6/15. In the other eye, where the cornea was very opaque, the improvement with the contact glass was from 'seeing hand movements at one to two metres' to 6/18, which astonished us. These successes proved that, in the presence of corneal cicatrisation, it is not the diminution of the incident light or luminous dispersion by the corneal scars that constitutes the principal factor for the reduction in visual acuity, but rather the irregularity of the corneal surface. One should use contact glasses more frequently. In all cases described, Zeiss contact lenses were used which are very well tolerated*." [37]

Procksch reported also that she had corrected a case of high myopia using ground Zeiss contact lenses:

"*In one case of high myopia in a 46- year-old female patient who did not tolerate her correction of minus 20 diopters, we used a contact glass that had been specially ground which reduced the myopia to 4 diopters. This situation allowed the patient to fulfil her domestic obligations, while, outside of her home and in the street, she wore spectacle glasses of -4 diopters that corrected her vision completely*." [38]

1.2.3 - Aust and Discussions of Lauber, Sachs, Lindner (1929)

In the spring of 1929, *Aust* reported to the Ophthalmological Society of Vienna that he had neutralized cases of high astigmatism for fundus photography using ground contact glasses, the origin of which he did not specify. Thus, he repeated the experiments that *Fick* had carried out previously in 1891. [39]

In the discussion that followed, *H. Lauber* indicated that he had proposed to *Zeiss* that they undertake a study on the feasibility of the correction of astigmatism and myopia by contact glasses, [40] but this cooperation had been declined, taking into account that these studies were already underway in another ophthalmology Clinic:

"*Lauber approached the Zeiss Company some time ago with a view to proposing to them that they undertake experiments with contact lenses for the correction of astigmatism and myopia. Zeiss declined this offer in view of the fact that these experiments were already under way in another clinic. He had basically envisaged that initiative for cases of oblique astigmatism where the optical correction turned squares into trapezoids*." [41]

At this same session *Sachs* reported that *Procksch* had successfully corrected a patient with minus 7.00 diopters of myopia, whereas *Lindner* had certain reservations and reported that, in several cases, the *Zeiss* contact lenses had caused corneal lesions. [42]

1.2.4 - Deutsch and Discussions of Lauber and Krämer (1929)

In the course of the same session, *A. Deutsch* reported his observation of the correction, at the University Ophthalmology Clinic in Vienna, of the high myopia in an opera singer, thanks to contact lenses for keratoconus # 90 of *Zeiss*. This patient wears the ground contact lens several hours a day on stage, but had succeeded in wearing a blown contact glass of *Müller* for a longer period [43]:

"*An opera singer had myopia of 22 diopters in his right eye with corneal cicatrisation. In his left eye his refractive error was -7.00 diopters. On stage, he could not wear his glasses and was unable to see the conductor. With a Zeiss # 90 contact lens and a -1.50 diopters sphere, he reached a visual acuity of 6/6. With the contact glass alone, but without any additional correction, he was well able to manage on stage, but he was only able to tolerate the Zeiss contact lenses for a few hours. A Müller contact lens, however, could be worn for a longer time and to the patient's greatest satisfaction.*" [44]

The example of this impressive fitting of contact lenses for this opera singer was quoted during the next ten years in many publications worldwide in order to illustrate the success of contact lenses in patients with high myopia.

During the discussion of this communication, *H. Lauber* indicated that in one patient with corneal nebulae accompanied by neovascularisation, the *Zeiss* contact lens was unexpectedly well tolerated. It did, however, provoke a vascular outgrowth and a corneal opacity, fortunately reversible after the removal of the contact lens. *R. Krämer* had also known cases where *Zeiss* contact glasses were not tolerated and where it had also been necessary to provide the patients with blown contact glasses. [45]

1.2.5 - The 49 Contact Lens Fittings of Deutsch (1929)

Several months later, *Deutsch* published an important paper inspired by Professor *K. Lindner*, on the successful fittings of 49 patients affected by irregular astigmatism, keratoconus and high myopia. After describing fitting procedures and how to choose the appropriate contact lens starting with the four Zeiss trial models, *Deutsch* presented a summary of his conclusions in 49 cases. He was able to demonstrate that eyes affected by keratoconus were fit successfully with Zeiss contact glasses, except for one patient. The latter tolerated a blown contact lens of which the radii of curvature, as measured with the Javal keratometer, were, however quite similar to those of the *Zeiss* contact glass. Contact glasses for keratoconus could also be used for the optical correction of corneal irregularities with nebulae caused by keratitis or scars (41 patients). Patients with high refractive errors could also be fit. These spectacular results appeared hard to believe, considering the limited number of contact shells models available and their primitive construction. *Deutsch* acknowledged, besides, that some patients included in the study did not tolerate contact lenses for more than a few hours a day. *Lindner*, who was the initiator of this study, claimed on this occasion the priority of using contact lenses for the correction of cases of high astigmatism. [46]

1.2.6 - Procksch's Protest and Lindner's Reply (1929)

The claim by *Lindner* that he was the first to use contact lenses for the correction of high astigmatism was challenged in a letter from *Procksch*, assistant at the Ophthalmology Clinic of Professor *Sachs*, and published in *Klinischen Monatsblätter für Augenheilkunde*. [47] In the journal, *Procksch* insisted that she had used *Zeiss* contact lenses since 1926 and had achieved improvements in 12 astigmatic patients. Under certain circumstances, myopes had also been fit with corrective contact lenses specially ground for this purpose:

"*On the initiative of Professor Sachs, I have been using contact lenses for three years not only for keratoconus, but also for all the other possible diseases associated with irregular astigmatism i.e. in corneal cicatrisation, corneal dystrophies, primary corneal degenerations, etc., also in a case of persistent descemetocele (…) and I have prescribed them in 12 of these patients because of a significant improvement in visual acuity. We have also in certain circumstances fitted myopes with specially ground contact glasses (hunters, skiers, high myopes not able to wear their eye glasses).*" [48]

The polemic became more venomous through an 'open letter', published in the same review, by Professor *Lindner* to *Procksch*. He recalled that the correction of the astigmatism associated with corneal nebulae had not been perfected in Professor *Sachs*'s Clinic, but *Fick*, who is cited in several treatises, had already practiced it. He himself had tried the method on several occasions since 1924 without publishing it. *Siegrist* had also recommended contact lenses for the correction of refractive errors [49]:

"*Professor Sachs, who is at the origin of the rectification by Dr. Maria Proksch, is mistaken if he imagines that he has discovered a new application for contact glasses. It is well known that Fick was the first to try contact glasses in patients with cicatricial astigmatism. Considering their success in the treatment of keratoconus, this indication has however passed on to the second stage. It has been mentioned several times later and is also cited in manuals. (…) For my part I have tried Müller contact lenses for cicatricial astigmatism several times since 1924.*
"The use of contact glasses for refractive errors is no longer a novelty. Siegrist recommends them specifically for these indications as often in his publications as well as in his Manual of Refraction published in 1925 on page 39." [50]

2 – The Zeiss Contact Shells for all Refractive Errors (1930-1933)

Towards 1930, the necessity for *Zeiss* to produce a more extensive range of trial contact shells became apparent. This would allow the fitting of contact shells for all refractive errors. Between 1930 and 1933 a major advertising campaign was launched promoting the 'New Zeiss Contact Glasses' promised to correct all types of refractive errors.
This presentation was distributed between its promoters: on the clinical side, professor *Leopold Heine*, director of the Kiel Ophthalmology Clinic and *Victor Much*, his assistant. On the other side was *Hans Hartinger*, engineer in charge of medical optics at *Zeiss*, Jena for both the optical theory and the commercial promotion. (*see Table 20-3 next page*)

2.1 - The Presentations of Leopold Heine (1929-1933)

2.1.1 - The Presentation to the Congress of Amsterdam (1929)

In September 1929, *Leopold Heine* presented to the 13th International Congress of Ophthalmology in Amsterdam, a communication under the title '*The correction of all refractive errors by ground contact shells*' (Die Korrektur sämtlicher Brechungsfehler des Auges durch geschliffene Kontaktschalen). This presentation caused a sensation and was to mark the opening of a new epoch for the *Zeiss* ground glass contact lenses. [51] *Heine* described in eulogistic terms the extremely favorable results that he had obtained with the new shells that would have the advantage of easy fitting, since it would be sufficient to read on the keratometer the dioptric power of the cornea and to add or subtract that from the refractive error in order to know the corneal curvature of the contact glass thus chosen:

Date	*Author*	*Publication*
1929	*Heine*:	Die Korrektur sämtlicher Ametropien durch geschliffene Kontaktschalen (The correction of all refractive errors using ground contact shells).
1930	*Heine*:	Über den Ausgleich sämtlicher Brechungsfehler des Auges durch geschliffene Haftgläser (On the correction of all ocular refractive errors using ground adherent glasses).
1930a	*Hartinger*:	Über Haftgläser vom Optischen Standpunkt (On adherent glasses from optical standpoint).
1930b	*Hartinger*:	Zur Berichtigung der Fehlsichtigkeiten mittels der geschliffenen Zeißschen Haftschalen (On the correction of failing eyesight by means of the ground Zeiss adherent glasses).
1930c	*Hartinger*:	Zur optischen Theorie des Haftgläser (On the theoretical optics of adherent glasses).
1930d	*Hartinger*:	Zur Haftglasberichtigung linsenloser Augen (On the correction by adherent glasses in aphakia).
1931a	*Heine*:	Neue Anzeigen zur Verwendung der Haftgläser (New indications for the use of adherent glasses).
1931b	*Heine*:	The use of contact glasses (in The Lancet).
1931c	*Heine*:	Hat die Haftglasbehandlung irgendwelche Gefahren? (Are there any risks in the adherent glass treatment?).
1931	*Much*:	Der Gegenwärtige Stand des Haftglasproblems, sowie die Möglichkeiten und Grenzen der Haftglastherapie (Present status of the adherent glass problem, as well as the feasibility and limitation of the therapy with adherent lenses).
1932a	*Much*:	Die optischen und therapeutischen Möglichkeiten des Haftglases (The optical and therapeutic possibilities of the adherent glass).
1932b	*Much*:	Das Haftglas und seine Anwendung (The adherent glass and his utilization).
1932c	*Much*:	Über Haftgläser 1/Geschichtliches (On adherent glasses 1/Historical part).
1932d	*Much*:	Über Haftgläser 2/Haftglastherapie des Keratokonus, nebst Bemerkungen zur Kasuistik der Erkrankung (On adherent glasses 2/Therapy of keratoconus using adherent glasses, with remarks on the causation of the disease).
1932	*Hartinger*:	Sonderformen (Special Forms).
1933	*Heine*:	Über Haftgläser (On adherent glasses).

Table 20–3
Chronology of the principal publications on the 'New Zeiss Adherent-glasses' by Heine, Much and Hartinger between 1929 and 1933.

"*The examination technique is very simple. If in the case of a myope we have measured a refractive error of 5 diopters and that we measure a corneal radius of 7.5 D, the optically effective part of the shell should have a radius of 8,5, in the case of a hyperopia of 5 diopters a radius of 6.5. This can be read directly on a suitable ophthalmometer*." (52)

Of course, the astigmatism would be eliminated by the dioptric power of the tear lens between the cornea and the shell. The correction of presbyopia would not pose any problem with the shells of which the optic could be ground accordingly. The 'mechanical' fitting of the scleral part of the new ground contact glasses

would be achievable by short duration trials with the corresponding shells. This would not cause any difficulty even with children.
The optical correction could be adjusted by a suitable grinding of the anterior surface of the contact shell and would create a state of total correction of refractive error that would cause the myopia to regress and would straighten out accommodative strabismus:

"*With the shells optically and haptically adequate, the eyes find themselves in a state of total correction of the refractive error, a state which according to all clinical experience approaches physiological conditions as closely as possible. The stabilisation of the myopia pleads in favour of this argument, if this therapy is used from the time of the first correction by glasses. In addition, muscular insufficiencies disappear, along with divergence insufficiency of myopes and convergence insufficiency of hyperopes.*" (53)

There would be no contraindication to the use of contact lenses. The shells would be particularly recommended to the professions and for those situations that require an enlarged field of vision; also for females, whose social behavior and psychological confidence would be improved. In some cases, there would also even produce a therapeutic effect on the glaucomas and an 'orthopedic regression' of the ametropias.

The communication did not include any clinical case histories. It was, however, preceded by a short historical introduction, unfortunately erroneous. According to the author *Fick* would have had some contact lenses blown in 1888 by *Müller* of Wiesbaden, *Sulzer* would have used in 1892 ground *Zeiss* shells for correcting keratoconus, and *Müller jun.* would have proposed, in his thesis upheld in 1920 at Marburg the use of blown contact shells for the correction of myopia. Unfortunately, these errors were widely diffused and served as a reference for many years to come.
The official report of the congress does not make mention of any discussion. Only *Karl V. Fukala* of Vienna intervened to affirm his conviction of the value of this refractive correction by contact lenses. (54)

2.1.2 - The Publication in the Münchner Medizinische Wochenschrift (1930)

Heine complemented his communications at the International Congress of Ophthalmology in Amsterdam a few months later in several publications. The first, on '*the correction of all the ocular refractive errors using ground glass adherent glasses*' that was to serve as a model for subsequent articles, which appeared in a weekly medical journal with a big circulation. It was followed by his presentation at the local ophthalmological society of ten clinical cases (5 myopes, 3 aphakes, a patient with astigmatism and one with hyperopia) which was also published in a review of general medicine. (55) The texts of these presentations were distributed by *Zeiss*, in the form of reprints and were reproduced in other generalist medical reviews. (56) In these conferences and publications, *Heine* often insisted on the psychological advantages particularly for females:

"*I would rather not quote Goethe who was unsympathetic to wearers of glasses. (…) On many occasions I have been told by young women that now, once again, a new life has opened up for them: social interaction, going to the theater, sport, (tennis, motoring and driving, skiing, bathing, swimming and so on). Only now do they enjoy these things and only now are these activities possible.*"(57)

2.1.3 - The Publication in The Lancet (1931)

In reply to a publication by *Rugg-Gunn* in The Lancet published several months earlier, *Heine* entrusted an article to this journal (The Use of Contact Glasses) where he announced that the period of intolerance with earlier models lenses had been revolutionized thanks to enlarged sets of new trial lenses (58):

"*From this set it is not desirable to attempt to produce a correction of more than four dioptres, (…) it is better to work with a second set in which the radius varies by 0,5 mm steps. (…) Best of all, however is to have a set of glasses progressing by 0.25 mm. (...) Moreover, the scleral radius is not sufficiently varied in a series running 11, 12 and 13 mm. (…) Glasses with a contact radius of 11,5 and 12,5 mm are needed. (…)*
All the writers on contact glasses in the past have used a fixed scleral radius of 12 mm and that is the reason why experiments on this form of correction have hitherto all failed. It is not the optics of the method that constitute the difficulty, but the application of the glass to the cornea, which demands not only correct scleral radius, but also a good relation to the optical dimensions. A glass that is relatively flat compared with the natural curve of the cornea must lie very lightly on the middle of the cornea, while a glass that is more highly

curved than the natural cornea must touch it equally gently around its circumference. Therefore it is of the utmost importance to adapt the glass accurately to the sclera."

Heine went on while extolling the virtues of tinted contact glasses for numerous indications:

"*This is the best possible protection to the eye against climatic conditions such as storms, dust, cold and heat. Children with ophthalmia like these glasses and do well with them. In my experience these lenses also constitute the best treatment for colour-blindness likewise photophobia, improving the vision and reducing the nystagmus.*
The contact glass is also valuable for serpentine corneal ulceration, progressive corneal abscesses, and other forms of keratitis, especially if the concavity of the glass is smeared with a disinfecting ointment."

He then takes a position on the visualization of colored rings, such as those that patients perceive at the time of glaucomatous attacks:

"*There is no fear of causing glaucoma by the use of these glasses, although anxiety is sometimes apparent when the patient seen rainbow colours round an open light. This is due to a misfit of the glass with the cornea, or the use of hard or distilled water, and can be obviated by appropriate fitting and the use of physiological saline*."

The article is supplemented with ten clinical cases, certain unedited, including those of a patient with dyschromatopsia corrected by a colored contact lens, of a sailor who was able to return to sea and a presbyopic orchestral conductor.

2.1.4 - The New Indications (1931)

Shortly afterwards, in 1931, the indications for tinted contact lenses in '*Umbral*' of *Zeiss* were described and presented on '*New Indications for the Use of Adherent Glasses*' [(59)]. The tint in the optical part is suitable for absorption of 25, 50 or 75%. The mildest filter, at 25% would be recommended for esthetic purposes in order to give more expression to the eyes of "*actrices and singers predominantly female*". Shells with denser filters effectively would be indicated for patients complaining of photophobia or glare. They could even be used in the absence of a refractive error as an alternative to sunglasses. They are also indicated for ocular irritations any kind, including trichiasis, iritis, corneal dystrophies, choroiditides and retinitis.

Aside from these wide-ranging triumphant claims, the audience engaged interesting discussions that witnessed both physician scepticism and a sense of economic realism amongst his ophthalmological colleagues. Thus *von Hippel* of Göttingen and *Rieck* of Stettin were disapproving of the *Zeiss* advertising to the ophthalmologists that gave the impression that the set of 21 shells would be sufficient for the trials, whereas *Heine* now suggested equipping with 200 shells. *Kreutzfeld* of Lübeck recommended a stricter selection of the candidates for correction and observed that the wearing time rarely exceeded a few hours, but could be extended to a whole day if the patient would wear the lenses alternatively the same day on one eye and then the other. *Görlitz* of Hamburg thought that females accepted more readily the discomfort of contact glasses. [(60)]

2.1.5 - The Absence of Risks from Adherent Lenses (1931)

Faced with these reservations and criticisms, *Heine* published a further article in 1931 in the general medical press in which he refuted the rumor that contact glasses would present a risk. [(61)] He confirmed that the fear of a direct lesion of the globe from the wearing of contact lenses or even an injury at the time of their insertion was in no way justified. Of course, cases of intolerance had been reported when keratoconus was corrected, but the literature cited no case of a severe ocular lesion. It is no longer justified to be mistrustful of contact lenses, taking account the enormous benefits that they bring in appropriate cases: e.g. myopic females, sportsmen, sailors besides all of the situations where the wearing of glasses was not possible or allowed, i.e. artists, actors, singers, and so on. *Heine* tried to explain why ophthalmologists showed little enthusiasm for this new modality. The reason seemed to him to be due to bad experiences with the preceding trial set of 4 lenses with a single scleral radius of curvature of 12.00 mm. Now that *Heine* had obtained from *Zeiss* the agreement for the firm to manufacture three scleral radii, namely 11.00 mm., 12.00 mm, and 13.00 mm, and that the corneal radii would thereforth be available between 5.00 and 11.00 mm, in a set containing 39 trial shells, these difficulties ought no longer to occur. If there were still failures, it would be because his

colleagues do not have trial lenses available in sufficiently great numbers. This statement in the general medical practitioner press was not particularly appreciated by the ophthalmologists, as is revealed by the reservations expressed by *F. Poos* in his critical comment. (62)

2.1.6 - Heine's Final Synthesis (1933)

In 1933, *Heine* assembled his final synthesis of the fitting procedure for ground contact lenses in a 32 pages supplement of the Klinischen Monatsblätter für Augenheilkunde that was widely distributed. (63) In his introduction, he explained that "*the theoretical optics of contact glasses*" was often presented as a challenging problem of physics and mathematics. This had discouraged physicians "*because the majority of physicians have a horror of formulas and curvatures*". In fact the procedure was quite simple, but often poorly explained.

For the choice of the scleral part, *Heine* proposed to base his choice on the appearance of air bubbles in the tear meniscus in front of the cornea. The scleral part of the shell had to be so adherent to the conjunctiva that it did not allow air bubbles to penetrate under the shell. The presence of air bubbles would be proof of too flat scleral part. If, on the other hand, the fitter observed a tightening of the scleral part of the shell, which translated into an interruption of the circulation of the conjunctival vessels causing corneal edema, he was obliged to choose a less steep shell.


ÜBER HAFTGLÄSER

VON

GEH.-RAT PROF. DR. L. HEINE

Direktor der Universitäts-Augenklinik in Kiel

MIT 15 ABBILDUNGEN

Beiheft zu den Klinischen Monatsblättern für Augenheilkunde, 91. Band

1 9 3 3

FERDINAND ENKE VERLAG STUTTGART

Figure 20-5
Heine's publication (1933).
The booklet 'Über Haftgläser' (On adherent glasses) was 32 pages long and had 15 illustrations. It was published in 1933 by Heine as a supplement to the monthly review Klinische Monatsblätter für Augenheilkunde.
(Heine L., 1933)

For the selection of the optic part, *Heine* proposed to read the corneal refraction on the dioptric scale of the keratometer and to add or subtract the ocular refraction to that figure. He quoted *Müller-Welt* as an example: *Müller-Welt* classified his trial shells not as a function of the corneal radius, but in corneal diopters, and the scleral radii in curves, thus demonstrating the optical and haptic duality of contact lenses:

"*Müller-Welt indexes his, in a hollow mold blown shell, according to this principle. He indicates the number in diopters, i.e. the refraction and not the radius of curvature only for the optical part. In contrast to this, he keeps the indexing of the haptic part as a radius of curvature and not in diopters. The duality of the adherent glass with its two parts, optic and haptic, is thus clearly expressed.*" (64)

Heine estimated that the patient would better tolerate the shells, if they were tinted. He proposed that the patient's apprenticeship in the techniques of insertion and removal should be confided to a nurse, who herself should be a contact glass wearer. Then he reproduced his preceding publication where he had revealed his arguments on the harmlessness and the absence of risks of the contact lenses. He railed against the rumors of ocular lesions that were rife. Such could not be supported by any reference in the literature. Each time he asked the author about the origin of the observation, that author could not verify it. This lack of verification was due either to a misunderstanding or remarks in the discussions had been reproduced in an erroneous manner or deliberately misrepresented. It could be that these rumors had been passed around by opticians, who however, do not have to fear that they will lose their eye glass (spectacles) clientele:

"*If the opticians have often been wary of this form of ocular correction, a certain self interest is apparent as far as they are concerned. Adherent glasses will not replace eye glasses (spectacles). The latter must always be kept in reserve, because adherent glasses represent just another form of treatment and complimentary to glasses.*"(65)

The listing of the indications for contact glasses follows *Heine*'s preceding presentations closely, but is illustrated by impressive stereotypes, not only of the glasses the patients were wearing, but also of the evolution of their mimicry before and after fitting contact glasses. The second half of the booklet describes 85 clinical observations where the therapeutic and optical effect of contact glasses is particularly conclusive. 26 myopes were involved, one presbyope, 4 anisometropes, 18 keratoconics, two marginal dystrophies and 23 other affections. These included trachoma, pannus, corneal erosions, herpes, ulcers, keratitis and iritis.

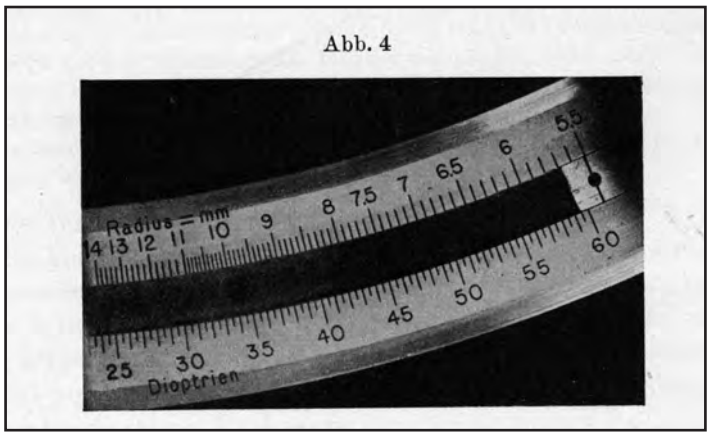


Figure 20-6
Vertical view on the graduated scale of the keratometer.
In his first presentations, Heine recommended that the corneal curvatures be read in diopters on the Javal-keratometer, then that the ocular refraction be added or subtracted thus enabling calculation of the internal curvature of the optical part of the lens. Shortly afterwards he abandoned these recommendations.
(Heine L., 1934, figure 4)

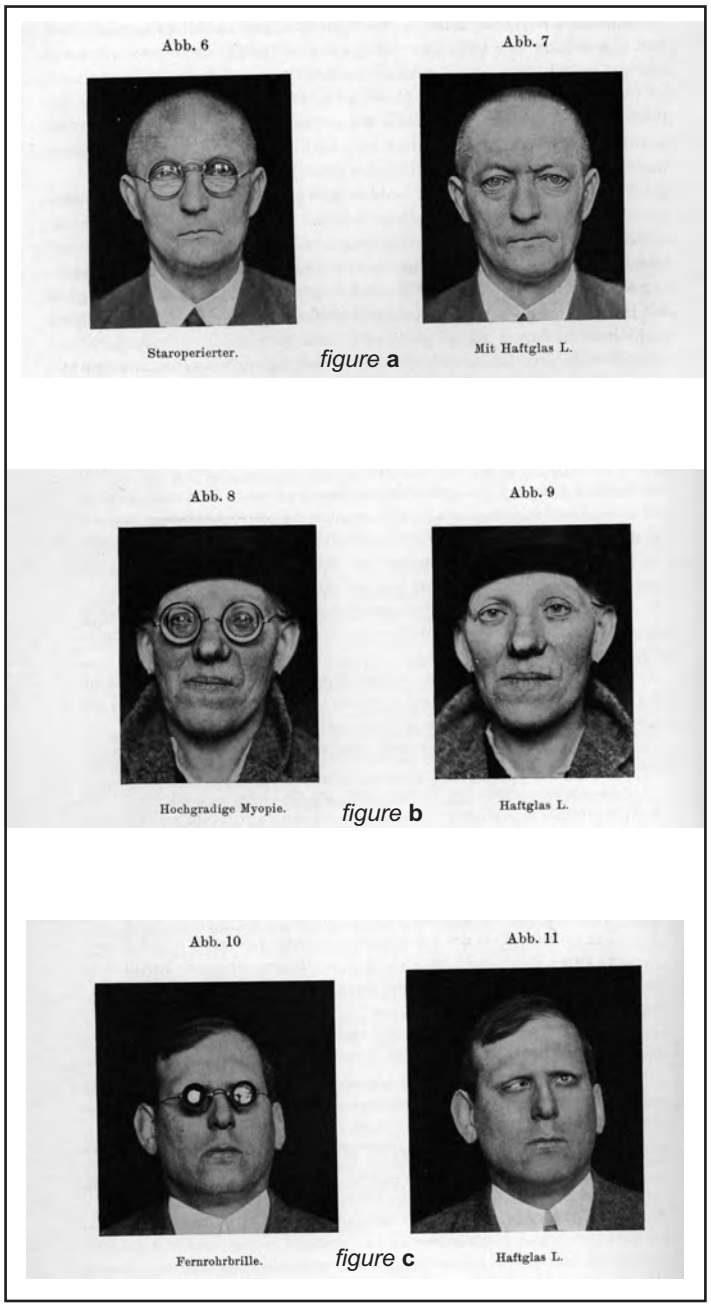


figure **a**

figure **b**

figure **c**

Figure 20-7
Illustrations by Heine showing success of contact glasses.
*In the left image, the patients are wearing glasses; on the right they are wearing contact glasses. From above to below: (**a**) an aphakic patient, (**b**) a high myope, (**c**) patient wearing telescopic spectacles.*
(Heine L., 1934, figures 6 to 11)

2.2 - The Presentations by Hans Hartinger

2.2.1 - Hartinger's 'Optical Theory' (1930)

The optical engineer of *Zeiss*, *Hans Hartinger*, was commissioned to present the 'optical theory of the adherent glasses' and to promote their marketing. The official presentation by *Zeiss* of its new ground contact lenses took place on 13th June 1930 in Heidelberg at the 48th Annual Congress of the German Ophthalmological Society and this marked the firm's actual entry into the medical field. (66)

Hartinger presented the '*Haftgläser*' (adherent glasses) that were manufactured by *Zeiss* as being suitable for the correction of all visual defects. As the four models of trial contact shells manufactured from the ten previous years for the correction of keratoconus were not suited to the correction of other errors of refraction, *Zeiss* had developed in the course of the previous three years and with *Heine*'s collaboration, a larger number of these contact glasses with different specifications.

Probierhaftgläser nach Prof. Heine

des Sklerateils des Tragrandes in mm		Krümmungsradius der augenseitigen Glasfläche des Hornhautteils in mm 5	6	7	8	9	10	11
		Bezeichnung						
Probiersatz I (21 Haftgläser)	11	1/5	1/6	1/7	1/8	1/9	1/0	1/1
	12	2/5	2/6	2/7	2/8	2/9	2/0	2/1
	13	3/5	3/6	3/7	3/8	3/9	3/0	3/1
		5,5	**6,5**	**7,5**	**8,5**	**9,5**	**10,5**	
Probiersatz II (18 Haftgläser)	11	1/55	1/65	1/75	1/85	1/95	1/05	
	12	2/55	2/65	2/75	2/85	2/95	2/05	
	13	3/55	3/65	3/75	3/85	3/95	3/05	

Auf Wunsch können auch Probierhaftgläser mit einem Krümmungsradius des Sklerateils von 10.5, 11.5 und 12.5 mm geliefert werden. Auch ist es möglich, Gebrauchshaftgläser mit stetigem Übergang vom Kornea- zum Sklerateil, mit erhöhtem Korneateil oder ovalem Sklerateil anzufertigen.

Figure 20-8
Zeiss-Heine trial contact lenses.
In 1934, the Heine-Zeiss trial shells in the standard box are presented with combinations of three scleral radii of curvature: 11.00, 12.00 and 13.00 mm. The 21 shells have radii of curvature in steps of 1.00 mm between 5.00 and 11.00 mm. The contact shells of the complementary box of 18 shells have intermediate steps of 0.50 mm for their corneal radii of curvature.
The notice gives the additional information that shells with scleral radii of 10.50, 11.50 and 12.50 are also available. The definitive shells can be furnished with a transition at the limbus, with a super-elevated corneal part or with an oval total diameter. (Zeiss Carl, 1934).

The trial glasses were available in all varieties of internal curvatures, both for the corneal as well as for the scleral part. The trial set of 39 '*trial adherent glasses*' (Probierhaftgläser) with corneal radii of curvature from 5.00 to 11.00 mm graded from 0,50 to 0,50 mm, and with scleral radii of curvature from 11.00, 12.00 and 13.00 mm were presented in a box with cover. The tear film imprisoned in the space between the glass and the cornea carried out the correction of the refraction. Additionally, this accumulation of tears automatically eliminated the corneal astigmatism by neutralization of corneal power. The definitive 'usable adherent glasses' (Gebrauchshafgläser) for the patient were individually prepared for each patient and could include, if necessary, a light supplementary optical grind.

Using graphs, *Hartinger* demonstrated the optical effect of the tear meniscus as a function of the corneal curvature and of that of the posterior surface of the optical part of the contact glass as well as the effect of enlargement of the optical image in the corrected myope. Then, using a table of coordinates established as a function of the corneal curvature in abscissae and the principal nodal points as ordinates, he explained the choice of the glass that would give the best correction and, if necessary, the power to be added. *Hartinger*'s presentation, using, as it did, the specialized technical language of optical engineers and making reference to the schematic eye of *Gullstrand*, including the indices of refraction of the glass and the tears, as well as to abacuses constructed as functions of the nodal points, was probably not well suited to the audience of this medical congress.

The communication was followed by interesting discussions that, without adding any arguments for or against *Zeiss* ground contact lenses, presents nevertheless a certain historical interest, considering that they allow us to collect evidential data on the problems encountered at this time by the ophthalmologists interested in this mode of correction.
Csapody of Budapest recalled his attempts with paraffin molding of the living eyeball and of molds made from plaster of Paris and metal that could be used for making contact lenses. He gave a demonstration of this and proposed sending samples to *Zeiss* for the manufacture of contact shells molded from these models.(67)

Figure 20-9
Box for 21 standard Zeiss-Heine trial shells.
The wooden box contains in its bottom a fixed Bakelite plate. The cover of the box is twice the expected thickness due to upholstering. A similar case of smaller dimensions is provided with 18 complementary shells following the composition mentioned in figure 20-8.
(Zeiss Carl, 1934)

For his part *Löhlein* (Jena) expressed his confidence in the possibility of correcting high myopes and astigmats, as the tests he had carried out at the Ophthalmology Clinic had given good results with the lenses of the preceding set, intended for keratoconus patients. He expressed, nevertheless, his reservations on the exaggerated optimism and the media publicity exhibited by *Heine*, who did not hesitate to present himself as inventor of the contact lenses. He expressed, nevertheless, his reservations on the exaggerated optimism and the media publicity exhibited by *Heine*, who did not hesitate to present himself as the inventor of the contact lenses. He recalled that, in 1888 *August Müller* had corrected his own myopia of 14 diopters with ground contact glasses, which fact neither *Heine* and *Hartinger* seemed to be aware of. (68)
Lindner (Vienna) recalled that the tolerance of a contact glass is not determined by the concordance of geometric parameters, but by the comfort of the patient and the absence of excessive adherence of the contact glass to the eyeball. (69) One should not choose the glass that would the best but that which is best tolerated. He quoted a case of a patient suffering from keratoconus who was followed at his clinic. This person saw 6/6 with well-selected contact glasses. He was not, however, able to accustom himself to these in spite of six months of persevering efforts. Furthermore, "*the Zeiss adherent glasses were sometimes so adherent, that one cannot remove them from the eye. Such adherent glasses are surely not tolerated*". The contact glasses of the *Müller* firm were often better tolerated, perhaps just because of their poorer optical and geometric qualities.

Figure 20-10
Case for delivery and preservation of Zeiss sclero-corneal shells.
(Zeiss Carl, 1934),

Stock (Tübingen) pointed out that the *Zeiss* contact glasses had been little used at the present time, for their distribution was reserved for certain privileged sites.(70) He had himself worn experimental *Zeiss* glass contact lenses of corneal diameter in 1912 when he was chief of the Ophthalmology Clinic in Jena. Their optical effect was perfect but their tolerance was limited to between 2 and 4 hours (71). *Stock* would accept contact glasses with less perfect optics if they were better tolerated. Contact glasses were not innocuous and a serious accident during their use could have significant medico-legal consequences.
Erggelet (Jena) reported that he had performed numerous contact glass fittings partly with the collaboration of *Zeiss*. (72) He had not himself tolerated contact lenses ground from a block of quartz for more than half an hour. He listed various causes of intolerance: chemical, mechanical and the individual sensitivity of the patient. The liquid used for their insertion, generally physiological serum, should not play a role in this intolerance, for it is eliminated quickly and is re-

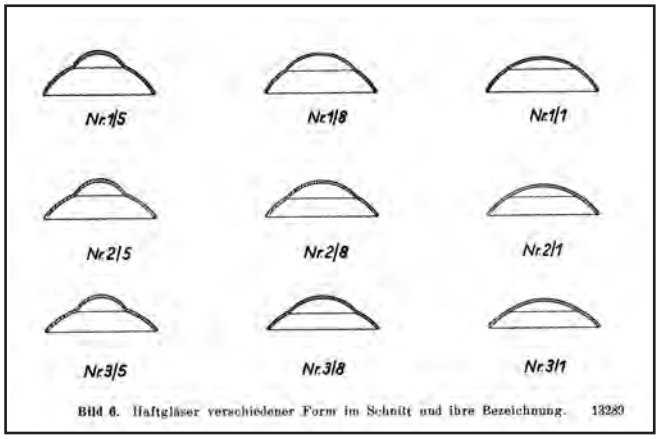


Figure 20-11
Zeiss 'adherent glasses' presented in section with description.
The first number in the notation corresponds with the scleral radius of curvature: 1 for a radius of 11.00 mm, 2 for 12.00 etc. The second number indicates the posterior corneal curvature: 5 for 5.00 mm, 75 for 7.50 mm, 1 for 1.10 mm. (Zeiss Carl, 1934).

placed by tears. The instillation of fluorescein demonstrates this exchange, which is better with the *Müller* shells, albeit geometrically imperfect, which are tolerated without symptoms for hours. He tried to combine the blown haptic of *Müller* glasses with the ground glass optic of those of *Zeiss*, as *Helmbold* had already tried in 1913 [73]:

"*Mr. Müller in Wiesbaden has been so kind as to manufacture at my request a series of shells of which the corneal part has been ground at a later stage by Zeiss. (…). To my enormous regret, these attempts failed, because the shells were not free of internal stresses. They shattered from the moment their grinding was commenced.*" [74]

Erggelet has nevertheless become convinced that the intolerance was due mostly to the pressure exerted by the ridge of the junction between the corneal and the scleral parts in the neighborhood of the limbus. In some cases, where the vascular compression was particularly evident in this region, a softening of this transition had allowed a significant improvement in the tolerance.

In his turn, *von Hippel* (Göttingen) described the experiments of *Wigand* and of *Henker* with Cellon (celluloid) contact lenses that were tolerated by several persons for up to 5 hours at a stretch, but were poorly tolerated in the longer term. *Clausen* (Halle) confirmed the comments of *von Hippel* concerning these experiments. They had given excellent results optically, but the shells that fitted the globe best were also the least well tolerated. These observations would also explain why blown contact glasses are better tolerated than ground ones. [75]

Wissman (Wiesbaden) reported that he knew numerous cases of patients with refractive errors that had been corrected using the blown contact glasses of *Müller-Wiesbaden* that were worn for up to 12 hours a day. He had never observed any complications, for which reason he preferred them to ground contact glasses, notwithstanding that the optics of the former had not been perfected. [76]

Hartinger responded to these criticisms that the best tolerance of blown contact glasses compared with ground contact glasses is related to the old generation of *Zeiss* shells. The latter were only available in three or four corneal curvatures and in one scleral curvature. The new trial contact glasses available in 39 models will permit the achievement of improved tolerance and, most importantly, excellent optical correction. [77] The presentation on 'optical theory' by *Hartinger* was to be published unabbreviated in a review of ophthalmic optics, included a 20-page in depth review of the physics and the optics. This document was widely distributed in the form of promotional off-prints. It was translated into most languages and was given away with every purchase of trial Zeiss contact glasses.

Not long afterwards, *Hartinger* presented a series of lectures at which he repeated his previous presentations on optical theory at the local congresses. [78] He also expressed his interest in fitting of aphakes with contact glasses because the correction of anisometropia and aniseikonia in this group was not possible using eyeglasses. It was tempting to apply this indication (aphakia) to contact glasses. Unfortunately, at this historical era, adequate grinding of the anterior surface of a contact glass was not achievable. The refractive correction proposed by *Hartinger* and *Heine* was based on the creation of a tear lens so thick that it caused the outpouring of the liquid, the formation of air bubbles and a strangulation of limbal vascular channels causing anoxia of ocular tissues. Nevertheless, *Hartinger* put great emphasis on the theoretical advantages that an adherent lens would bring to a patient with unilateral aphakia, particularly the fusion of images and binocular vision in all directions of gaze. [79]

2.2.2 - The Improvements in Zeiss Contact Glasses and 'Special Shapes' (1930-1931)

Confronted by these polemics, the *Zeiss* adapted to suggestions coming from physicians, like *Dallos*, using shells with an aspheric cup-shaped central part and those with an attenuated corneo-scleral junction, the patents for which were registered in 1930. [80] These innovations were accompanied by an extension of the parameters of the radii of curvature and of the diameters together with announcements to the congresses of the advantages of a more rounded external edge and the removal of the ridge between the corneal and scleral parts, replaced by an intermediate curvature.

Then, in the following year, along with those contact glasses ground to specially required geometry (Sonderformen), *Zeiss* manufactured ground contact lenses with an elevated corneal portion (gehobene Korne-

alteil). By means of the addition of an annular cone of 0.50 to 1.00 mm between the scleral and corneal parts, those shells that had a more protruding profile, avoided contact between the corneal apex and the glass in patients with high myopia and keratoconus. At the same time, the anterior grind of the optical zone was changed to 12.00 diopters with a reduction of its diameter to 8.00 mm.
These modifications, which had been developed by *Dallos* were patented by *Zeiss* in Europe and in the United States. (81) They represented an evolution of the mentality of the *Zeiss* engineers and caused the failure of the 'optical theory' of refractive error correction by the tear meniscus that *Hartinger* had advocated up to that time. (82)

On *Weve*'s order in 1932, *Zeiss* delivered to the Utrecht Ophthalmology Clinic ground contact lenses of a corneal diameter suitable for fundus examination during diathermy for retinal conditions. (83)
Shortly after, *Zeiss* proposed still more modifications, available on order, such as reduction of the width of the sectors, grinding of gutters and channels, oval lens diameter and so forth. In 1933, *F. Fertsch* completed *Hartinger*'s research on optical correction by the lacrimal film in order to adapt it to the most recent modifications of *Zeiss* contact glasses. (84)

2.3 - The Presentations by Victor Much

2.3.1 - The Clinical and Historical Publications

The engagement by *Heine* to the new contact glasses seemed to have been exhausted to the extent that he threw himself in defence against the criticisms of his colleagues. At the Kiel Ophthalmology Clinic, *Heine* followed the fittings of many patients only from a distance. There were, of course, patients that his promises through the media had sent running to him from all over Europe.

In 1931, *Heine* succeeded in hiring a young ophthalmologist, *Victor Much*, trained in contact lenses by Professor *Lauber* in Vienna, to whom he now entrusted the responsibility for running the contact lens service of the Kiel Ophthalmology Clinic. *Heine*, without completely losing interest, kept his distance to an increasing extent, while at the same time inspiring and orienting some of *Much*'s publications. (85)

In 1931, in his first publication, *Much* took an impassioned and objective stand on the question of contact lenses.(86) He distinguished for the first time in the literature, the absolute from relative indications. The first category included the diseases

Figure 20-12
Cover page of an information and advertising document for Zeiss 'adherent glasses' (1934). (Zeiss Carl, 1934).

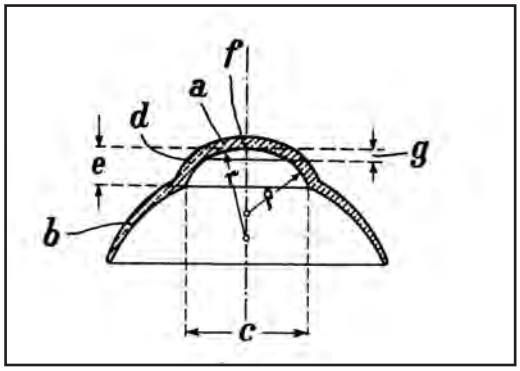


Figure 20-13
Zeiss patent on improved sclero-corneal shells.
The patent DRP # 545,734 'Haftglas mit schalenförmigen Kornealteil und ringförmigem Skleralteil' (Adherent glass with cupuliform corneal part and ring-shaped part) had been registered in June 1930. Dallos had proposed these modifications especially for the eyes of high myopes and for patients of keratoconus with high antero-posterior axis. (Zeiss Carl, 1930b).

where contact lenses are indicated because these were superior to other treatments known in that era. Essentially, these involved keratoconus of which *Much* presented two clinical observations, also corneal scars, pannus and marginal corneal dystrophies. He recommended the application of a shell filled with eye ointment for recurrent corneal erosions. Cases of myopia and other mild refractive errors were included among non-urgent indications. He expressed reservations on the correction of unilateral aphakia and anisometropia. His list of indications is illustrated by clinical cases of 14 patients followed in the course of the last six months at the Kiel Ophthalmology Clinic.

Much reported using tonometry in contact shells wearers in order to verify the alleged pressure-lowering effect of contact lenses:

"It was tempting to use the hypotensive effect of contact shells in glaucoma, but lowering of the eye pressure did not always occur under these circumstances. (…) It would be possible, perhaps, to make a rapprochement with the observations of Knapp who found that the glaucomas in which an ocular hypotensive effect was produced by massage, had a better prognosis. In contrast, no effect on ocular pressure was noted in healthy eyes." [(87)]

After his presentation on the fitting procedure, he stated bitterly that, "*for the time being, we are lacking objective methods to determine the exact measurements of the anterior segment of the eye*." *Much* noted also that the Kiel Clinic possessed about 300 trial shells and that he checked systematically the parameters of the contact glasses delivered by the manufacturer. This leads one to suppose that he had doubts concerning the reliability of their manufacture.

This work was to be taken up again and in more depth in a two part article: one part was historical and the other clinical.
The historical part of his publication consisted of the analysis of 162 bibliographical references. [(88)] It was a remarkable work considering the practically virgin territory that the author explored. *Much* avoided the trap of the historical errors already disseminated during this epoch and benefited from his knowledge of language in order to verify the articles within his scope. His publication was to serve for two decades as a reference and an inspiration for the publications of European authors, especially for *Emile Haas* in France and *Ida Mann* in Great Britain.

2.3.2 - The 'Orthopedic Treatment' (1932)

The clinical part deals essentially with keratoconus and its treatment. [(89)] This lengthy document comprises a plea for the 'orthopedic treatment' of keratoconus and myopia. His premise is based on 16 detailed clinical case descriptions showing modifications of the corneal curvature under the effect of contact lenses. The article cites 22 biographical references to authors who have advocated corneal compression, starting with *Purkinje*, followed by *Panas*'s presentation and including the observations of his contemporaries regarding a possible orthokeratologic effect of the contact lenses. This article was received with reservations and, notably, gave rise to a controversy between its author and *Dallos* who became, from then on, the defender of respect for ocular tissues and their metabolism.
During the same period, *Much* published other articles in reviews targeting general medical practitioners. [(90)] The political situation in Germany obliged him shortly afterwards to leave Kiel for Lucerne, where he pursued his specialist activities in contact lenses at the Ophthalmology Clinic of the Cantonal Hospital in that city. His successor in Kiel, *Helmut Dannheim*, who was oriented towards surgery, did not recommence these abandoned studies and the interest in contact lenses decreased rapidly at the Kiel Ophthalmology Clinic.

2.4 - The Epilogue to the Commitments of Heine and Much

The role of *Heine* was that of an initiator. One has to wonder why he developed this sudden interest in contact lenses. During a two-year period, he had been involved in the promotion of imperfect contact shells. It is possible that he quickly became aware of the errors and the incoherencies of his demonstrations, for, from the time of the arrival of *Much* at the Kiel Clinic, he discharged onto the latter the management of the contact glass equipment and publications, but did not allow any deviation from or criticism of his early publications. *Heine* had shoved *Much* along the false pathway of 'orthokeratologic reshaping' of corneae with refractive error. *Much* had found a follower of this theory in *Strebel* at Lucerne, where he too had taken refuge.[(91)]

Dallos had demonstrated that this reshaping, in reality iatrogenic, resulted from the compression of the corneal tissues and was itself the cause of the intolerance and the reason why the contact glasses of *Heine* could not to be worn for longer than a few hours. Inspired by *Heine* and *Strebel*, *Much* published in 1934 one last defence of the orthopedic treatment to the annoyance of *Dallos*. [92] He corrected himself later, however, with a historical article in which he described the genial research and the clairvoyance of *Dallos* in the face of numerous errors that were circulating at that time. [93]

3 – The Evolution of Zeiss Ground Glass Shells (1933-1944)

3.1 - Dallos' Short Collaboration with Zeiss (1930-1931)

In March 1929 at the Hungarian Society of Ophthalmology *Joseph Dallos*, assistant at the First Ophthalmological Clinic of the Royal Hungarian Péter Pázmány University of Budapest (Professor *Emil von Grosz*) explained that, from an optical standpoint, the *Zeiss* contact shells were distinctly superior to *Müller* shells. In support of his opinion, he presented the observations of four patients afflicted by keratoconus, who were

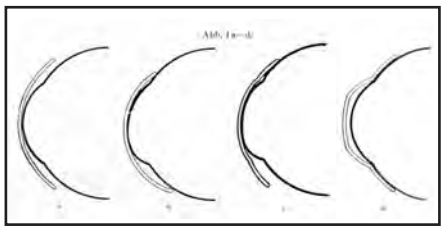
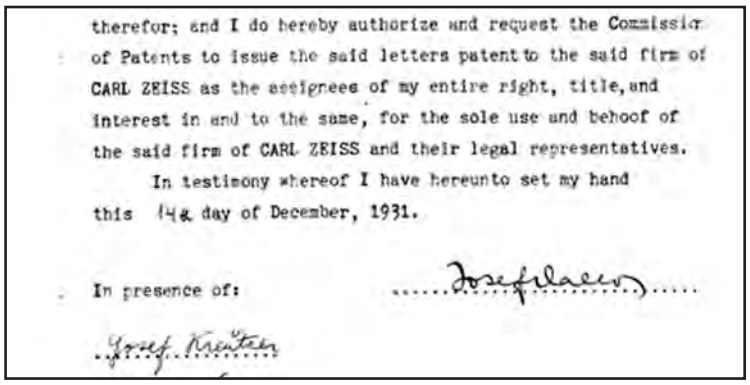


Figure 20-14
Demonstration by Dallos for the need of a shell with elevated corneal part.
(a) The flattest contact glass of Zeiss (# 90, 2/9), is poorly tolerated and does not possess sufficient curvature for the correction of myopia by tear meniscus.
(b) A glass with a higher scleral curvature would need to be selected for the correction of myopia.
(c) However, such a glass would not cling to the eyeball and would be poorly tolerated.
(d) By equipping the corneo-scleral shell with an intermediate segment between the scleral and corneal parts, the correction of myopia by tear film would be facilitated.
(Dallos J., 1936b).



therefor; and I do hereby authorize and request the Commissio
of Patents to issue the said letters patent to the said firm of
CARL ZEISS as the assignees of my entire right, title, and
interest in and to the same, for the sole use and behoof of
the said firm of CARL ZEISS and their legal representatives.
In testimony whereof I have hereunto set my hand
this 14th day of December, 1931.

In presence of:

Figure 20-15
Extract of assignment of transfer from Dallos to Zeiss of the patent for corneo-scleral shell with elevated corneal part.
By an assignment of 14th December 1931, Joseph Dallos transfers to Carl Zeiss his rights relating to patent # 1,869,336 of United States Patent Office.
(Document Archives Zeiss, Jena)

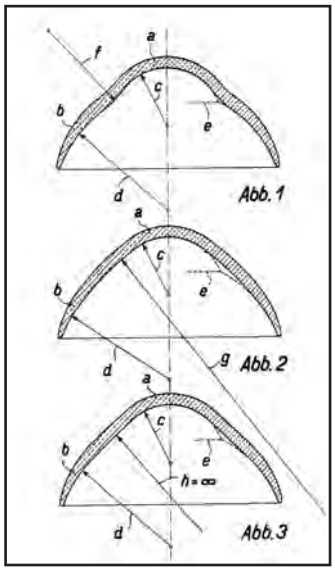


Figure 20-16
Dallos-Zeiss Patent for contact shell with elevated corneal part and correction effect.
Extract of illustration of patent from United States Patent Office, # 1,869,366. 'Contact Glass' (Joseph Dallos of Budapest, Hungary, assignor to Carl Zeiss of Jena, Germany. Application filed December 1931 and in Germany, 6th January 1931.)
The drawing illustrates in central sections on an enlarged scale two constructional forms of the new contact glass. Figures 1 and 2 show contact glasses having a converging and a diverging effect respectively. Both constructional forms have annular sclerotic parts and vaulted corneal parts; the exterior surface of each corneal part being composed of two differently curved surfaces and the interior surface being only one single surface. (Zeiss Carl, 1931a, c)

perfectly corrected by *Zeiss* contact glasses. One of these tolerated the shells without symptoms for as much as 10 hours a day. (94)

At the end of the same year (1929), *Dallos* presented to the same Society his observations of fitting ground glass *Zeiss* shells to 17 keratoconic, 2 keratotoric and 15 astigmatic patients. After several training attempts, the patients succeeded in inserting their shells without the appearance of air bubbles. They removed these shells with a prosthesis hook. By taking care that the shell did not touch the cornea, they insured that no irritation occurred. Nevertheless, *Dallos* was relatively disappointed, because he noted the paradoxical fact that the shells were better tolerated when they were fit to aspherical ocular globes, where they were less adherent and more mobile and where they provided a space for the passage of tears.

Dallos-Zeiss Shells with Elevated Cornea

In June of the following year (1930) *Dallos* reported to the meeting of the Hungarian Society of Ophthalmology that, at his request, *Zeiss* had manufactured shells with three curvatures (Dreiflächenglass), which also had a super-elevated corneal portion for the correction of high myopias. This modification, by moving the optic part away from the haptic, had to allow better positioning of the cornea and thus avoids contact with, or the destruction, of corneal tissue, notwithstanding the flattened curvature of the glass. The latter was indispensable for the correction of the myopia by the lachrymal meniscus. *Dallos* had thus corrected 58 myopic eyes with refractive errors ranging from -18.00 to -28.00 diopters. Also, at his request, *Zeiss* had reduced the diameter of the optical zone to reduce the weight of the shells. These improvements were immediately patented by *Zeiss* who, after the following year, advertised '*Contact shells modified according to Dallos*' in their catalogue. (95)

3.2 – Documents Showing Use of Zeiss-Heine Contact Glasses

In 1931, *Rall* (Tübingen) reported his experience with the new *Zeiss* contact lenses that he had tried out on 10 patients, 6 of whom were physicians. All the subjects had significant irritation with ciliary injection and epithelial lesions. He recommended that these contact lenses not be prescribed:
"*After ¾ to 2 hours, marked tearing and pain occurred in almost all of them. Objectively, ciliary injection was observed and often epithelial lesions. In one case only, the shells could be worn on alternate eyes up to 14 hours. But in this case also, ciliary injections appeared after two days of wearing. There were epithelial lesions, tearing and pain. Contact glasses could not be prescribed in any of these cases*„ (96)

During the discussion, *Baumgartner* noted that he had observed the same examples of intolerance in a female myope with a blown-glass contact lens of *Müller* and *Stock* reported again his bad experiences with the primitive celluloid contact lenses of *Zeiss*. (97)

In the following year, 1932, *Maria Procksch* (Vienna) described her first experiences of fitting the new *Zeiss-Heine* contact glasses in her article entitled '*Concerning contact glasses*' (Über Kontaktgläser). After a historical review she referred to *Much* and *Heine* in order to state the indications for these. She thought that about 20 trial contact shells would be sufficient for current fittings. (98)
In the same year, *Procksch* dedicated a publication to the use of contact lenses in the management of the corneal edema of acute glaucoma. She recalled her earlier successes in the treatment and the improvement that occurred in lesions of the cornea including corneal opacities. She described the successful use of contact glasses in four patients for the examination of the fundus through an edematous cornea. She concluded that the drop in visual acuity in acute glaucoma was also due to corneal irregularity and that the contact lenses permitted a preview of the potential for vision. Thus, they were useful for visual prognosis and for fundus examination during the acute phase of glaucoma. (99)

In 1934, at a congress of ophthalmology held at Jena, there occurred straight after a communication from *Lobeck* on the selection and prescription of *Zeiss* contact glasses, a passionate discussion between *Erggelet*, *Fleischer*, *Hartinger*, *Seidel* and *Clausen* (100). Essentially, these criticized the spherical haptic of the *Zeiss* shells, whereas the contact shells of *Müller-Wiebaden*, *Müller-Welt* and those of *Dallos* conformed to the geometric irregularities of the sclera. *Seidel* (Jena) described the improvement of the tolerance of *Zeiss* contact glasses by re-grinding the haptic part, which he asked the *Zeiss* Company to carry out:

"*The rectification of the scleral part of the contact shells by partial grinding is a very useful means for making the glasses conform. Since we have been using this means, the fitting of the shells has clearly improved.*" (101)

During the discussion, *Erggelet* drew attention to the risk of contact between the corneal apex and the contact glass, particularly in keratoconus, that should no longer occur with the special '*Dallos shells*' with super-elevated corneal apices. He reported having performed resistance experiments with contact shells placed on the eyes of rabbits, while glass balls were projected at high speed into the eyes. This demonstrated that the contact lenses were more resistant than eyeglasses and that their breakage did not cause any significant ocular wound.

During the same year, *Richard Krämer* made a presentation describing the new contact glasses to general medical practitioners in Vienna. He used the 39 shell trial contact glass set (102). He listed the advantages and disadvantages of contact lenses, but, in spite of the progress made, regular eye glasses cannot be discarded.

In the course of this epoch, *Zeiss* was confronted with competition resulting from the marketing of the first corneo-scleral shells manufactured by *Müller-Welt* of Stuttgart. The *Zeiss* archives in Jena preserve the documents of this era, including a list of sales from which it is evident that approximately 6.000 adherent glasses (Haftgläser) were sold, including 3.600 for export. One can estimate that, at this period, about 200 trial lens sets were in the hands of fitters and that more than 1700 contact glasses had been prescribed in the course of the preceding 5 years. (103) Confronted by this situation along with the disengagement of *Heine*, *Zeiss* tried to collaborate more closely with the principal fitters in the German speaking parts of Europe, like *C.H. Sattler*, and fitters from those countries where *Zeiss* had opened agencies and branch offices, such as *Obrig* in the USA.

3. 3 – The Contributions of C.H. Sattler

3.3.1 - The Doubts of Sattler (1930)

In 1930, *Carl Huber Sattler*, professor of ophthalmology at Königsberg, had presented a first in-depth study of the *Zeiss* contact lenses that he had tried beginning nearly one year previously with mixed results. (104) In 19 trial fittings, 14 had an encouraging result. Certain shells had been worn for up to 15 hours, in one case even 26 hours at a stretch. He concluded that contact lenses represented significant progress, but that certain patients were intolerant to these. He had also came to the conclusion that, in certain cases, the trial lens was well tolerated for up to about 10 hours for several days, but that the definitive lens, ordered according to this model and delivered by *Zeiss* was intolerable because it was too thick. He had also noted that the diameter of one of these poorly tolerated shells was less than that ordered. He complained that certain patients rejected the contact lenses because of their high price and because the fitting period was lengthy and lasted two weeks on occasion. Nevertheless, one patient was able to wear the shells for 26 hours without a break, but after their removal *Sattler* had observed a transient epithelial change in both eyes. After listing the numerous advantages brought by contact lenses, he expressed the wish that the manufacturer lower the price and improve the quality:

"*According to my experience, adherent glasses represent an exceptionally beneficial aid to vision. Nevertheless, one meets at the present time numerous patients who cannot become accustomed to them because of the unexpected occurrence of irritations*." (105)

3.3.2 - Sattler's Veil and the Contact Glasses of Zeiss-Sattler (1935)

In 1935, *Sattler* published a second study where he reported his recent observations on contact lenses and described what *Dallos* will later, in 1946, name, '*Sattler's Veil*'. (106)
He noted that approximately half of the patients fitted with *Zeiss* ground contact glasses complained of visual symptoms, often with the perception of rainbow-colored rings around lights. These appeared 2 to 3 hours after their insertion and became more noticeable. These were unaccompanied by any painful sensation or pressure:

1/ *For fitting of the optical part: A set of 9 corneal shells of 8.00 mm radius, of 20.00 mm total diameter, and a refractive power varying in steps between –16.00 and +12.00 diopters.*

Scleralcurvature	*Cornealcurvature*	*Diameter of the Optical Zone*	*Total Diameter*	*Refraction*
12.00	8.00	12.00	20.00	+3.00
12.00	8.00	12.00	20.00	+6.00
12.00	8.00	12.00	20,00	+9.00
12.00	8.00	12.00	20,00	+12.00
12.00	8.00	12.00	20.00	-3.00
12.00	8.00	12.00	20.00	-6.00
12.00	8.00	12.00	20.00	-9.00
12.00	8.00	12.00	20.00	-12.00
12.00	8.00	12.00	20.00	-16.00

2/ *For fitting of the haptic part: A set of 8 afocal shells, each of 8.00 mm corneal radius, of 12.00 mm optic diameter, with a scleral radius between 11.50 and 12.50 mm, and a total diameter of 20.00 or 22.00 mm.*

Scleral Curvature	*Corneal Curvature*	*Diameter of the optical zone*	*Total diameter*	*Refraction*
11.50	8.00	12.00	20.00	afocal
11.75	8.00	12.00	20.00	afocal
12.00	8.00	12.00	20.00	afocal
12.25	8.00	12.00	20.00	afocal
12.50	8.00	12.00	20.00	afocal
11.50	8.00	12.00	22.00	afocal
12.00	8.00	12.00	22.00	afocal
12.50	8.00	12.00	22.00	afocal

The following 19 contact lenses could usefully complete this collection:
a) *For the optical correction: refractions of +3.00, +5.00, +12.00 D and -16.00, -12.00, -9.00, -3.00 D with scleral curvature of 12.00 mm, corneal curvature of 7.50 mm, a diameter of the optical zone of 12.00 mm and a total diameter of 20.00 mm.*
b) *For the haptic correction: four shells with a total diameter of 20.00 mm, with scleral curvatures of 11.25, 11.00, 12.75 and 13.00 mm, and two shells of total diameter of 22.00 mm with scleral curvatures of 11.75 and 12.25 mm.*
It could be useful to try tinted 'Umbral' lenses 25% and 50%

Table 20-4
Proposal by C. H. Sattler for the composition of a set of 17 trial contact glasses.

"*One of the somewhat disturbing on-going complications that occurs unexpectedly in almost half the cases after a prolonged wearing of adherent glasses is the appearance of a visual veil. This is associated with the perception of colored rings like a rainbow around lights*." (107)

Examination of the eyes affected thus shows only a very subtle epithelial disturbance. If there happened by chance to be an air bubble under the lens, the epithelial disturbance does not appear in this area. After removal of the lens, the phenomenon still persists from half an hour for up to two hours:

"*The examination of the eye of a patient complaining of a veil over the vision, usually does not reveal any irritative state. With the biomicroscope and slit-lamp, one observes a very mild regular epithelial disturbance, which could be the explanation of the veil. If, by chance, there would be an air bubble under the contact glass, that could not be displaced, in this precise area there is no epithelial disturbance. After removal of the glass, patients still see the veil and the colored rings for a certain period of time. However, the sharpness of this phenomenon diminishes rapidly and disappears totally in half an hour to two hours*. " (108)

Sattler did not concur with the opinion of *Much* that the veil and the visualization of colored arcs would disappear as the patients became accustomed to the contact glasses. He observed that the use of *Ringer*'s solution delayed the appearance of the veil. This did not happen with physiological saline. Thus, he recommended the use of *Ringer*'s solution, and to take out the lenses from time to time for 1 to 2 hours, or to wear the contact glasses alternatively on one eye and then on the other.

Sattler had many reservations on afocal contact shells with correction by the lacrimal meniscus. Already, in his preceding paper he had noticed that harmful corneal contact occurred in myopes corrected by flat contact shells, which could even cause an instability of the whole shell. In aphakes and hyperopes, the afocal shells were often better tolerated, although there occurred sometimes a suction phenomenon with the formation of air bubbles that interfered with vision. In these cases, the instillation of fluorescein demonstrated that there was no diffusion of dye under the shell. Bad positioning of the haptic part of the shell often produced the intolerance.

Sattler recommended that there should be better appreciation of scleral contact with a more extensive set of 30 shells with scleral radii of curvature between 11.00 and 13.00 mm from 0.50 to 0.50 mm steps with a total diameter of 20.00 mm. Under certain circumstances, shells of total diameter of 22.00 mm or oval shells (e.g. 20.00 x 18.50 mm, 20.00 x 17.00 mm, 22.00 x 20.00 mm.) can prove themselves useful. Sattler noted that patients with tight eyelids or narrow interpalpebral apertures did not tolerate contact lenses. Shells with a corneal radius of curvature of 8.00 mm. are generally better tolerated and should be preferred, which obliged that the optical correction be ground onto the anterior surface of the corneal part.
Sattler gave his approval to the three basic principles put forward by *Dallos* to ensure good tolerance:
1.) There should be only a virtual (capillary) space between cornea and lens.
2.) The shell should only rest on the superior nasal sclera and the inferior temporal sclera.
3.) The shell should be separated from the superior temporal sclera in order to provide a passage between the precorneal capillary space and the external world.

In order to dissociate corneal from scleral fitting, *Sattler* proposed replacing the set of afocal shells of *Zeiss-Heine* by a new two-series set of trial lenses. The first series would be destined for corneal fitting and optical correction, with a corneal radius of curvature of 8.00 mm and powers between -16.00 and +12.00 diopters. The second series, suitable for scleral fitting, would consist of two sets of 20.00 and 22.00 mm of total diameter, with finely graduated scleral radii.

Sattler fitted 80 patients with lenses thus chosen. The shells could be worn all day in the great majority of cases. Failures occurred above all in those patients where the scleral ovality was very marked, in which situation he recommended reverting to the ocular molds and contact shells of *Dallos*. *Sattler* himself moved to Budapest in order to learn the technique of making Negocoll molds, preparing a positive in Hominit, examining the shell placed on the eye and marking the areas to be retouched. The Hominit positives prepared in Königsberg were sent to *Dallos* for the manufacture of the contact glass and the grinding of adequate optical parts. *Sattler* considered that the principle of *Dallos* was accurate and in conformity with ocular physiology.

To conclude, *Sattler* described the essential points of his research: Contact glasses with an optical radius of

curvature of about 8.00 mm were better tolerated than those with smaller radii of curvature and, above all, those with larger radii of curvature. Contact glasses of 22.00 mm total diameter are better tolerated than those of 20.00 mm, for they distribute the pressure over a larger surface of sclera. The afocal trial contact glasses have to be replaced by two series of shells, of which one, with refractions between +12.00 and -16.00 and a corneal curvature of 8.00 mm would be intended for optical fitting. The other series, with diameters of 20.00 and 22.00 mm, with scleral radii of curvature in steps was intended for haptic fitting. Those patients unable to be fitted with these lenses needed to be supplied with molded shells according to *Dallos*.

Sattler's paper met with a great echo of approval within the community of fitters who, in turn, referred to it during their presentations. In a comment sent to the journal, *Csapody* reminded *Sattler* that the latter had omitted to mention that it was he who had recommended and described the technique of molding that he had used before *Dallos*. (109)

3.3.3 - Sattler's Experience (1937)

Two years later, in 1937, *Sattler* presented his third publication that described his experience with the fitting of contact lenses. He confirmed in this paper that he had never had any irreversible incidents in the course of more than 200 fittings. (110) The incidents and the intolerances observed with the afocal contact glasses of *Zeiss-Heine*, that touched and rested on the corneal apex, no longer occurred with the present day shells modified on his initiative. Those shells with radii of curvature between 7.50 and 8.50 mm and an optical grind on their anterior surfaces were the best tolerated. The primitive afocal shells of *Heine* were intolerable and it was not necessary to wait for an optical correction of the refractive error by the tear film.
He confirmed that shells with total diameters of 20.00 mm were better tolerated than those with 22.00 mm diameters, for the pressure is spread over a larger area of the sclera. With his new set of 17 and of 19 trial shells, *Sattler* determined the best scleral radius of curvature to approximately ¼ mm accuracy. He always started the correction process using *Zeiss* contact glasses chosen by the method of trial fittings and ordered the definitive lens when the chosen trial contact lens was tolerated for 5 hours' duration.
Sattler delivered statistics on the 120 patients recently fit, where the contact glasses were worn for the whole day, sometimes with removal for a short time in the middle of the day. The majority of the patients presented a veil over their vision after several hours of wearing the contact glasses. This was observable on the slit-lamp in the form of a diffuse epithelial disturbance and perceived by the wearer in the form of colored rings around sources of light. The veil was less obvious when *Ringer* solution was used rather than saline solution. It did not appear if the contact glass is separated from the cornea by a capillary slit which aspirated tears.
The 24 patients who were intolerant to *Zeiss* shells were fit, in 10 cases, by *Dallos* shells, starting with molds that were made in Königsberg, in 11 cases by contact shells of *Müller-Welt* and the remaining 3 by contact shells made by *Müller*-Wiesbaden. These cases involved very asymmetric eyes that had pronounced astigmatism, to which the *Zeiss* contact shells were unsuited. After *Dallos* left Budapest for London, *Sattler* fitted these difficult cases with contact shells of *Müller-Welt*. He chose the best-supported shell with a molded haptic, onto which *Müller-Welt* ground an adequate optic. The contact shells of *Dallos*, of *Müller*-Wiesbaden and of *Müller-Welt*, which are more mobile on the globe of the eye, produced less visual veil and were easier to remove than those of *Zeiss*. Finally *Sattler* reported the successful fitting of a telescopic system with strongly divergent contact lenses of *Müller-Welt* and convergent spectacle glasses.

3.4 – The Evolution of the Zeiss Contact Shells

3.4.1 - Zeiss Shells with Molded Haptic (1936)

In 1938, *Hermann Serr* (Jena) presented to the German Ophthalmological Society congress his experience with a new type of *Zeiss* contact glass, of which the scleral part was manufactured according to an ocular molding with Negocoll. (111) Starting with the idea, that shells with ground haptics do not give the comfort and the expected results, and that their sphericity is not adapted to all the different shapes of sclera, he supplied *Zeiss* with ocular molds in order that they might manufacture shells from them. *Zeiss* research produced a glass lens that can be both molded and ground:

Description	*Date of first marketing*	*Number sold*
Trial adherent-glasses (Versuchshaftgläser)	1929	4.210
Use adherent-glasses (Gebrauchhaftgläser)	1929	1.720
Adherent-glasses sold in Germany		2.300
Exported adherent-glasses		3.600
Comberg's contact shells for localization by X-ray	1930	33
Weve's corneal diameter contact lenses for diathermy	1932	62
Dallos' triple surface contact glasses (Dreiflächenglass)	1932	14
Glass with elevated optic part (DRP #545,734)	1932	18
Glass with reduced transition ridges (DRP #542,372)	1934	4

Table 20-5
Inventory by category of Zeiss contact glass sales in 1934 .
When Zeiss was confronted by the first Müller-Welt contact shells, the company drew up an inventory of the sales from the precedings years.

"*Before my experiments, Zeiss had already found a quality of glass and methods of production necessary to allow shaping of the haptic part of these adherent glasses exactly according to the mold obtained from the human eye. This glass also possessed the characteristic quality necessary for an optical grind for the corneal part*." (112)

Like *Dallos* and *Sattler*, he used *Poller*'s procedure with aluminium cups equipped with a handle, of which the concavities are filled with Negocoll, then placed gently on the eye avoiding all pressure from the cup or the eyelids. After two minutes, the cup is removed. In view of the fact that Negocoll dries quickly and shrinks, it is kept in a moist atmosphere up to the time of preparation of a positive in Hominit or plaster.

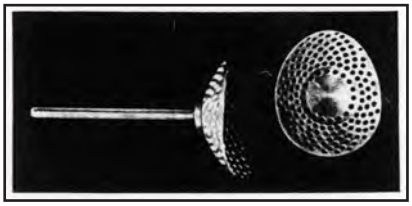


Figure 20-17
Serr's aluminium molding shell (1938).
In 1938, Hermann Serr recommended that, in difficult Negocoll moldings, an appropriate aluminium molding shell be used and then to forward the positive cast to Zeiss for manufacture a contact lens with molded haptic. (Serr H., 1938)

During the discussion of this communication, *Sattler* was delighted that *Zeiss* had at last succeeded in manufacturing usable shells by molding. (113) Recently, he had also sent Hominit positives to *Zeiss* and had obtained a corresponding contact lens. He recalled that in 1934 he had already made molds of the eye, the technique for which he had learned in Budapest and that he had fitted the molded contact shells of *Dallos* in ten patients who were unfittable with the ground glass shells available at this time. He reported the case of one female patient, where the *Dallos* contact shell had not been tolerated because the glass was too thick. *Zeiss* had made a copy of this that was thinner and was well tolerated. He recalled also that the veil associated with corneal epithelial disturbance that routinely occurred with *Zeiss* contact shells, had not been observed with the *Dallos* shells:

"*I have never observed the famous veil caused by epithelial disturbance while using contact shells molded according to a Dallos ocular molding procedure. The latter often appears several hours after wearing the current adherent glasses of Zeiss, even without subjective symptoms and that makes the wearing of those shells impossible.*" (114)

The second speaker in the discussion, *Lindner* (Vienna), reported that his assistant *Ramach* had also learned the molding technique with *Dallos*. (115)

In the Königsberg Ophthalmology Clinic, *Sattler* had also oriented *Martin Schmidt* towards research on the pathology of keratoconus and the corneal changes that occur without warning under the contact glasses [116]. With the approach of World War II, *Hasslinger* asked whether contact glasses could be used in the army. [117] He had reservations for their use in extreme conditions, but recommended enlisting also soldiers whose vision was rendered possible with contact glasses.

3.4.2 - Hartinger's Assessment (1938)

A new evaluation was put forward in 1938 by the *Zeiss* Company engineer *Hans Hartinger* who listed the various commercialized models of ground glass shells [118]:
- the traditional lenses of *Zeiss-Heine* with 21 and 18 trial shells,
- those of *Zeiss-Sattler* with 17, 19 and 9 pieces,
- and 'special shapes' including the superelevated shells of *Zeiss-Dallos*.

Finally, *Hartinger* recalled the experiments under way with *Serr*, *Obrig* and others, for the manufacture of shells the haptic part of which was molded on a positive contratype in Hominit from a mold taken from the globe, whereas the optical part is ground according to the requested correction. The principle of blowing the contact glass against an ocular mold, as in the method of *Müller-Welt*, had been patented by *Zeiss* years before, but the current production of these was recent. [119]

In the discussion, the question of the possibility of producing shells from plastic materials was discussed. According to *Hartinger*, the trials carried out by *Zeiss* after World War I gave poor results and demonstrated that plastic materials were not tolerated, that the contact shells went out of shape, lost their geometric and optical properties and that the surface of these was subject to streaks because these materials were very delicate. By way of contrast, the present *Zeiss* contact lenses were manufactured from a very highly resistant glass both chemically and thermally, which guaranteed their high quality:

"*The contact glasses in plastic materials change their shape at the time of wearing and thus lose their optical qualities. Besides, these contact glasses would very easily deteriorate as the transparent materials presently available are all definitely more fragile than glass.*" (120)

3.4.3 - Reviews of Serr and Fertsch (1942)

In 1942, *Serr* reported that he had obtained from *Zeiss* that the radii of curvature of their corneal shells be graduated from 0.25 to 0.25 mm, which would facilitate the selection of intermediate fittings and sometimes avoid the need return to moldings. [121]
Confronted by the first successes and hope placed in plastic materials, *Ferdinand Fertsch*, engineer at *Zeiss*, made in 1942 an passionate plea in favour of glass contact lenses. He recalled the failures of celluloid shells from the 1930s to defend the superiority of glass. He listed and criticized the patents on contact lenses in plastic materials: *Möller*, *Wilhelm*, IG Farben, *Feinbloom*, *Row*, *Wingate*, *Teisler* and *Dannheim* as well as the trials undertaken by *Thier*, *Fritz* and *Györffy* the successes of which were far from guaranteed. For *Fertsch* the trial fitting with plastic materials were doomed to failure and *Zeiss* had reason to pursue the manufacture of glass shells, of which not only the optical quality but also the chemical and physical stability were incomparably superior. [122]

3.4.4 - Obrig and Zeiss Molded Contact Shells

Several years later, *Obrig* was to report the difficulties and the disappointments that he had encountered when he collaborated in the trials of the molded glass contact shells of *Zeiss*. [123] The first shells were oval, with transparent glass of high quality and chemically inert. These first generation possessed a corneal part resembling that of the traditional spherical lenses of *Zeiss*, enlarged by means of a third curvature on the nasal and the temporal sides. *Obrig* attributed the failures to the poor quality of the molds that were insufficiently broad and often of poor reliability that he had submitted to the manufacturer. According to *Obrig*, the two major errors of these shells were related in one part to the overall diameter, which, though traditionally 20.00 mm, varied from 20.00 x 21.00 mm sometimes 21.00 x 23.00 mm. The second error was related to the too much-reduced corneal diameter; even it was broader than in the case of the old ground contact shells. Very soon these faults had been corrected by new geometries of the scleral part and by broader corneal diameters. Added to that were the difficulties due to delays of 4 months for deliveries and retouching and

above all because of the excessively high weights of the glass corneal shells. *Obrig* offered a nostalgic judgement on the period of his collaboration with *Zeiss*:

"*The molded lenses supplied by Zeiss were oval and of the general dimension ordered. They were made entirely of clear, transparent, chemically resistant glass. The posterior surface of the scleral portion appeared somewhat uneven, with much the same appearance as the scleral portion of the cast. The corneal portion was ground and polished to prescription with the care and accuracy expected of a top quality ophthalmic company. The corneal portion was widened by forming a third curve nasally and temporally, adjacent to the corneal portion*."

Without regretting his years of collaboration with the *Zeiss* Company, *Obrig* concluded:

"*We fitted literally hundreds of Zeiss molded glass contact lenses. We owe to Zeiss Company a debt of gratitude for their pioneering and cooperative effort in producing a molded contact lens which enabled us to profit from their difficulties*."

Notes in Chapter XX

1. See volume II, chapter 18: The Zeiss Contact Lens Prototypes.
2. Stock W., 1920. See volume II, pp. 287-288: The Second Jena Experiment and Stock's Communication on Ground Contact Shells for Keratoconus.
3. Dohme B., 1922 a, b, c. Presentation of patient to the Berlin Ophthalmological Society (Berliner augenärztlichen Gesellschaft) on 23 March 1922. "Dohme zeigt einen Kranken mit Keratokonus, der die neuen Kontaktgläser von Zeiss trägt. Sehschärfe ohne Gläser 4/50, mit Gläsern 5/6. Die Gläser können vom Patienten selbst eingesetzt und herausgenommen werden, und werden sehr gut vertragen (Preis 500 Mark)."
4. "Die Zeißschen Gläser sind außerdem einfacher zu verpassen als die Müllerschen. Aus einem Probesatz von 3 Normalgläsern wird das betreffenden Auge am besten aufliegende ausgesucht und dann die noch erforderliche Korrektion mit sphärischen Gläsern durch Skiascopie und Funktionsprüfung bestimmt. Diese Korrektion wird von Zeiß in das betreffende Kontaktglas eingeschliffen. Da von den 12 so korrigierten Augen bei 11 das Glas mit den kleinsten Abmessungen (Zeiß Nr. 3) am besten anlag, schlägt Dohme vor, ein viertes Normalglas mit kleineren Abmessungen anzufertigen."
5. Dohme B., 1922 c.
6. "An ein ideales Kontaktglas, (…) das imstande ist, einen Keratokonuspatienten zufriedenzustellen, muss man (…) folgende Anforderungen stellen: Das Glas muss eine völlig sphärische Hornhautoberfläche haben. Das Glas darf das Auge nicht reizen, es muss für längere Zeit beschwerdenfrei vertragen werden, das Glas muss durch den Patienten selbst leicht eingesetzt werden und wieder entfernt werden können. Das Glas muss sowohl im Trageteil wie im Kornealteil der Augenform genau entsprechen, damit das Festsetzen von Luftblasen zwischen der Schale und dem Auge vermieden wird. Das Glas muss fest am Auge haften, so das es nicht herausfallen und auch nicht beim Lidschlag herausgeschoben werden kann. Das Glas darf den Patienten nicht entstellen. Das Glas darf durch die Tränenflüssigkeit nicht angegriffen werden. Eine andere Forderung besteht in der Möglichkeit, dem Kornealteile eine beliebige Brechtkraft geben zu können, damit es gelingt, die durch die Verlängerung des optischen Systems infolge Vorsetzung des Kontaktglases bedingte Myopie wieder aufzuheben und sonst noch bestehende Brechungsfehler auszugleichen. Die Probiergläser müssen nach gewissen Massen normiert sein, damit das Ausprobieren des geeigneten Glases und die Nachbestellung erleichtert wird."
7. "Ein Kontaktglas, das alle diese Anforderungen erfüllt hat die Firma Zeiß herstellen können. Es ist zuerst von Stock im Jahre 1920 in Heidelberg gezeigt worden. Das Zeißsche Kontaktglas besteht aus einer dünnen, geschliffenen, runden Glasschale, deren peripherer Teil der Sklera anliegend als Trageteil dient, während das Zentrum der Schale, der Kornealteil, starker gewölbt ist und den Ausgleich der Hornhautverbildung bewirkt. Diesem Kornealteil kann durch geeigneten Schliff beliebige Brechkraft gegeben werden."
8. "Es gehört überhaupt für die Patienten ein gutes Stück Gedult dazu, die Prozedur des wiederholten Einsetzens der Gläser beim Ausprobieren des geeigneten Kontaktglases über sich ergehen zu lassen und das Vertrauen zu haben, dies ihm zunächst so schwierig erscheinende Manipulation selbst erlernen zu können."
9. "Zeiß hat uns zwei gleiche Sätze von je drei verschieden geformten Kontaktschalen, die mit Nr 1, 2 und 3 bezeichnet sind, als Probiergläser geschickt. Von den drei Modellen suchen wir durch Probieren das bei dem Patienten am besten sitzenden Glas, d. h. das Glas das gut anliegt und keine Luftblasen sich bilden läßt, aus, ohne zunächst Rücksicht auf die Funktionsprüfung zu nehmen, und bestimmen dann durch Skiaskopie und Funktionsprüfung das noch erforderliche sphärische Glas. Der optische Effekt ist nach der Korrektion durch sphärische Gläser bei allen drei Modellen der gleiche, falls es gelingt, die Kontaktgläser ohne Luftblasen einzusetzen. Man braucht daher beim Ausprobieren nur Rücksicht auf den guten Sitz des Glases zu nehmen. Nach den so gefundenen Form- und Refraktionswerten schleift dann die Firma Zeiß das Gebrauchglas, das in Form und Brechtkraft den bestimmten Maßen entspricht."
10. Only the total diameter (20.00 mm) corresponds with the specifications given by Zeiss at this era, which are as follows: corneal diameter: 12.00 mm, scleral radius: 12 mm, scleral width: 4 mm; height of the corneal apex (arrow): # 1 = 2.30 mm, # 2 = 2.60 mm, # 3 = 3.30 mm, # 4 =4.00 mm; posterior radius of curvature: #1 = 8.19, # 2 = 9.00, # 3 = 7.13 mm, # 4 = 6.50 mm. (Zeiss Carl, 1927a).
11. Siegrist A., 1920, a, b. Presentation to the Swiss Society of Ophthalmology (Schweizer Ophthalmologische Gesellschaft) at Berne on 12-13 June 1920 & Siegrist A., 1925 a, b.
12. "Meinen Forderungen suchten in der Folgezeit auch die Zeisswerke gerecht zu werden, indem sie neue, und wie ich verlangt, geschliffene Kontaktgläser schuffen. Die neuen Zeissschen Kontaktgläser werden in 3 Variationen hergestellt. Sie tragen die Nummer 1-3. Sie gleichen vollkommen den Strübinschen Kontaktgläsern, auch haben sie grosse Ähnlichkeit mit dem Kontaktglase, welches Sulzer seinerzeit in Paris hatte herstellen lassen. Sie sind durch die stärkere oder schwächere Brechkraft voreinander verschiedenden„. (…)
"Das Glas Nr. 1 hat eine Tiefe resp. Wölbung von 8 mm; Das Glas Nr. 2 hat eine Tiefe resp. Wölbung von 9 mm; Das Glas Nr. 3 hat eine Tiefe resp. Wölbung von 7 mm. Entsprechend diese Wölbungsdifferenz besitzt das Kontaktglas Nr. 1 eine Brechkraft von 45,0 D. Kontaktglas Nr 2 eine Brechkraft von 50.0 D. Kontaktglas Nr. 3 eine Brechkraft von 40,0 D."
13. "Im Gegensatz zu diesen Zeiss-Gläsern hat das Strübinsche Kontaktglas eine Tiefe von 5.5 resp. 6 mm und eine entsprechende Brechtkraft von 43,0 resp 44,0 D."
14. Friede R., 1926 c.
15. Sommer F., 1927. Thesis presented on 12 November 1927 at the Faculty of Medicine of Freiburg im Breisgau, on the initiative of Professor Axenfeld. See also in Chapter 22 the observations of patients fitted with Müller blown-

glass contact shells.

16. “Es sind viermal Versuche mit Zeissschen Kontaktgläsern gemacht worden. Trotz erheblicher Verbesserung der Sehkraft traten bei zweien so starke Reizzustände, dass die Gläser nicht vertragen werden konnten.”

17. “Fall 12 (…). Patient hat die Müller’schen Kontaktschalen gut vertragen. Als die Zeiss’schen Kontaktgläser aufkamen, erhielt Patient das Kontaktglas Nr 3 +2.0 sphärische an einem Stück kombiniert für beide Augen. Damit Visus: R=1,0, L=1,0.“mm„

“Patient trägt die Kontaktgläser ohne die geringsten Störungen den ganzen Tag. Er hat sich anfänglich zur Herausnahme der Gläser des von Siegrist angegebenen Gummisaugers bedient, jetzt entfernt er die Gläser mit der bloßen Hand.„

“Fall 13 (…). Typischer Keratokonus am rechten Auge, das linke Auge ist noch emmetrop. Patient erhält das Zeiss’sche Kontaktglas 1. Damit Visus R=0,75.„

“Patient hat in der Klinik einige Tage gelernt, das Kontaktglas selbst einzuführen. Er trägt es jetzt einige Stunden täglich bei der Arbeit und sieht binokular.”

18. Hegner C.A., 1927.

19. Zeiss, 1927. The term 'Auflageglas' ('Auflagegläser' in the plural) is translated literally 'overlay glass', 'glass for placement on (the eye)', 'glass for placing on top of (the eye)' or 'glass to be placed above (the eye)'.

20. “Die unter dem Lide liegende dünne Glasschale nimmt an den Blickbewegungen des Auges teil, ist ganz unauffällig, und da sie auch so geschliffen werden kann, daß Achsenametropien des Auges bis zu etwa + und -6 dptr berichtig werden, so sind die Kontakgläser als gerade ideale Sehhilfen zu bezeichnen, sofern sie ohne Reizung des Auges dauernd vertragen werden können.”

21. "Sie sind fein poliert und alle Kanten sind aufs sorgsamste abgerundet. (…) Die Auflagefläche für die Hornhaut ist völlig sphärisch geschliffen."

22. "Für die Bestellung bzw. die Nachbestellung eines Auflageglases genügt die Angabe der auf die Form bezügliche Nummer und des zur Berichtigung der Achsenametropie erforderlichen Scheitelbrechwertes. Das Gebrauchs-Auflageglas muß dieselbe Krümmung der Innenfläche haben wie das verwendete Probier-Auflageglas, damit es der Hornhaut gut anliegt. Den zur Berichtigung der Achsenametropie erforderlichen Brechwert erhält das Auflageglas durch eine entsprechende Krümmung der Außenfläche."

23. Zeiss, 1927. Often the medical publications copy or translate textually the promotional publications of Zeiss.

24. Clausen W.v., 1929. Presentation to the 30th Meeting of the Union of Central-German Ophthalmologists (Vereinigung mitteldeutscher Augenärzte) at Leipzig, 8th December 1928. See volume II, pp. 289-294: The Cellon Experiments.

25. Erggelet H., 1929. Discussions at the 30th Meeting of the Union of Central-German Ophthalmologists (Vereinigung mitteldeutscher Augenärzte) at Leipzig, 8th December 1928.

26. “Von manchen Leuten werden die Zeißschen geschliffenen Haftgläser gut vertragen. Diese geschliffenen Gläser haben den Vorteil, dass ihre Hornhaut eine optische einwandfreie Kugelfläche besitzt, deren Krümmung nach Wunsch hergestellt werden kann. Manche vertragen aber diese geschliffenen Haftgläser nicht, wohl aber die von Müller in Wiesbaden geblasenen. Aber auch für solche Fälle, die das Zeißsche Haftglas nicht dauernd vertragen, ziehe ich sie gern zur Untersuchung heran, um festzustellen, ob man sich verlohnt, weiterzusuchen. Wenn der Hornhautkegel nähmlich Trübungen aufweist, so kann man nicht ohne weiteres sehen, ob eine Verminderung der Sehschärfe auf diese zurückführen ist oder ob etwa die Schalenoberfläche nicht ganz einwandfrei ist.„

“Was den Ursprung der Belästigung angeht, die geschliffenen Haftgläser oft verursachen, so kann man häufig sehen, dass die scharfe Kante zwischen dem Hornhaut- und Lederhautteil die zum Limbus hinziehenden Gefässe abdrückt. In einem Falle war ein weisser, sichelförmiger Bezirk entweder ganz blutleer oder wurde nur von wenigen grossen, nicht völlig leergedrückten Gefässen durchschnitten und schloss einen dem Hornhautrand benachbarten, düster roten Saum nach aussen ab. In diesem inneren Gebiet waren die feinste Gefässe prall gefüllt in Massen zu sehen. (…) Nach der Beseitigung der Kante konnte der Kranke das Glas ohne Beschwerden tragen.”

27. Fischer F.P., 1929a. Discussions at the 30th Meeting of the Union of Central-German Ophthalmologists (Vereinigung mitteldeutscher Augenärzte) at Leipzig, 8th December 1928.

28. “Gelegentlich experimenteller Untersuchungen über die Zugkraft der Augenmuskeln habe ich mich Zeißschen Kontaktgläser bedient und die Festigkeit, mit der sie auf dem Bulbus haften, gemessen. Die Zeißschen Kontaktschalen haften außerordentlich fest, es ist eine Zugkraft von mindestens 100 g notwendig, um sie auszuziehen. Tropft man Methylenblau in der Bindehautsack ein nach Aufsetzen der Zeißschen Kontaktschalen, so dringt das Methylenblau unter die Schale nicht ein, und man sieht nach Entfernen des überschüssigen Methylenblau den Bezirk der Bindehaut, auf dem das Kontaktglas festsass, ungefärbt bleibend, also ausgesprart. Bei den Müllerschen Schalen, dringt Methylenblau sofort unter die Schale. Die Müllersche Schale sitzt nie so fest und exakt wie die Zeißschen Schalen, was für eine exakte optische Wirkung unerlässlich ist.”

29. Hartinger H., 1929. Discussions at the 30th Meeting of the Union of Central-German Ophthalmologists (Vereinigung mitteldeutscher Augenärzte) at Leipzig, 8th December 1928.

30. « Es ist nicht ausgeschlossen, daß die Ursache der beim Tragen von Zei schen Haftgläsern manchmal auftretenden Beschwerden in der Abweichung des Bulbus von der Kugelform zu suchen ist. Natürlich kann auch die den Übergang vom Skleralteil zum Kornealteil darstellende Kante unangenehm wirken, besonders wenn das Glas zu stark angesaugt wird. Wir werden jedenfalls unsere Versuche mit der Abrundung dieser Kante fortsetzen. »

31. Zeiss, 1930 a, b.

32. Goldschmidt, 1929; Fischer F.P., 1929 b. Presentation to the 30th Meeting of the Union of Central-German

Ophthalmologists (Vereinigung mitteldeutscher Augenärzte) at Leipzig, 8th December 1928.
33. Lauber H., 1927, 1928. Presentation of the 21st November 1927 to the Ophthalmological Society in Vienna (Ophthalmologische Gesellschaft in Wien) followed by discussions by Fuchs, Sachs, Meller, Kestenbaum, Lindner and Krämer.
34. "Sachs, Meller, Kestenbaum and Krämer bestätigen den gelegentlich ausgezeichneten Nutzen der Kontaktgläser und betonen die Überlegenheit der Zeissgläser. Kestenbaum hebt hervor, dass mitunter wiederholte Versuche nötig sind, um eine gute Verträglichkeit des Glases zu erreichen.„
"Sachs hat eine Anzahl von Fällen mit Erfolg mit Kontaktgläsern behandelt darunter einen Apotheker und einen Arzt. Er verwendet ausschliesslich Zeißsche Kontaktgläser.„
"Krämer: Der Forschritt ist auf den Umstand zurückzuführen, dass nicht die Hornhaut, sondern die Sklera das Kontaktglas trägt. Die Zeißchen Gläser sind besser, aber auch teurer. Der vor Jahren vorgestellte Patient mit hyperbolischen Gläsern ist damit zufrieden."
35. Procksch M., 1928 a. – Sometimes spelled 'Proksch' or 'Prosksch', we have adopted the orthographic form 'Procksch', such as appears in the Biography of German Ophthalmologists (Ophthalmologen-Verzeichnis) of Fritz Hollwich, 1964, p. 334.
36. "Kontaktgläser können nicht nur mit dem Vorteil bei Keratokonus Verwendung finden, sondern auch bei verschiedenen anderen Erkrankungen der Hornhaut. So wurden z. B. Patienten mit ekzematösem alten Pannus und prominenten degenerativen Knötchen der Hornhaut mit Kontaktgläsern behandelt, nachdem andere Mittel versagt haben. (…) Bei einem Patienten mit dieser Krankheit, hob sich das Sehvermögen mit dem Kontaktglas von 1/24 auf 6/30 und der Kranke konnte mit dem Kontaktglas auch lesen. Er trägt jetzt das Glas 8 Stunden im Tag und verträgt es sehr gut. In einem zweiten gleichen Falle hob sich das Sehvermögen von 6/36 auf 6/8, in einem dritten Falle, von Handbewegungen oder bestenfalls Fingerzählen auf 6/60. In einem Fall primärer Hornhautdegeneration hob das Kontaktglas die Sehschärfe von 3/60 auf 6/24. Auch bei alten ekzematösen Hornhautnarben bessert oft das Kontaktglas die Leistungen von 1-2 Zeilen der Snellenschen Tafel. Gelegentlich steigt die Sehschärfe auf das 6fache des Ursprünglichen. Besonders gute Erfolge wurden bei Hornhautnarben mit Iriseinheilung erreicht. In einem Fall von dauernder Descemetokele stieg die Sehschärfe von 3/36 auf 6/15."
37. "Bei Keratitis parenchymatosa wurde in einem Fall auf einem Auge das Sehvermögen von 6/36 auf 6/10 verbesset. Am anderen Auge war die Hornhaut so trüb, daß man sich mit Handbewegungen 1-2 m zufrieden gab und sehr erstaunt was, wie das Kontaktglas das Sehvermögen auf 6/18 hob. Diese Erfolge beweisen, daß bei den Hornhautnarben nicht die Verminderung der eintretenden Lichtmenge oder die diffuse Zerstreuung des Lichtes durch die Hornhautnarbe das wichtigste ist, sondern die Unregelmäßigkeit der Oberfläche. Man sollte Kontaktgläser viel häufiger verwenden. In allen erwähnten Fällen wurden die Kontakgläser von Zeiss verwendet, die sehr gut vertragen werden."
38. "In einem Fall von hoher Myopie bei einer 46 jährigen Patientin, die ihre Korrektur von -20 D. nicht vertrug, wurde ein eigens geschliffenes Kontaktglas in Verwendung genommen, das die Myopie auf 4 D. herabsetzt. Dieser Zustand ermöglicht es der Kranken, ihren Obliegenheiten zu Hause gut nachzukommen, für die Strasse trägt sie eine Brille von 4 D., so daß sie voll korrigiert erscheint."
39. Aust, 1929. Meeting of the Ophthalmological Society in Vienna (Ophthalmologische Gesellschaft in Wien) on 18th March 1929. - In 1892, Fick had presented fundus photographs of rabbits through a cornea neutralized by contact glasses to the German Society of Ophthalmology. See volume II, chapter 13, pages 145-146: Fick's Procedure for Fundus Photography.
40. Lauber H., 1929 a, in discussion Aust, 1929. Meeting of the Ophthalmological Society in Vienna (Ophthalmologische Gesellschaft in Wien) on 18th March 1929.
41. "Lauber ist vor einiger Zeit an die Zeisswerke herangetreten, um in Verbindung mit ihnen über die Korrektion des Astigmatismus und der Myopie mit Kontaktgläsern Versuche anzustellen. Die Zeisswerke gingen nicht darauf ein, weil bereits eine Klinik solche Versuche im Gange habe. Besonders hatte er Fälle in Aussicht genommen, bei denen es infolge von Astigmatismus mit schiefen Axen nach Korrektion zu Verzerrungen von Rechtecken in Trapeze kommt."
42. Sachs M., 1929; Lindner K., 1929 b, in discussion Aust 1929. Meeting of the Ophthalmological Society in Vienna (Ophthalmologische Gesellschaft in Wien) on 18th March 1929.
43. Deutsch A., 1929 b. Presentation at the meeting of the Ophthalmological Society in Vienna (Ophthalmologische Gesellschaft in Wien) on 18th March 1929. The contact glass # 90 from the new set of 4 Zeiss trial glasses corresponds to trial glass # 2 of the old set that had three contact glass models.
44. "Bei einem Opernsänger bestand am rechten Auge eine Myopie von -22 Dptr. mit Hornhautnarben, am linken Auge -7,0 Dptr. Auf der Bühne kann er kein Glas tragen, sieht ohne Glas den Dirigenten nicht. Mit Zeisssschen Kontaktglas Nr 90 und -1.5 Dpt hatte er S. = 6/6. Ohne das Korrektionsglas konnte er mit Kontaktglas auf der Bühne sehr gut auftreten, er vertrug aber die Zeisssschen Kontaktgläser nur für Stunden. Ein Müllersches Kontaktglas dagegen konnte viel länger getragen werden und befriedigte den Patienten."
45. Lauber H., 1929 b; Krämer R., 1929 b. Discussions in Deutsch A., 1929b at the meeting of the Ophthalmological Society in Vienna (Ophthalmologische Gesellschaft in Wien) on 18th March 1929.
46. Lindner K., 1929 c; Deutsch A., 1929 b.
47. Procksch M., 1929.
48. "Über Veranlassung von Prof Sachs verwende ich seit 3 Jahren Kontaktgläser nicht nur bei Keratokonus, sondern auch bei allen möglichen anderen Krankheiten, die mit unregelmässiger Hornhautoberfläche einhergehen: bei Hornhautnarben, Salzmannscher Hornhautdystrophie, primäre Hornhautdegenerationen usw., auch bei persistierende Descemetokele (…) und haben sie wegen wesentlicher Verbesserung des Sehvermögens bei 12 solchen Patienten ver-

schrieben. Auch Myope haben bei besonderen Anlass (Jäger, Skiläufer, Hochmyope die die Gläserkorrektur nicht vertragen) eigenens geschliffene korrigierende Kontaktgläser von uns bekommen."
49. Lindner K., 1929. This author is referring to Siegrist's manual, 1925.
50. "Prof. Sachs, der die Berichtigung von Frau Dr. Procksch veranlasst hat, irrt aber, wenn er glaubt, irgendeine neue Einzelheit bezüglich der Verwendung Kontaktgläsern angeregt zu haben. Bekanntlich hat Fick als Erster Kontaktgläser versucht, aber in erster Linie für Fälle von Narbenastigmatismus. Gegenüber den Erfolgen bei Keratokonus ist jedoch diese Verwendungsart in der Hintergrund gerückt. Immerhin wurde sie später einige Male erwähnt und steht auch in Lehrbüchern verzeichnet (…). Ich selbst habe bereits 1924 bei Narbenastigmatismus Müllersche Kontaktgläser versucht.„
"Auch die Verwendung von Kontaktgläsern für Ametrope ist nicht neu. Siegrist hebt sowohl in seinen Arbeiten wie auch im Lehrbuch der Refraktion 1925 S.39, dieses Anwendungsgebiet ganz besonders hervor."
51. Heine L., 1930 a. Presentation to the 13th Concilium Ophthalmologicum in Amsterdam, September 1929.
52. "Die Technik der Untersuchung ist sehr einfach. Haben wir bei einem Myopen eine Ametropie von 5 D festgestellt und messen wir bei ihm einen Kornealradius von 7.5 D, so muss der optisch wirksame Teil der Schale einen Radius von 8.5 haben, bei einer Hyperopie von 5 Dioptrien einen solchen von 6.5. An einem geeigneten Ophthalmometer kann man das direkt ablesen."
53. "Mit optisch und haptisch richtigen Schalen befinden sich die Augen im Zustande der Vollkorrektion der Ametropie, ein Zustand der nach allen klinischen Erfahrungen den physiologischen Verhältnissen am nächsten kommt. Dafür spricht das Stationärwerden der Myopie, je eher dieser Zustand therapeutisch eingeführt wird bei der Brillenkorrektur. Dafür spricht ferner das Verschwinden der muskulären Insuffizienzen, der dynamischen Divergenz bei Myopie, der dynamischen Convergenz bei Hyperopie."
54. Fukala V., 1929. According to the proceedings of Klinische Monatsblätter für Augenheilkunde.
55. Heine L., 1930 b. Published on 5th January 1930 in Münchner Medizinische Wochenschrift and presented at the Medical Society in Kiel (Medizinische Gesellschaft in Kiel) on 23 January 1930.
56. Heine L., 1931 a. We have been able to verify the identity of the contents of the articles in the reviews for generalist physicians. Other articles were published in the general press or popular medical reviews; we have not included them in our bibliography.
57. "Ich will nicht Goethe zitieren, dem bekanntlich der Brillenträger unsympathetisch war. (…) Mehrfach ist mir von jungen Frauen gesagt, jetzt, fingen sie noch mal ein neues Leben an: Geselligkeit, Theater, Sport (Tennis, Autofahren und –steueren, Skilaufen, Baden, Schwimmen usw.) machen ihnen jetzt erst Vergnügen oder seien ihnen jetzt überhaupt erst möglich."
58. Heine L., 1931 b.
59. Heine L., 1931c. Presentation to the Meeting of North-West German Ophthalmological Society (Nordwestdeutschen augenärztlichen Gesellschaft) on the 28th February 1931 at Hamburg-Eppendorf.
60. Hippel v., 1931; Rieck 1931; Kreutzfeld 1931; Görlitz 1931. Discussions at the Meeting of the North-West German Ophthalmological Society (Nordwestdeutschen augenärztlichen Gesellschaft) on the 28th February 1931 at Hamburg-Eppendorf.
61. Heine L., 1931 d.
62. Poos F., 1931.
63. Heine L., 1933.
64. "Nach diesem Prinzip hat Müller-Welt seine in eine Hohlform hinein geblasenen Schalen nummeriert, indem er für den optischen Teil nur die Dioptrie-Bezeichnung, also die Brechkraft, nicht den Radius nennt, diesen für den Randteil, die Haptik, aber beibehält, da es bei dieser nur auf die Krümmung, nicht auf die Brechung ankommt. Der Doppelcharakter des Haftglases in Optik und Haptik findet darin deutlich seinen Ausdruck."
65. "Wenn die Optiker das Publikum vielfach vor dieser Behandlung gewarnt haben, so ist hier in einem gewissen Grade (…) berechtigter Interesse zu verstehen. (…) Diese Meinung ist Irrtümlich, Durch die Haftgläser dürfte kaum eine einzige Brille verdrängt werden, da sie noch immer als Reserve beibehalten wird und das Haftglas immer nur eine Ergänzung der Brillenbehandlung darstellen wird."
66. Hartinger H., 1930 a, b, c. Presentation on 13th June 1930 at the German Ophthamological Society (Deutsche Ophthalmologische Gesellschaft) in Heidelberg.
67. Csapody I. v., 1930 b.
68. Löhlein W., 1930 b.
69. Lindner K., 1930.
70. Stock W., 1930.
71. Stock W., 1912. See volume II, chapter 16, §1.2, pp. 241-246.
72. Erggelet H., 1930. Erggelet had participated in Jena with Stock in experiments in Physiological Optics with ground contact glasses of corneal diameter. See volume II, chapter 16, pp. 244-247: Contact Lenses for Physiological Studies.
73. Helmbold H.L.v., 1913. See volume II, chapter 15, pp. 210-211: The Eye-shell of Helmbold.
74. "Herr Müller in Wiesbaden hatte die Freundlichkeit, auf meinen Vorschlag insofern einzugehen, als er mir eine Anzahl von Schalen angefertigt hat, deren Hornhautteil nachträglich von Zeiss geschliffen wurde. (…) Zu meinem großen Bedauern scheiterte die geplante Entwicklung aber daran, dass die Schalen nicht spannungsfrei geliefert wurden. Sie platzten meist schon beim ersten Beginn der Schleifarbeit."
75. Hippel v., 1930, Clausen W.v., 1930. See volume II, chapter 13, pp. 289-292: The Cellon Experiments.

76. Wissmann, 1930.
77. Hartinger H., 1930 e.
78. Hartinger H., 1930 f. Presentation at the 32nd Meeting of the Society of Rhineland-Westfalia Ophthalmologists (Rhein-Westfälischen Augenärzte) held at Dortmund on 23rd March 1930.
79. Hartinger H., 1930 g. Meeting of the Union of Central German Ophthalmologists (Vereinigung mitteldeutscher Augenärzte) held in Dresden on 30th Aug 1930.
80. Zeiss, 1930 a, b, c.
81. Zeiss, 1931 a, b, c, d, e. For Dallos, see chapter 21, § 2: The Dallos Alternative.
82. Hartinger H., 1932. Presentation to the meeting of the Union of Central German Ophthalmologists (Vereinigung mitteldeutscher Augenärzte) on 26th and 27th November 1932 in Leipzig.
83. Weve H.J.M., 1932 a, b. See chapter 27, § 3.2.6: Zeiss Corneal Contact Lenses for H.J.M. Weve (1932).
84. Fertsch F., 1933.
85. Much had been involved on the budget of the Organisation for Financial Aid to German Science (Nothgemeinschaft der Deutschen Wissenschaft). I met Victor Much in October 1981 and he gave me a long interview. His remarks regarding the Ophthalmology Clinic in Kiel during the 1930's inspired this chapter.
86. Much V., 1931 a.
87. “Es lag nahe sich der drucksenkenden Wirkung der Kontaktgläser bei Glaucom nutzbar machen, doch war bei diesen Zuständen die Tensionsverminderung nicht immer vorhanden, (…). Vielleicht lassen sich hierdurch weitere Kontrollen Zusammenhänge mit einer älteren Beobachtung Knapp’s herstellen, der Glaucomen bei denen sich durch Massage Druckherabsetzung erzielen ließ, eine günstige Prognose stellte. Keinerlei nennenswerten Einfluss auf den Augendruck ließ sich dagegen bisher bei gesunden Augen feststellen.”
88. Much V., 1932 a. Certain of these references are second hand and have been made starting from the biographical analyses of the Zentralblatt für Augenheilkunde. Note the curious citation of the ophthalmologist Mules, born in the town of Bowdon. His name has been transcribed by Much as 'Mules-Bowdon'. This error was repeated many times by all the authors who have evidently not consulted Mule’s original document. See volume II, chapter 21, p.316: The Softened Iodoform Wafers of Mules (1894).
89. Much V., 1932 b.
90. Much V., 1931 b, 1932 c.
91. Strebel J., 1931.
92. Much V., 1934. For Dallos see in this volume, chapter 21, § 2: The Dallos Alternative.
93. Much V., 1948.
94. Dallos J., 1929. Presentation to the Hungarian Society of Ophthalmology in Budapest, 8th March 1929. See chapter 21, § 2.
95. Dallos J., 1931a. Presentation at the meeting from 28th to 29th June 1930 of the Hungarian Society of Ophthalmology at Debrecen. - Carl Zeiss, Patents 1930 a, b, c; 1931a.
96. “Nach ¾ bis 2 Stunden stellten sich bei fast allen starkes Tränen und Schmerzen ein. Objectiv fanden sich ziliare Injektion und meist Epitheldefekte. Nur in einem Falle konnten die Schalen wechselnd bis zu 14 Stunden getragen werden. Auch hier waren jedoch noch nach 2 Tagen ziliare Injektion und Epitheldefekte und subjektiv Tränen und Schmerzen vorhanden. In keinem Falle hätten Kontaktschalen verordnet werden können.”
97. Rall, 1931. Presentation to the Würtemberg Ophthalmological Society (Würtembergische Augenärztliche Vereinigung) at Tübingen on 28th June 1931, followed by the discussions of Baumgärtner, 1931 (Halle) and Stock, 1931 (Tübingen)
98. Procksch M., 1932 a.
99. Procksch M., 1932 b.
100. Lobeck, 1934. Presentation to the Union of Central German Ophthalmologists (Vereinigung mitteldeutscher Augenärzte) at Jena on 17th June 1934. Discussions by Erggelet, 1934; Fleischer, 1934; Hartinger, 1934; Seidel 1934; Clausen, 1934.
101. “Das teilweise Abschleifen des Skleralteils der Kontaktschalen ist ein sehr wichtiges Hilfsmittel um die Gläser passend zu gestalten. Seitdem wir dieses Hilfsmittel kennen gelernt haben, ist das Anpassen von Haftschalen bedeutend erleichert.”
102. Krämer R., 1934. Presentation at the College of Viennese Physicians. (Wiener medizinisches Doktorenkollegium) on 22nd January 1934.
103. Document from Zeiss Archiv in Jena.
104. Sattler C.H., 1931. Presentation to the Union for Scientific Therapy (Verein für wissentschaftliche Heilkunde) in Königsberg.
105. “Nach meiner Erfahrung sind die Haftgläser für viele Patienten eine außerordentliche wertvolle Sehhilfe. Allerdings gibt es vorläufig noch eine beträchtliche Zahl von Patienten, die (…) sich wegen des Auftretens von Reizerscheinungen nicht daran gewöhnen können.”
106. Sattler C.H., 1935.
107. “Eine in etwa die Hälfte der Fälle sich bemerkbar machende mehr oder weniger störende Begleiterscheinung des längeren Tragens von Haftgläsern ist das Auftreten eines Schleiers, der mit Sehen von regensbogenfarbigen Ringen um Lichter verbunden ist.”
108. “Die Untersuchung des Auges eines über einen Schleier klagenden Patienten ergibt in der Regel keinen Reizzustand. Mit dem Hornhautmikroskop und der Spaltlampe sieht man als Erklärung des Schleiers eine ganz feine gleich-

mäßige Epitheltrübung. War unter dem Haftglas zufällig eine sich nicht verschiebende Luftblase, so ist an dieser genau ausgesparten Stelle eine Epitheltrübung nicht vorhanden. Nach Herausnehmen des Haftglases beobachten die Patienten zunächst den Schleier und die regenbogenfarbigen Ringe noch weiter. Doch nimmt die Deutlichkeit dieser Erscheinung ziemlich rasch ab und ist nach eine halben bis 2 Stunden völlig verschwunden."

109. Csapody I. v., 1935.

110. Sattler C.H., 1938 a. Presentation to the Union of Ophthalmologistes of East Prussia and Danzig (Verein der Augenärzte von Ostpreussen und Danzig); Sattler C.H. 1938 b.

111. Serr H., 1938. Presentation to the German Ophthalmological Society (Deutsche Ophthalmlogischen Gesellschaft) on 5th July 1938.

112. "Den Zeisswerken war es gelungen schon vor Beginn meiner Versuchen Glassorten und Verarbeitungsverfahren ausfindig zu machen, welche es gestatten den haptischen Teil dieser Haftgläser genau nach dem vom lebenden Auge gewonnenen Abguss zu formen, die aber auf der anderen Seite auch die bekannte hochwertige optische Zuschleifung des Cornealteils erlauben."

113. Sattler C.H., 1938b. Discussions at the German Ophthamological Society (Deutsche Ophthalmologische Gesellschaft) on 5th July 1938.

114. "Den Schleier durch Epitheltrübung, der beim Tragen der gewöhnlichen Zeissschen Haftgläsern nicht selten nach einigen Stunden Auftritt, und sogar manchmal das im übrigen beschwerdenfreien Tragen der Haftgläser unmöglich macht, habe ich bei Verwendung der nach Abguss gemachten Dallosschen Schalen nicht beobachtet."

115. Lindner K., 1938. Discussion at the German Ophthalmological Society on 5th July 1938.

116. Schmidt M., 1938.

117. Haslinger H., 1936.

118. Hartinger H., 1938.

119. Zeiss, 1933 (Patent).

120. "Haftgläser aus Kunstmassen verändern beim Tragen ihre Form und damit ihre optische Wirkung. Im übrigen würden solche Haftgläser sehr leicht beschädigt werden da die zur Verfügung stehenden durchsichtigen Werkstoffe all wesentlich weicher ist als Glas . "

121. Serr H., 1942 a, b. Presentation on 6 -7th December 1941 at the meeting of the Union of Rhine-Main Ophthalmologists (Vereinigung Rhein-Main Augenärzte) in Frankfurt.

122. Fertsch F., 1942.

123. Obrig T.E., 1942