CHAPTER XXVI

Corneo-scleral Shells Made from Pmma Throughout the World (1940-1950) *Except the USA*

Introduction

As seen in the preceding chapter, the development of contact lenses in the USA underwent an extraordinary trajectory compared with that noted in other parts of the world. World War II did enormous damage to some European countries and divided continental Europe into two entities, while meantime, the English-speaking world had acquired a definite technical advantage in this field. In Europe itself, the UK had also benefited, above all, in comparison with certain other countries on the European Continent, which had been seriously disrupted by battles fought on their territories. This chapter begins with a paragraph dedicated to the UK before we note the developments in other European countries and elsewhere throughout the world.

1 - In the United Kingdom (1940-1950)

The UK presents a particularly interesting case in the history of corneo-scleral shells made from thermoplastic materials. Stimulated by the interest from the physicians and surgeons of Moorfields Eye Hospital, primarily *Ida Caroline Mann*, then *Frederick Ridley*, Great Britain had become, in fact, an active centre of research in contact lenses and their application. When, in 1937, *Joseph Dallos* arrived in London, accompanied by his technician *Georges Nissel*, there occurred an immediate positive and beneficial effect on the manufacturers of contact lenses: thus *Charles Keeler*, *Clement Clarke* and *Theodor Hamblin* created their own manufacturing facilities and completed the development jointly, in 1938, with the Amalgamated Dental Company of a new product for molding that could be used at room temperature. So-called 'British Zelex' was intended to replace Negocoll, which originated in Continental Europe. Several therapeutic successes were published during this epoch, indicative of spectacular clinical improvements in nearly desperate cases. [(1)] These research advances were essentially centered on glass contact shells, which were mostly fit individually after a molding following *Dallos*'s technique. They were intended mainly for medical use.

The marketing of pmma Transpex by ICI allowed contact shells to be more easily shaped, modeled, ground and polished than glass and radically changed the situation. Although hampered by the war, the development of these products was actively pursued so that they could be disseminated when peace returned. The advances were also favored by the breakaway from rigid continental optical traditions and the revelation of new ideas, which were emerging following the utilization of pmma in the United States.

The first post-war years saw the manufacturers *C.W. Dixey & Son*, *Harry J. Birchall* and his engineer *Cyril Winter*, on the one hand, and, on the other hand, *Clifford Hall* and *Norman Bier* grind, primarily in pmma, the classical models.
These pioneers also registered manufacturing patents for plastics, including the patent applied by *Wingate* of *Hamblin*'s for: "*transparent eye-shields worn under the eyelids (...) made of transparent thermo-plastic resin, either by moulding or grinding from a block*." [(2)]

Next to follow, especially after the end of the 2nd World War, were figures, papers and articles by *Bier*, *Dickinson* and *Hall*, *Dixey*, *Turner*, *Hamblin*, *Kelvin*, *Nissel*, and others, not forgetting the contributions from the medical staff of Moorfields Eye Hospital in London, and the researches of *Dallos*.

1.1 – The Companies

1.1.1 - Norman Bier

Between 1945 and 1955, London optometrist, *Norman Bier* became famous because of a series of publications that frequently appeared simultaneously in the UK and USA. These confirmed the importance of the circulation of tears under contact shells and the direct link between the disturbances of lachrymal circulation and intolerance to wearing contact lenses as shown by *Sattler*'s veil.
Also in 1945, in his first publication, 'Contact Lens Considerations', *Bier* had made a particularly pessimistic assessment in regard to the fitting and the prescription of contact lenses by professionals who were inclined to not to pursue ocular molding: "*Molding should be avoided if possible since drugs anesthetics, etc, are used. (...) At this stage contacts can be worn only for a few hours without fogging and irritation. Marked in-*

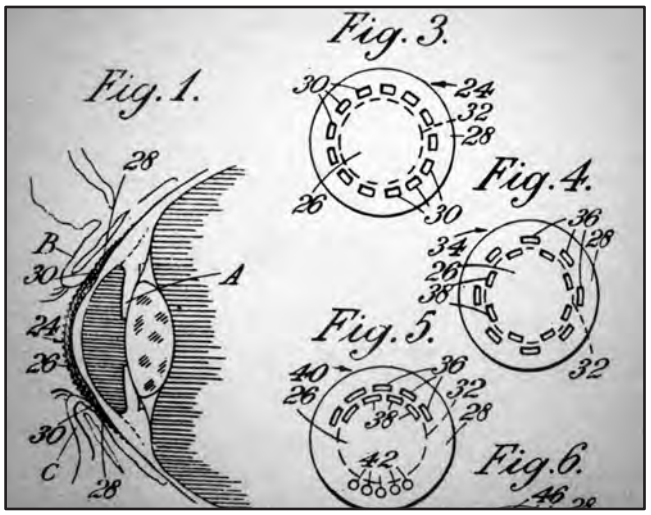

Figure 26-1
Bier's 'perforated' contact shells.
Extract from Norman Bier's patent on 'perforated' contact shells: 'a contact lens with a plurality of holes situated in the scleral or corneal portions, or at the junction of the scleral and corneal portions, for the purpose of permitting lachrymal fluid to flow through the lens.' (Bier N. 1945b. Patent #592,055)

dentations are noted on the sclera. Pressure may cause some capillary disturbance and interfere in the nerve flow. Arteries often suffer from stricture due to pressure. The contact lens is a foreign body in the eye and may cause trouble; lachrymal fluid is upset and must be replaced by artificial fluid — the solution is very difficult to mix, being slightly different for each patient. Then the patient's outlook, stamina and sensitivity of his eyes, which involves mucus formation, asphyxia, photophobia, fatigue, allergy, etc., must be kept in mind. Therefore, if contact lenses are to become popular, considerable research and training must be pursued." (3)

Bier's Patent and Publications on Fenestration and Sattler's Veil (1945-1947)

However, in the same year as this pessimistic assessment appeared, *Bier* had applied to register a patent for some 'Improvements in contact lens for personal wear' in order to resolve the difficulties described, by creating ventilation orifices in the scleral part of the shell: "*According to the present invention, there is provided a contact lens with a plurality of holes situated in the scleral or corneal portions, or at the junction of the scleral and corneal portions, for the purpose of permitting lachrymal fluid to flow through the lens while it is in position on the eye*." (4)

When, in 1947, the patent was registered, *Bier* had just returned from a trip to visit the American fitters and then he left *Dixey*'s in order to found with engineer *Gunther Wingate* the Omega Contact Lens Company Ltd. The purpose of this was to develop instruments and products for grinding and polishing pmma in the curvatures and varieties recommended in his new approach to the fitting of contact lenses. (5)

The 'Ventilated Minimum Clearance' Contact Lens (1947)

In a publication from the same year on the 'Tolerance factor and Sattler's Veil as influenced by a new development of contact lens making', *Bier* revealed that, in the course of the preceding years, he had practiced trials that led him to recommend the ventilation of the precorneal space by slots and ducts and to install a capillary minimal apical clearance in order to be certain of having a continuous flux of lachrymal circulation. He stated: "*In plotting variations of the tolerance factor against various types of scleral fittings, it was noted that, in some cases, poor scleral fitting gave a reasonably good tolerance. Other experiments showed that a 1 mm limbal clearance and certainly not more that 2.5 mm clearance produced the most satisfactory results. A lens inserted purposely with a bubble produced a longer tolerance and delayed the onset of the veil. (...) Having regard to this result, the writer felt that, if it were possible to do away with the artificial solution used, and replace it by a normal flow of lachrymal fluid and, in addition, permit air to enter the hitherto enclosed chamber between the anterior surface of the cornea and the posterior surface of the contact lens tolerance would improve. (...)*
The author has therefore developed a new type of contact lens with a plurality of holes in the scleral or corneal portion or at the limbus. These holes are provided to permit lachrymal fluid and/or air to flow through the lens while in position in the eye. The apertures may be in the form of slots, or circular or triangular or substantially rectangular cross-sections. (...)
The improved contact lens is so mounted as to provide for a permanent presence of flowing lachrymal fluid over the entire pupillary region. The contact lens must be fitted sufficiently close to the cornea to provide for such filling and neutralization." (6)

Notwithstanding the above, the fitting procedure remains traditional: "*Fitting techniques are the same as practiced at present with the exception that minimal apical clearance must be achieved so that the posterior*

contact lens surface approximates in curvature to the curvature of the cornea for at least over an area of 2 mm beyond the maximum regular pupillary diameter."

The first results obtained by *Bier*, after these modifications, are convincing: "*Some patients already wearing contact lenses were refitted with the modified lenses and a marked increase in tolerance was at once noted. (...) The colored haloes did not appear at all. (...) It was found that the size and the number of the holes, as well as their distribution, showed a marked influence on the mistiness. A typical case is that of a young student who, with a well-fitted orthodox lens, obtained a maximum tolerance of 5 hours continuous wear with comfort, although, by the end of this period, an appreciable Sattler's Veil was present; upon being refitted with the modified lens, he obtained practically indefinite tolerance. On one occasion, he wore his lenses for nearly 16 hours*."

The 'Solutionless Minimum Clearance Ventilated' Contact Lens (1949)

Shortly afterwards *Bier* published several articles that complemented and confirmed this new fitting method. The most detailed appeared in 1949, entitled, 'The practice of ventilated contact lenses'. This coincided with the marketing of the 'Solutionless Minimum-Clearance Ventilated Contact Lenses'. Included with these was a special fitting set accompanied by new fitting instructions. *Bier* recommended a minimum set of 6 preformed trial lenses, classified as a function of the posterior central radius of curvature and corneal diameter: "*With the trial lenses, not only can one stipulate the correct radius, but also the diameter, in consequence the corneal height: thus the correctness of the corneal curve may be predetermined, its clearance and position may be immediately observed, giving the data which will be required for the final lens.*" (7)

However, for a more precise fitting, he recommended a preformed trial set of 49 lenses with staged radii of curvature in 0.25 steps. For scleral and corneal fitting he recommended as follows: "*Regarding the scleral fit, a finally satisfactory result is achieved if the lens contains a 'curved' construction, as we find in lenses made to individual casts of eyes or various constructions of curved preformed lenses. In order to attain the correct corneal fit, the writer thinks it essential to employ a specially designed ventilated corneal fitting case. (...) A corneal ventilated trial lens comprises a corneal portion surrounded by a narrow scleral rim of approximately 2 mm width, so constructed as to give the flattest scleral fit likely to be called for.*"

As far as the ventilation orifices are concerned: "*The writer generally starts off with a single vent placed temporally on the inside of the limbal juncture or on a line between the internal and external canthus. After extensive experimentation, a circular vent of 1.2 mm in diameter is now most generally employed and considered satisfactory for the final lens. (...) It has been found that actual ventilations are more effective than ducts, channels or porous perforations, with the majority of patients*."

For the 'scleral rim': "*In my experience, after due experimental results, it may be advisable for a scleral rim in contact lenses to be held off and balance the optics from the cornea preventing any pressure."*
A good 'capillary-like central clearance' must be characterized by the *"absence of central bubble formation and fluorescein displaced upon central apical finger pressure*."

The Corneal Fit (1950)

In the following year, (1950), *Bier* published a new focal point entitled 'Development in contact lens practice'. He emphasized corneal fit in particular, while giving a "*summary of the latest trends resulting from contact lens experiments and from further experience gained in practice, showing that distinct progress in contact lens technique has been made. (...) Provided a well-balanced haptic fit has been created, the control in the corneal fit now remains the outstanding factor in the final and successful contact lens toleration.*" (8)

He describes the controversial tendencies, which were becoming apparent since his first description of the 'ventilated minimum-clearance contact lens': "*One school advocates lenses fitted with minimum clearance form with retro-lens space preferably filled with some standard contact lens solution, although the scleral fit may be somewhat loose. The second school, with lenses fitted in minimum clearance form, advocates ventilation to permit a more rapid interchange of lachrymal fluid as well as to allow for normal atmospheric con-*

ditions to play their full part. A third school, combining both previous theories, but advocating minimum normal corneal contact is not dealt [with]."

He summarizes the three tendencies, which are, in his opinion, very important:
"*The success of tolerance lies in the control and then in maintenance of minimum corneal clearance of no less than 5-7/100 mm and no more than 10-12 mm. A single vent positioned in the palpebral aperture will suffice in the majority of patients. (...) When additional vents are thought necessary, they are generally incorporated to hasten lachrymal circulation. Ventilated contact lenses have proved to give longer toleration and better results by the majority of those wishing to wear contact lenses for as long a period as at all possible either for cosmetic reasons, vocational purposes or sporting events*."

The Manual 'Contact Lens Routine and Practice' (1953)

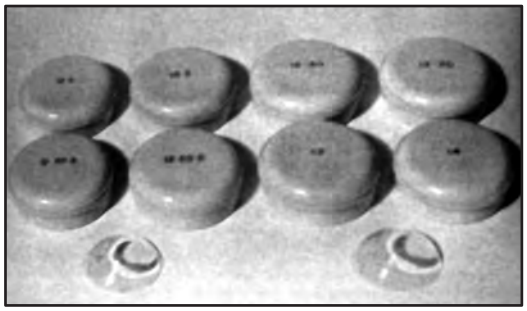

Figure 26-2
Bier's 'Transcurve' fitting set.
For Norman Bier, eight lenses constitute a minimal regular 'Transcurve' fitting set. The sizes of the small and standard trial set are 221/2 mm and 231/2 mm respectively. (Bier N., 1957, fig.7)

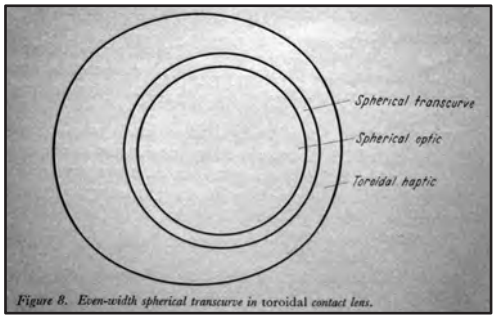

Figure 8. Even-width spherical transcurve in toroidal contact lens.

Figure 26-3
Even-width spherical 'Transcurve' in toroidal contact lens. (Bier N., 1957, fig.8)

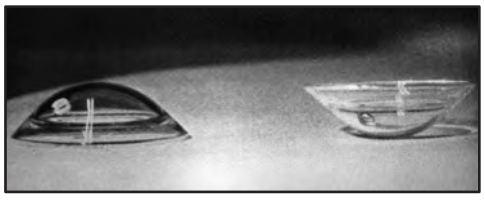

Figure 26-4
Bier's 'ventilated' contact lenses.
Picture showing corneal 'ventilated' contact lenses. On left convex, on right concave surface facing upwards. (Bier N., 1957, fig. 11)

In 1953, *Bier* published a manual, entitled 'Contact Lens Routine and Practice'. In this book, *Bier*, as historian, is severely critical of the effort expended by his colleagues and predecessors in an attempt to find the answer to the problem of Sattler's veil by choosing between different buffer solutions:
"*Looking back, it cannot be understood today why so much effort was exerted in the experimentation of the buffer solution and it is now difficult to conceive why variations in the shape of the fluid chamber were not more frequently tried*." [(9)]

Bier conferred on himself the merit and the glory of having been the first to resolve this difficult problem: "*That a bubble, trapped between lens and eye, had any effect upon the veiling problem. (...) This observation, as well as the observation made that lenses fitted loosely often gave less veiling than more orthodox or tightly fitting lenses, originally caused the author to reorientate his thoughts on the whole question. (...) A plurality of ventilations, in the form of channels, perforations, slots and ducts were all tried in those early days. This was the birth of the principle underlying the 'ventilated solutionless contact lens'. (...) It was found that, by the introduction of the solutionless ventilated contact lens, in addition to its greater convenience in insertion and use, the limitation of Sattler's veil could be overcome. An indefinite tolerance was often reported in place of a formerly limited wearing time*."

Bier's manual received favorable critical review. For example, *Sir Stewart Duke-Elder*: "*He presents clearly the technicalities of the subject and gives much detailed and sound practical advice on fitting the lenses and on their wear and aftercare by patients.*" [(10)]

The 1953 manual was followed three years later by a second, revised and enlarged edition. [(11)] This detailed the three recommended phases of fitting:
1. The 'corneal fit', with corneal clearance, ventilation and corneal alignment by means of a peripheral contour.
2. The 'limbal fit', with an internal transition, the 'transcurve'.
3. The 'haptic fit', with horizontal, oval and toroïdal contact shells.

Bier's claim that he originated the idea of haptic ventilation was disputed by *Dallos*, who recalled how, in 1946, he had already recommended perforations for the prevention of *Satt-*

ler's Veil: "*Bier is stated as reporting on the effect of ventilation in 1943; this date is presumably quoted from his account of his Patent 592055, applied for in 1945 but not published before 1947, so that, far from any report, not even any technical publication on ventilated contact lenses was in existence before my clinical findings appeared in your Journal in 1946.*" [(12)]:

In the following years, *Bier* continued with his investigations of contact lens tolerance and devoted himself to fitting difficult cases, i.e. presbyopes, children and amblyopic patients. In the era of corneal diameter contact lenses, he produced a model with ventilation, the 'Contour Lens', which was based on his previous experience. [(13)]

Bier deserves to be credited with having demonstrated, developed, codified, popularized, publicized and, above all made known to contact lens manufacturers and fitters, what had been known for a long time, but was ignored by most professionals. In fact, *Dallos* was always railing against the absurdity of a vast precorneal liquid space and had demonstrated that channels in the haptic and holes drilled near the corneo-scleral junction delayed or even prevented completely the appearance of corneal edema. Besides, the shells of *Müller-Welt* were also based on the principle of an aspheric haptic and a precorneal capillary space, so-called 'fluidless'. These predecessors are generally forgotten and the fact that *Bier* turned himself into an ardent propagator of these 'new ideas' caused him often to be considered the inventor of "*solutionless minimum-clearance ventilated contact lenses*."

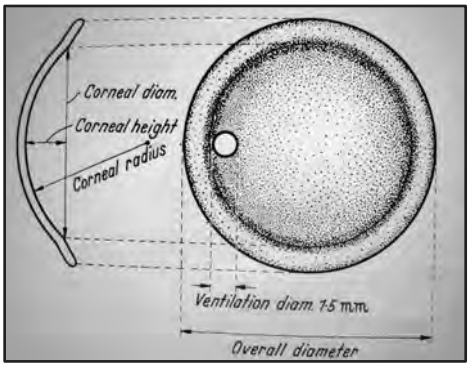

Figure 26-5
Corneal 'ventilated' contact lens in cross-section and plan.
(Bier N., 1957)

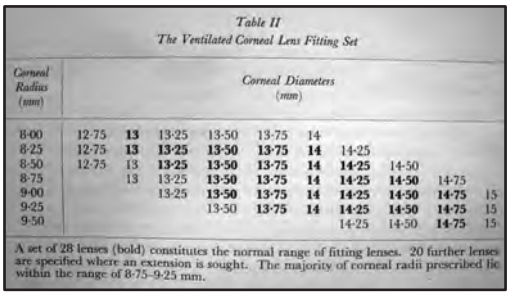

Table II
The Ventilated Corneal Lens Fitting Set

Corneal Radius (mm)	Corneal Diameters (mm)									
8·00	12·75	**13**	13·25	13·50	13·75	14				
8·25	12·75	**13**	**13·25**	**13·50**	**13·75**	**14**	14·25			
8·50	12·75	13	**13·25**	**13·50**	**13·75**	**14**	**14·25**	14·50		
8·75		13	13·25	**13·50**	**13·75**	**14**	**14·25**	**14·50**	14·75	
9·00			13·25	**13·50**	**13·75**	**14**	**14·25**	**14·50**	**14·75**	15
9·25				13·50	**13·75**	**14**	**14·25**	**14·50**	**14·75**	15
9·50							14·25	14·50	**14·75**	15

A set of 28 lenses (bold) constitutes the normal range of fitting lenses. 20 further lenses are specified where an extension is sought. The majority of corneal radii prescribed lie within the range of 8·75–9·25 mm.

Figure 26-6
The 'ventilated' corneal lens fitting set.
Bier's comment: 'A set of 28 lenses (bold) constitutes the normal range of fitting lenses. 20 further lenses are specified where an extension is sought. The majority of corneal radii prescribed lie within the range of 8.75 -9.25 mm.'
(Bier N., 1957)

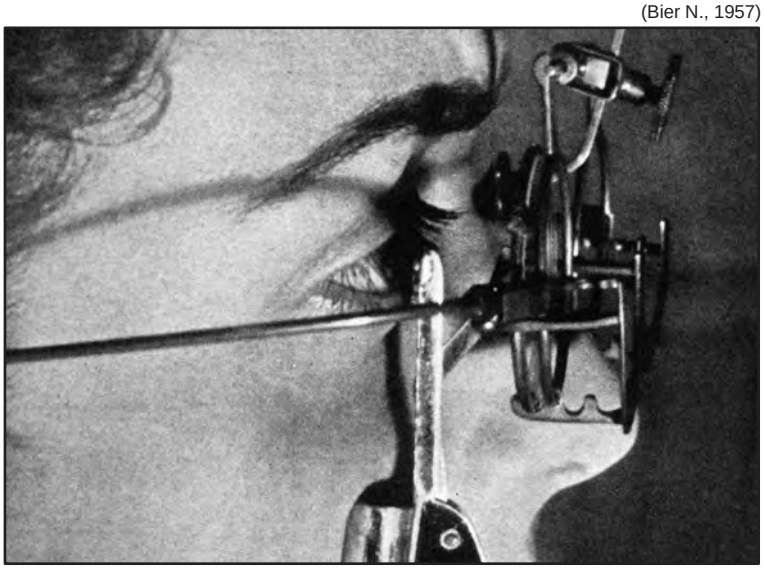

Figure 26-7
The 'distometer'.
The instrument illustrated is called a 'distometer' and is made in the U.S.A. This instrument is preferable to the customary stenopaeic slit and rule. It permits simpler and more accurate assessment of the back vertex power, the refractive lens does not have to be removed from the cell of the trial frame.
(Bier N., 1957)

1.1.2 - Joseph Dallos

Needless to say, in London, *Joseph Dallos* remained the respected expert and, in spite of his discretion, was the only major specialist in molded corneo-scleral contact shells. In fact, he does not figure in this chapter, devoted, as it is, to contact shells made from pmma except in a historical role because, during the whole of his career, he fit glass contact shells. Witness to his excellent results is evident in several publications. In 1964, when corneal contact lenses and contact shells made from pmma triumphed, he resigned from *Hamblin*'s where he had been working since 1937 when he first arrived in London and opened his own fitting

and manufacturing facility. Always faithful to glass, *Dallos* nevertheless made use of pmma for the fitting procedure, because of its ease of use for making adjustments. However, the shell delivered back to the patient was always a glass copy. Its haptic part was floppy in order to facilitate tear circulation and the ground optic part was separated from the cornea by a lenticular liquid film. One or more fenestrations at the corneo-scleral junction facilitated the exchange of tears and eliminated any suction tendency. *Dallos* always maintained his loyalty to corneo-scleral lenses made from glass. He is estimated to have fit approximately 7,000 patients in the course of his career. (14)

1.1.3 - Frank Dickinson and Keith Graham Clifford Hall

Two colleagues and friends, *Frank Dickinson* and *Keith Graham Clifford Hall* became partners with the purpose of developing plastic contact glasses during the post-war years. They became in fact close friends after meeting each other in 1939 on the Queen Mary while crossing the Atlantic. They were on their way to visit *Feinbloom*'s and *Obrig*'s laboratories.
In 1945, *Dickinson* had described a contact lens fitting on an eye that presented corneal scars secondary to keratitis. The monocular diplopia that resulted from those scars disappeared and binocular vision was restored. (15) Then, in 1946, *Hall* distanced himself from the evolution of contact lenses in the USA: "*Commercialism has gained a foothold in the field of fitting contact lenses in America. He finds contact lens fitting is a highly technical job requiring much time, special equipment and skill. Hall observes also that the lenses themselves can still be improved and that additional work is required in this direction. He suggested the formation of a British Research Society.*" (16)

In 1946, *Dickinson* and *Hall* published 'An Introduction to the Prescribing and Fitting of Contact Lenses'. This was the first publication on this subject in the U.K. and it contained 65 illustrations and 32 diagrams. *Dickinson* was responsible for the technical part, *Hall* for the practical chapters. At the beginning, both authors made the following statement: "*The perfectly fitted patient may not, for any number of reasons, enjoy perfect tolerance. (...) Daylong wearers form quite a minority. Reports indicated that the average period of comfortable wear is somewhere between five to eight hours*." (17)

After a historical outline describing the development of contact lenses, the authors described the optical principles and distinguished optical, physiological, chemical and psychological phases of fitting. (18)
The use of contact lenses is limited by economic, psychological, physical reasons as well as by '*Fick*'s phenomenon' or '*Sattler*'s veil'. For these authors, the fitting of the corneal part remains uncertain: "*The majority of practitioners favour complete central clearance, a small minority make a practice of fitting contact lenses to conform to the corneal curve. They claim for the method increased comfort and the virtual elimination of the fluid lens*."

Dickinson and *Hall*'s publication gave the composition of trial contact lens sets from that era: the various versions and copies of *Zeiss* shells available before the war, followed by those of *Kolllmorgen*, *Obrig*, *Feinbloom* and *Gualdi*. After that, they give much detail on the contact lenses of their own manufacture and recommend the following: round, oval and decentered lenses. To conclude, they document the clinical histories of 78 patients successfully fit under their care. These authors subsequently continued their research and publications. Thus, *Dickinson*, in 1953 recommended the systematic employment of contact lenses even for cosmetic use. (19)

1.1.4 - C.W. Dixey & Son

The *C.W. Dixey Company* had imported *Zeiss* contact lenses since 1930. In 1942, they announced the manufacture of pmma corneo-scleral shells. These were bispherical shells, preformed by molding on steel matrices; several years later these were ground from plastic blocks using grinding towers of their own manufacture. The fitting of these lenses (copies of classical *Zeiss*-type shells) was plagued by the same intolerance problems as the original lenses. Learning from *Dallos*' reflections, along with those of *Müller-Welt*, *Feinbloom* and others, *Dixey* subsequently modified his manufacturing technique and developed instruments suitable for grinding and polishing pmma. This is what *Frederick Ridley*, stated in 1946:
"*Messrs Dixey of London attacked the problem of contact lens production from an entirely new angle. They*

evolved a lathe of such precision that a lens may be turned from the solid block of Transpex. The lenses are not afocal, but calculated upon a known base curve for the back surface of the cornea, 7.0, 7.5, 8.0, or 8.5 mm radius being employed. (...) But, in their new lathe, Messrs Dixey had an instrument of such flexibility that lenses of any corneal or overall diameter, lenses decentred to any amount, lenses made oval to any extent and decentred to any required amount along any axis in relation to the long axis of the oval, were soon produced." (20)

1.1.5 – A.J. Forknall

In 1946, *Arthur James Forknall* (Nottingham) unsuccessfully took up again the idea of the combined contact lens of *Feinbloom* and registered a patent describing this: "*The corneal lens is mounted in the scleral rim so that the edge of the lens is located in a groove formed in the rim and so shaped that the sides of the groove extend towards the anterior posterior axis of the lens.*"

In his publication of the following year, *Forknall* described that "*with this process, the finished correction has exactly the same distance between the anterior surface of the cornea and the posterior surface of the corneal segment of the contact lens, thus affording no variation in the depth of the liquid lens or consequent change in refractive power.*" (21)

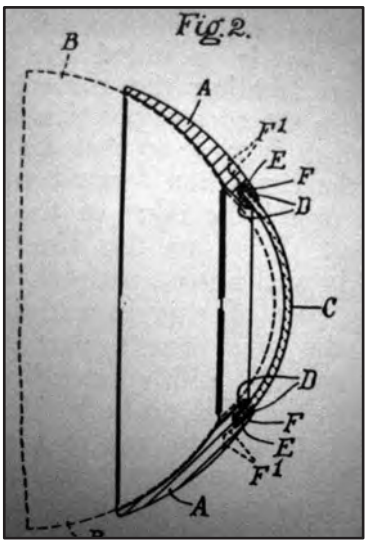

Figure 26-8
Forknall's 'combined' contact shell.
Extract from patent of the 'combined contact shell of Arthur James Forknall of Nottingham. The picture demonstrates the incorporation of a corneal contact lens in the haptic part of a corneo-scleral shell. The edge of the corneal lens is located in a groove formed into the rim portion and so shaped tt the sides of the groove extend towards the anterior posterior axis of the lens.
(Forknall A.J., 1946, Patent # 607,641)

1.1.6 - Theodore Hamblin Ltd.

The optical company, *Theodore Hamblin Ltd.*, directed by *Wingate*, acquired in 1937 *Dallos* and his technician *Nissel*, who was also his brother-in-law. The latter remained there until 1946, *Dallos* till 1964. While at *Hamblin*'s, *Nissel* was the first to use a clockmaker's tower equipped with diamond instruments for working on glass in order to manufacture the contact shells required by *Dallos*. Grinding the fragile junction between the cornea and the sclera was particularly delicate and the corneal part sometimes separated from the haptic. It was reported that *Dallos* sometimes used these corneas after having polished their borders in order to test the corneal curvature of patients and the power required. Thus he was the first to use corneal contact lenses. When pmma came onto the market, *Hamblin* was the first to use a hydraulic press for molding *Zeiss*-type spherical contact shells. This was prior to the marketing of ground contact shells and, of course, *Hamblin-Dallos* Lenses.

1.1.7 - Charles Davis Keeler Ltd. Contact Lenses

After their in-depth initiation into the manufacture of and the fitting of contact shells in Utrecht (Netherlands), *Charles D. Keeler* and *Len Rutter* opened their manufacturing workshop,* then their fitting Clinic in London*. For fitting, *Charles Keeler* was soon to be assisted by *Arthur Poole* who had done his apprenticeship under *Dallos* while the latter was at *Hamblin*'s. Progressively, *Len Rutter* improved manufacture by updating the machine equipment and simplifying the process. Thanks to the technical know-how of the newly assembled team, *Keeler* Lenses enjoyed a well-earned commercial success during the years of switchover to pmma. Because of his dissatisfaction with Negocoll, which had its origin in continental Europe and which is used at a hot temperature and requires a certain time to solidify, *C. Davis Keeler* formed an association with *Clement Clarke* and *Theodore Hamblin* to develop a new product for molding. In conjunction with The Amalgamated Dental Company, a new product of molding, 'British Zelex' was developed in 1938: a product that could be used at room temperature. It was later to be widely employed on a large scale in English-speaking countries. *you are now being linked to watch a historic film on *Youtube*, to come back, please, use your browser.

1.1.8 - Kelvin Lenses Ltd., (British Feincone Lenses)

After visiting the United States, *Raymond Kelvin Watson*, owner of *Kelvin Lenses Ltd*. (Manchester) began, in 1946, to manufacture Feincone-type lenses in the U.K. He introduced a molding procedure with a set of polished metallic molds that combined two parts: scleral and corneal. This allowed him to manufacture a large range of contact shells of differing geometry. Depending on their model, these lenses had conical haptics and are provided with a large limbal transition zone and a temporal flange. The basic fitting set contained a minimum of 15 lenses. In 1947, *G.D. McKellen*, who had accompanied *R.K Watson* to New York in order to visit *Feinbloom*, described the advantages of Feincone contact lenses. In 1949, he described their fitting procedure in detail and expressed great satisfaction with these lenses. He obtained valid results in 50% of would-be wearers of contact lenses and had results that were at least as good as any obtained by other methods:

"*This lens is made of three parts: the spherical 'optic', the conical ' haptic' and a temporal 'flange'. The purpose of the flange is to carry the temporal edge into the outer fornix and bring it into bare contact with the bulbar conjunctiva. The cone angle determines the position of the area of contact of the haptic for a given eye. The smaller the angle of the cone, the further the area of contact. (...) Conical lenses are now being made in England as the 'Kelvin'. They are based on the same principle as the 'Feincone' lenses, but are made of a harder plastic and are thinner.*" (22)

McKellen insisted on the absence of a transition ridge in these lenses and that the lens did not touch the limbus. For the time being, the addition of fenestrations had not yet been attempted; nevertheless these lenses did not require moldings: "*It has shown that the glove fit is not necessarily the correct ideal to strive for, and that a design far removed from the moulded lens may yet prove to be the answer to some of the problems.*"

In the same year, *Ewin Steele* also published a detailed assessment of the prescription technique and fitting of the Feincone lens. In the following year, he confirmed the success of Feincone lenses in an interesting comparison between two fitting centers: the Contact Lens Clinic of the Pennsylvania State College of Optometry in the USA and the Contact Lens Clinic at the London Refraction Hospital in the UK. (23)
He noted that, in Philadelphia, most of the fittings were performed with *Feinbloom* tangent cone lenses and the remaining contact lenses were molded: "*At the end of 1947, following the return to England of a number of British practitioners, who had visited the United States, tangent cone lenses became very popular and were fitted to a large number of patients. Results varied and while some patients obtained very satisfactory wearing times there were many more who did not.*"

He noted also that fenestration was more utilized in the UK than in America, both for molded lenses and preformed stock lenses. He recommended that his American colleagues should introduce fenestration:
"I hope that perhaps my references to the fenestration technique may encourage its adoption at the Philadelphia Clinic as I am sure it will be found of value in those cases which do not respond satisfactorily to other types of lenses."

Thus he highlighted the difference in approach into fitting contact lenses in the USA as compared with the U.K. The latter country had, of course, benefited from the thoughts and the studies of both *Dallos* and *Bier*.

1.1.9 - George Nissel and 'Wide-angled Preformed' Lenses

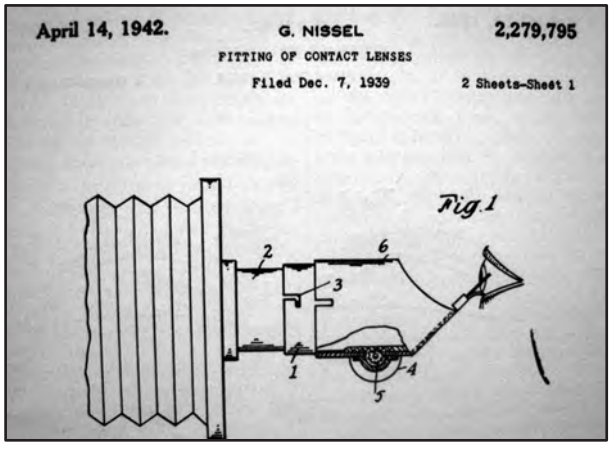

Figure 26-9
Nissel's patent for a photographic measurement of the corneal curvatures. *According to the invention, the method includes steps of taking photographs in at least two meridians of the eyeball and with eye in extreme lateral deviation.* (Nissel G., 1939, Patent # 2,279,795)

George Nissel came to London in 1937 with *Dallos*, and *Theodore Hamblin Ltd*. engaged both. As in Budapest, *Nissel* first manufactured glass contact shells using a clockmaker's tower equipped with diamond cutting pieces. When pmma became available, he tried to mold it under pressure and then to grind it on the tower. It is to be noted that after 1938, *Nissel* had regis-

tered a patent for a photographic method for measuring the lateral view of the cornea and sclera. Other patents concerning the manufacturing process followed this. [24]

In 1946, *Nissel* resigned from *Hamblin*'s and founded with *George Grimes* the enterprise *G. Nissel and Company*. *Nissel*'s new enterprise specialized in the manufacture of clock-makers' towers and polishing machines specifically intended for contact lenses. The first of these was delivered in 1947. The company was successful and *Nissel* was soon employing 11 associates and technicians. After designing and then marketing sufficient grinding and polishing instruments, *Nissel* introduced a contact lens called 'the wide-angle preformed contact lens', of which the posterior surface of the optical zone possessed an aspheric profile and which was provided an extensive flattened area between the corneal and scleral parts. He devised aspherically ground towers for the manufacturing of such contact lenses. This ventilated minimum-clearance contact lens with flat transition and limbal clearance was to enjoy a well-merited success.

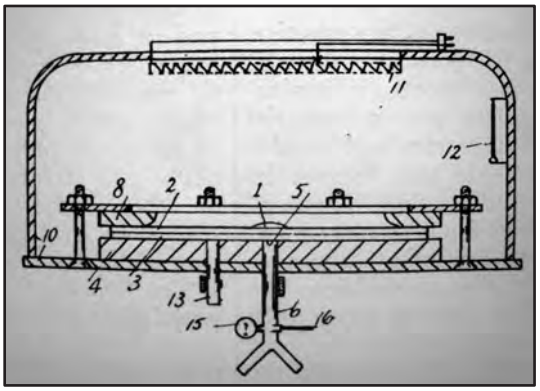

Figure 26-10
Extract of the patent Nissel & Lambda.
Picture from the patent G. Nissel & W. P. Lambda 'Improvement in or relating to a method of producing contact lenses'.
(Nissel G., Lambda W.P., 1945, Patent # 590,289)

1.1.10 - R. A. Turner

The engineer-optician, *R.A. Turner*, who had worked with *Dallos* since 1948 opened in 1954 his own company, named *GT Optics* for manufacturing a complete range of machinery specific for contact lens fabrication. This equipment replaced the previously used clock-makers towers. He achieved great success with a 'multi-spindle', which made possible the manufacture of several lenses at the same time, even including towers made for bifocal and toric lenses. [25]

1.2 - Medical and Research Activities

Certain London physicians were very active in the contact lens field, first with glass contact lenses, then using pmma. At Moorfields Eye Hospital attention was focused on complicated cases for which the expertise of *Dallos* was available, whilst the others did not leave the opportunity to fit esthetic cases solely to the ophthalmic opticians and optometrists.

1.2.1 - F.A. Williamson-Noble and Frederick Ridley

In 1944, *Williamson-Noble* described in the popular press the history, the advantages and disadvantages of contact lenses. [26] Also in 1944, *Frederick Ridley* presented a report on the state of knowledge in regard to tears, emphasizing the difficulty of collecting them in order to make an objective analysis. Finally, in 1946, he published a fairly optimistic and enthusiastic assessment entitled, 'Recent Developments in the Manufacture, Fitting and Prescription of Contact Lenses of Regular Shape'. [27] In a brief historical reference, he recalled the failure of the afocal lens approach of *Zeiss* and the practical difficulties of the *Dallos* glass molded contact lenses. However, in 1937, and after

TABLE II.—ANALYSIS OF 200 CONSECUTIVE CONTACT LENS CASES.

Contact Lens Measurements ordered			% second 100*
Scleral radius :	11·5 mm. or less	...	0
	11·75 and 12·0	...	23
	12·25 12·5	...	45
	12·75 13·0	...	32
	over 13·0	...	0
Corneal radius :	7·5 mm.	... ...	6
	8·0 ...	... ...	65
	8·5 ...	... ...	29

Corneal diameter :	12·0 mm. or less	...	0
	12·25 and 12·5	...	12
	12·75 13·0	...	33
	13·25 13·5	...	43
	13·75 14·0	...	12
	over 14·0	...	0

* A wider range of trial lenses became available for the second hundred cases.

Figure 26-11
Ridley's analysis of 200 consecutive contact lens cases.
The table shows the distribution of contact lens measurements. The majority of sclera have a radius of 12.50 mm. The corneal diameter is at least 13.00 mm on the average. There is no correlation between the scleral and corneal measurements.
(Ridley F., 1946, tab. 2)

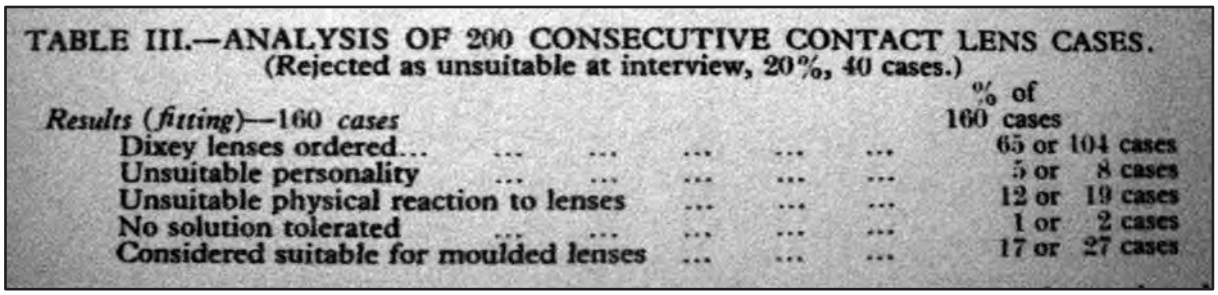

TABLE III.—ANALYSIS OF 200 CONSECUTIVE CONTACT LENS CASES.
(Rejected as unsuitable at interview, 20%, 40 cases.)

Results (fitting)—160 cases	% of 160 cases
Dixey lenses ordered...	65 or 104 cases
Unsuitable personality	5 or 8 cases
Unsuitable physical reaction to lenses	12 or 19 cases
No solution tolerated	1 or 2 cases
Considered suitable for moulded lenses	17 or 27 cases

Figure 26-12
Ridley's analysis of 200 consecutive contact lens cases.
After 40 cases, 20% of patients, have been rejected at interview, the table shows that 5% react badly to the fitting and 12% develop reddening or weeping sufficient to make the ordering of lenses inadvisable. Of the total 65% have been fitted with Dixey lenses and 17% were considered suitable for moulded lenses but not suitable for Dixey lenses. (Ridley F., 1946, tab. 3)

introduction of "*glass-like plastics especially those based upon methyl methacrylate*" everything changed. In the UK, pmma was developed by ICI under the trade name *Transpex*. The latter is "*available with a guaranteed refractive index of extreme precision (...) free from strain and perfectly homogeneous*."

Ridley explained the smallest details of the fitting of these new plastic lenses with measurements of their corneal diameters using gauges. The corneal radii of curvature were measured on the keratometer that had been previously calibrated using a steel ball of known radius. He selected an afocal contact lens based on these criteria and placed it in the eye without topical anesthesia, checking the best fit with fluorescein viewed in cobalt blue light. In 200 patients that he studied (mostly mild myopes), only 40 could not be fit with standard lenses and required molding: "*With such regular lenses (...) about three quarters of the cases suitable for contact lenses can be adequately fitted, the remainders need irregular lenses.*
The patient should be warned that, on the 'average', contact lenses are worn not more than four hours continuously. (...) There is a personal limit, varying from case to case. (...) Four hours a day and twenty-eight hours a week is the average of all cases."

Ridley detailed the values of measuring the scleral and corneal radii of curvature and corneal diameter. The average duration of wearing time was 4 ½ hours. During the discussion following his communication, *Ida Mann* remarked correctly that *Ridley* had fit "*a group of cases of which she had no real experience. Her own cases had not been comparable, in that she had omitted the cosmetic group and had dealt almost entirely with patients showing an absolute rather than a relative indication. With the Dallos molded lenses, her patients attained a minimum tolerance of 8 hours a day*."

In the same year (1947), *H. Treissmann* and *E.A. Plaice* published a small volume, which included a description of contact lenses, comparison with spectacles, indications for uses and tolerance. They devoted the major part of the volume to the contributions of *Dallos* and his new molding techniques. The publication coincided with *Dickinson* and *Hall*'s manual and was less successful than the latter. [28]

In 1948, *Frederick Ridley* returned to the question of the corneal veil under the title of 'Contact Glasses and Veiling'. Following his experiments with ocular moldings using paraffin as well as molded plastic shells in 12 patients, he concluded that the corneal edema was caused by a suction phenomenon:

"*This negative pressure may be developed as follows: a lens with corneal clearance, but with an edge fit, when pressed (by the lids) against the globe creates a positive pressure in the fluid under the lens which easily escapes at the lens edge. When the pressure is released, however, the lens edge acts as a valve and neither air nor tears can flow in to fill the space, which tends to reform under the lens as the eyeball tends to resume its normal shape. A negative pressure is thus created*." [29]

In order to remedy this, *Ridley* proposed making "*a channel of suitable dimensions and location [which] is cut on the underside of the contact lens from the lens edge to the pre-corneal space*."

In 1949, he presented a remarkable and comprehensive report on the state of contact lenses, the progress achieved and the problems awaiting resolution. [30] In his position as Consultant-in Charge of the Contact Lens Department of Moorfields Eye Hospital, High Holborn Branch, *Ridley* went on to publish other notable

papers on the theory of contact lenses during the following years, the treatment of keratoconus, eye drops and eye-rubbing with contact lenses. *Ridley* was an active contributor in ophthalmological congresses and prompted, by his example, the use of contact lenses in pemphigus and trachoma. These publications reflected the unparalleled experience that physicians and technicians of the Moorfields Contact Lens Department had acquired under his direction at High Holborn. Thus it was that, between 1951 and 1955, they had fit more than 2,000 patients, of whom 92 were afflicted by keratoconus. When the era of corneal contact lenses opened, *Ridley* emphasized the need to pursue corneo-scleral shells in certain pathologies and on the role of ophthalmologists in these decisions. (31)

1.2.2 - The 'Flush–fitting' Scleral Contact Lenses

Frederick Ridley became the advocate for 'flush-fitting' scleral contact lenses. Such lenses were used worldwide as therapeutic lenses during the whole of the second half of the 20th Century. The flush-fitting lens is an exact copy of the mold of the anterior segment of the eye, reproducing accurately the surface contour of cornea and sclera. The shells are separated from the globe by a single capillary layer of tears. They have no posterior optical grind. Because of the exact replication of ocular surface irregularities, a capillary tear layer is introduced that is constantly renewed. The therapeutic efficacy of such flush-fitting scleral lenses is to be attributed to corneal protection from the rubbing of the eyelids and to the continuous exchange and renewal of tears. In *Ridley*'s own words, these lenses are, "*a perfect glove fit and the most satisfactory of all contact lenses from the wearing point of view*."

1.2.3 - Contact Shells made from Pmma in Aviation

In wartime, the use of contact lenses in aviation posed particularly dramatic problems, the solution of which was sometimes ambiguous or even contradictory.
Thus it was that in 1943, an official statement from the R.A.F. indicated, that, in spite of their requirements, personnel corrected by contact lenses could not be accepted in the flight crew: "*There has never been idea of accepting personnel into the Service with visual acuity below R.A.F. Standards, but which can be fully corrected by contact lenses. It is not in the interest of the R.A.F that this should be so*." (32)

Nevertheless, *Dickinson* and *Hall* reported: "*It is now well known, for instance, that a limited number of experienced R.A.F pilots are permitted to wear contact lenses for flying duties, whilst other members of airplane crews also appreciate their greater safety and unrestricted visual field*." (33)

This is confirmed by *Allan H. Briggs* who published the copy of an R.A.F. pilot's letter, who, because of his -8.00 myopia had been fit in 1938 by *Dallos* with corneo-scleral contact shells. He had been recruited without his refractive error being noticed and his contact lenses were not spotted at the time of several medical examinations. He had an incredibly adventurous career: shot down, escaped prisoner, and flight deck commander in tropical regions, he wore contact lenses up to 16 hours per day during a 10 year period without his entourage being aware of it. (34)
From among these clinical histories quoted in their book, *Dickinson* and *Hall* reported several other observations involving airmen: "*Flying Officer B.B: was able to wear his lenses long enough to cover a trip over enemy territory. Returning from one such mission he shot down three enemy planes.*
Solder D.V.B: During voyage between Alexandria and Malta, under constant air and sea attack, the patient's ship was torpedoed. He reported that the lenses were instrumental in saving his life. Whilst in Malta, his right lens was broken by enemy action whilst asleep! (...) He wore them continuously without removal for twenty-six days whilst taking part in the invasion and conquest of Sicily. Now transferred into the R.A.F., he holds the rank of Flying Officer and has been accepted for flying duties.
Flight mechanic K.G.: The patient was unable to persuade his C.O. to recommend a review of his ocular conditions for flying duties. He therefore took a risk, flying a plane without permission, to prove his ability to fly. The result was a court martial, with subsequent reprimand and sentence. (...) The patient ultimately obtained his wings."

In his 1949 assessment, *A.G. Cross* also addressed the use of contact lenses in 31 Flying Members of the R.A.F. The majority of these were satisfied, two had unilateral aphakia and the remainders were basically myopes: "*One found his lens entirely satisfactory, and he flew 350 hours while wearing it in single-seated fighters and noticed no diplopia, while his judgment was unimpaired*." (35)

1.2.4 - Corneo-scleral Shells for Radiological Examination

In 1946, *J.L. Reis*, an ophthalmologist in a Polish general hospital published a report entitled 'The use of contact corneal rings in X-Ray localisation of intraocular foreign bodies'. He reviewed the different devices available for localization of foreign bodies, and then he proposed an opaque limbal marker ring 12 mm in diameter: "*A thin metal ring exactly fitting to the corneal margin (...) a flat lead and tin alloy, about 0.1 mm thick. The width of the ring is 1.5 mm. The external diameter varies for different eyes, five sizes - 10.5 mm, 11 mm, 11.5 mm, 12 mm, 12.5 mm - should be sufficient.*" (36)

1.2.5 - Other Noteworthy Publications

In 1947, *C.G. Kay Sharp* published an article in the popular press, reporting his experience at the Contact Lens Center of the Royal Eye Hospital, at Elephant and Castle in London. Then, in 1948, *A.G. Bennet* published an in-depth review entitled 'The Optics of Contact Lenses'. (37)

In 1949, *A.G. Cross* delivered a detailed statistical analysis, with 28 illustrations in the form of tables, on the appreciation expressed by patients fit with contact lenses for a minimum of four years. Most of the fittings came from *Dallos* at *Hamblin's Ltd.*, but a few were also from *Clement Clarke Ltd* and *Davis Keeler Ltd.* This enquiry encompassed 875 patients and showed that a third of them did not tolerate prescribed contact lenses or did not wear them. In the remainder, 30% wore them for more than 8 hours a day, approximately 60% for 4 hours a day. The veil often appeared after 4 hours. Two thirds of the lenses were inserted with the aid of physiological serum, the others without liquid. The best results were observed in cases of keratoconus and monocular aphakia. Cross's questionnaire would be repeated 5 years later by *Desmond P. Choyce* and specially oriented towards *Dallos*'s ventilated glass contact shells.(38)
In another highly detailed and in-depth report, *H. Treissman*, who was himself a student of *Dallos*, reviewed the various types of contact lenses. He described the phenomenon of 'choked cornea' which was responsible for corneal veiling and concludes: "*Corneal misting is due to:*
a) Annular pressure on the globe by a lip or by excessive swelling of the conjunctiva.
b) Stagnation of the precorneal fluid, especially when there is excessive corneal clearance. When annular pressure is present, precorneal fluid stagnation is present also and the result is veiling and intolerance.
c) Excessive corneal clearance alone may cause veiling without discomfort because complete replacement of the precorneal fluid by the tears is a much slower process than where a capillary film of fluid is present.
Corneal veiling must not be treated as an isolated symptom, but is inevitably bound with the subject of fitting. It is due to defects of fitting which give rise to circulatory obstruction of various degrees of severity, or to stagnation of the precorneal fluid, or both. (...) The remedy lies in correcting or avoiding the defects, not in relieving their consequences by drilling holes in the lens." (39)

In 1950, *Istvan Györffy* published in the UK an interesting and exhaustive article on the use for therapeutic indications for plastic corneo-scleral shells. One such shell was perforated and used for the prevention of symblepharon. He went on to describe his new molding technique with a complete historical section and a description of a new molding shell made from plastic material: " *[with its] inner side roughened to ensure better adhesions. [It] has a small handle attached to the center of its corneal part. The handle has a central hole to which a record can be fixed.*" (40)

Also in 1950, *A. Hirtenstein* reported that he had fit 18 unilateral aphakia patients with corneo-scleral shells made by *Dallos*. After orthoptic reeducation, 16 of them regained binocular vision and wore their lenses without complications. Among medical indications for contact lenses also to be noted, is the fitting by *Robert Irving* (Glasgow, Scotland) of a patient suffering from exophthalmic goiter. The lenses were well tolerated and improved the patient's vision. In contrast to this, *A. Sarwar*, in 1954, reported the use of diagnostic contact lenses and proposed a polyvalent lens for examination of the fundus. (41)

1.1.6 - The Contact Lens Society - Ida Mann

A purely scientific society in objectives and organization called 'The Contact Lens Society' was formed in 1947 for the study of contact lens work in all its aspects. The members were: *Ida Mann*, *F.A. Williamson-Noble*, *K. Clifford Hall*, *A.C. Cross*, *G.H. Giles*, *C.H. Keeler*, *J.H. Doggart*, *G.B. Ebbage*, *F.A. Juler*, *Sir Stuart Duke-Elder*, *F. Dickinson*, *H.B. Marton*, *G. D. McKellen* and *J. Hamblin*. (42)

This elite group of manufacturers and fitters chose *Ida Mann* as President of the Society. In her opening discourse, she presented a remarkable clinical summary that was both objectives, yet at the same time, relatively pessimistic of the situation in 1947 of contact glasses and fitting. (43)
Ida Mann made a logical distinction between two types of problems: optical and haptic.
1). For the optic part, there was much still to be done to obtain an optic that was as good as that of glasses, for one did not know how to grind prisms or cylinders and bifocal contact lenses had a long way to go. *Mann* also believed that the optimal material for contact lenses had yet to be found.
2). The more pressing problems, however, were those concerned with tolerance.

With a view to doing some statistical research, *Mann* carried out a randomized interrogation 100 consultants who had been fit with contact lenses: all were individually fit, some of them having first failed with *Zeiss* contact shells. There were 61 myopes among them, 2 with keratoconus, 10 unilateral aphakes. The average age was between 30 and 40 years, with the youngest being 14 and the oldest 73. 74 patients said they were satisfied and declared themselves ready for a refit. 55 wore their lenses every day with variable tolerances. 23 had discontinued wearing contact lenses. For insertion, half of them inserted dry and tolerated the lenses well, one quarter used saline solution and the other quarter distilled water. Some were satisfied to wet their lenses in their mouths and some to moisten with saliva. In a few exceptional cases, tolerance reached 14 hours, or twice 7 hours with a pause at half time between hours of wearing. Visualization of the corneal veil was taken as evidence of intolerance. This is a physiological problem and would probably be resolved by modification of the fitting procedure, as *Dallos* had demonstrated experimentally with holes and slits in the lens. However, *Mann* emphasized that relationships between state of the eyelids, allergies and conjunctival bacterial flora might also be causative.

1.1.7 - Research Studies

Several research studies on corneal metabolism were also published at this time. Thus, in 1938, *M. Klein* and *J. Sàrkàny* studied the diffusion of water and chloride ions across preparations of excised corneas. They arrived at the conclusion that water could cross the corneal barrier in both directions under the influence of osmotic pressure. The literature of the era often made reference to 'respiration' of the cornea. *Duke-Elder* inferred that "*the cornea possesses a respiratory mechanism, whereby gases are automatically transpired through the agency of the epithelium and the endothelium*". On the other hand *A. Bakker* (Histological Institute, University of Groningen) returned in 1947 to the experiments conducted by *Fischer* and arrived at a different conclusion, namely, that the absence of oxygen does not inhibit normal corneal metabolism, which however remains transparent in an atmosphere of carbon dioxide. (44)

2 - Pmma Corneo-scleral Shells in Continental Europe

After the end of World War II, different countries in continental Europe emerged only very gradually from the era of glass corneo-scleral shells. In most countries, experimental work and research had been interrupted and the publication of papers recommenced only slowly during the post-war years. *Fritz* in Belgium and *Györrfy* in Hungary seemed the only individuals to be pursuing the studies and fittings that they had begun before the war.

2.1 - In Hungary

2.1.1 - István von Györffy

After the publication of his pioneer research in 1940 regarding the use of pmma for the manufacture of contact lenses *István von Györffy* presented new experimental results in the following years, particularly on aniseikonia. He also published a remarkable paper on the role of the tear meniscus. This was an encyclopedic research paper, carried out in 1942 on liquid refilling, in which he amalgamated the opinions of some American authors of the era and made a connection between their opinions and those of *Sattler*. He concluded that, while the cause of *Sattler*'s Veil was acidification of the liquid due to accumulation of C02, encouraging the exchange of lachrymal liquid exposed the eye to the risk of introducing air bubbles, thus causing un-

comfortable vision. In the course of his experiments, he produced a prolongation of between 20% and 100% in the length of tolerance. As a preventative measure, he recommended a solution derived from egg white albumen mixed with antiseptic preservative. (45)

In 1944, *Györffy* reported his experience of fitting contact lenses over a 5-year period. This was the most important publication on acrylic contact lens fitting from continental Europe. However, because the publication was in German and occurred just before the military surrender of the Axis powers, it did not meet with the audience or the success it deserved. In the previous years, *Györffy* had fit more than 100 eyes. In Professor *Joseph Imre*'s University Clinic Laboratory in Budapest, he had proceeded through all the phases of fitting and manufacture of contact lenses. He had discontinued the systematic use of Negocoll moldings in favor of a trial set of specific trial shells taken from the most current moldings. The best-adapted shell was further improved following the indications from these observations. When the fluorecein image is satisfactory, a plaster copy is made which acts as a matrix for the definitive lens. After adjustments and completing the modifications for the final lens, the technician grinds the posterior surface of the corneal part first, then, after carrying out the refraction, the anterior surface. *Györffy* answers the criticisms still being made in Germany against plastic materials: certainly these material were more liable to scratches, but these did not happen in the eye and, in any event, did not affect the vision. Finally, he published a statistical survey of his last 100 fits. There were 52 males and 48 females, aged between 12 and 64 years. He found that 17 complained of fatty deposits, three of which were significant. With the exception of 5 patients, wearing time exceeded 4 hours. The complications were, for the most part, due to manufacturing defects and faulty adjustments of the shells. The most important complication was Sattler's veil. This was sometimes avoidable by maintaining a discrete contact between the summit of the cornea and the shell. The liquid was chosen according to the result obtained from measurement of the tear pH. Patients who had previously been fit with glass shells appreciated the lightness of the plastic shells. Shells made from resins also had the advantage of being distinctly less fragile than those made from glass, from the standpoint of manufacture, necessary adjustments and manipulations. (46)

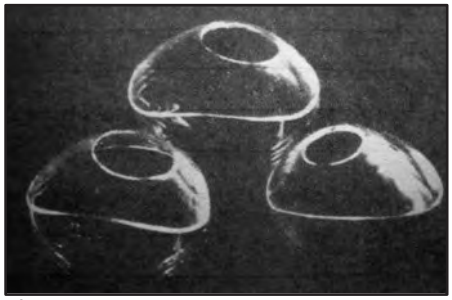

Figure 26-13
Györffy's therapeutic ocular shells.
Therapeutic shell with a corneal opening of 10-12 mm for treatment of symblepharon.
(Györffy I.v., 1950, fig.1)

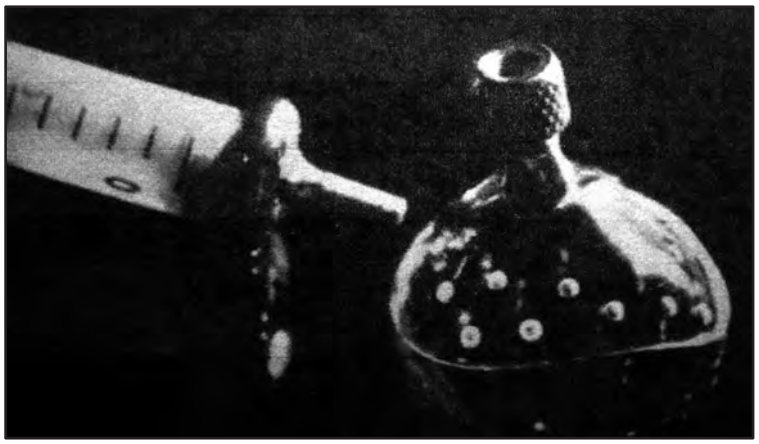

Figure 26-14
Györffy's moulding shell.
Perforated moulding shell having a small handle attached in the centre of its corneal part. This handle has a central hole to which a record syringe can be fixed.
(Györffy I.v., 1950, fig. 2)

Györffy was optimistic about the future of plastic contact shells. In the Budapest Clinic, these shells were manufactured in one piece according to relatively standardized molds. It would take little to develop a manufacturing procedure. He concluded on an optimistic note, predicting a better future for plastic shells than could have been expected from those made from glass: "*The resin contact lenses are appreciated by the patients in contrast to glass ones. They have a great future due to the advantages described and also to simplicity of manufacture, a result of development of the resin industry*."

During the post-war years, *Györffy* reported experiments in attempts to lengthen the duration of tolerance of contact lenses, using instillations of antihistamines, which had sometimes increased wearing time. One detailed publication on the therapeutic use of corneo-scleral shells gave him the opportunity to describe perforated shells for symblepharon and a molded shell modified for medication injection by syringe. He then tackled the risk/benefit ratio associated with the use of contact shells: in 4 cases the shells protected the eye from serious injuries; in two patients, the shells were worn for 80 hours. However, the resultant epithelial lesions cured themselves in a few days. It was in correction of unilateral aphakia that *Györffy* obtained the most satisfactory results with the reestablishment of binocular vision, according to a statistical survey,

in 24 patients. Another study showed the effectiveness of contact shells in the correction of keratoconus, 500 cases of which had been fit between 1950 and 1964: 80% of these wore their shells on a regular basis, 6% did not exceed 6 hours of wearing time, and the remaining 14% did not wear the shells. In the following years, *Györffy* concentrated more particularly on the history of contact lenses and tried to fill in the gaps and rectify errors concerning history as related by Anglo-Saxon authors in an area outside their influence. (47)

2.1.2 - Géza Mihàlyhegyi

At the time of the presentation of *Györffy*'s main work on the use of plastic materials at the Hungarian Society of Ophthalmology, in October 1939, *Géza Mihàlyhegyi* contested the priority of the presenter by insisting that *Thier* had preceded him by one year. He criticized the use of plastic materials, the advantage of which would be minor when compared with their major disadvantage: the lack of durability of plastic material, rendering the grinding and the optical surfacing of it difficult. Also of concern was exposure of the lenses to fissure formation, requiring frequent re-polishing. Following his first 11 fits of keratoconus patients with glass contact shells, *Mihàlyhegyi* noted improvements in the visual acuity of these individuals and reduction of the refractive error caused by pressure exercised on the summit of the corneal cone. During the following years, *Mihàlyhegyi* published several works, some in Italian, on individualized fits of contact lens patients and on measurements of their scleral and corneal curvatures, especially in keratoconus. He also described improvements in his technique for ocular molding. If one takes into consideration that the shell used for molding as recommended by *Dallos* actually deformed the sclera, *Mihàyghegyi* recommended his own modification of *Csapody*'s technique. Here, the molding material is poured into cylindrical metal tubes. He also reported that the visual improvement obtained in 7 myopic patients affected by chorioretinal lesions was distinctly better with contact lenses than with glasses. (48)
When war ended, *Mihàlyhegyi* returned with increased application to his research projects. In 1947, he reported his results after 6 years of fitting contact lenses. He used the technique of ocular molding exclusively, judging it satisfactory enough to avoid the need for adjustments. He was critical of *Györffy* whose trial lens set exceeded a hundred, resulting in increased difficulty selecting lenses. He made a plea for contact shells made from glass, a material known since ancient Egyptian times, the incomparable properties of which allowed the wearing of the same lenses for many years. He ended on a tendentious historical note regarding contact shells made from plastic, emphasizing the disadvantages, but without any mention of *Györffy*, his compatriot (both Hungarian). Continuing with his plea, he went on as follows: "*Plastic lenses do not break easily when dropped, but they have certain disadvantages. They are easily produced but the grinding of the optical surface is much more difficult; they scratch more easily than glass lenses, therefore they need frequent polishing; they become opaque; nearly every chemical substance, with the exception of benzene, damages them. The glass lens has only one disadvantage, it breaks when dropped*." (49)

In 1950, *Mihàlyhegyi* published an interesting study on the curvatures and the lateral view of the anterior segment of the ocular globe. After experimenting with different palpation methods, he made a photographic study of the globe in lateral view, coming to the conclusion that there existed large inequalities of curvature in different meridians. This divergence increased towards the equator and did not appear to be related to the degree of myopia. In 1954, he studied keratoconus more specifically and observed, "*the changed form of the frontal section of the eye in keratoconus is like a cone whose upper part is the cornea and the lower part the sclerotic.*" (50)

2.2 – Belgium

In Belgium, *Adrien Fritz* had begun fitting contact lenses on the eve of World War II and restarted publications, beginning in 1945. He and his brother, *Raoul Fritz*, manufactured and fit contact glasses made from organic materials with aspheric anterior optical surface and others, the tolerance of which was increased by the introduction of radial slits in the haptic portion. They attributed these improvements in tolerance equally to the increased flexibility of the shell, the effect on pumping and tear drainage. At the time of the discussion of their presentation, *Roger Weekers* recalled the experiments of *Fischer*, which showed that the cornea used oxygen dissolved in tears for metabolism and removed carbon dioxide by the same route. *Charles Schepens* believed that these concerns had no justification, taking into account that "*the cornea is in contact with the air around it via the liquid layer that covers it and the wearing of a contact glass has no effect on this liquid layer*."

Schepens described his experience from London, where *Dallos* refused to use plastic materials because they could be pushed out of shape. He feared that contact shells with radial splits as recommended by *Fritz* were even more liable to this. This was when *Schepens* also described the difference between the fitting procedures in Europe and those practiced in the United States: "*The procedure used by several American firms is different. Over there, it's the treating oculist who takes one or two molds from the eye and sends them to the firm specialized in the manufacture of contact glasses. The latter fabricates prostheses in plastic from molds. The oculist receives the contact glass and tries it out in the patient's eye. This procedure is much more unrefined than the Dallos procedure and has to be associated with a higher failure rate.*"

Following these communications and discussions, *Félix Bonhomme* (Liège) describes the indications and procedures for fitting contact lenses. He concentrates particularly on molding by means of British-Zelex and the adjustments required to obtain a good fit. (51)

In the following year, *Fritz* redescribed in great detail the fitting techniques for contact glasses. These molded lenses were produced in Belgium and had a thickness of 0.3 mm as compared with 1.0 mm thickness for the other European and the American lenses. This allowed better tolerance. A study of the molded lenses showed that the anterior corneal surface is ellipsoidal. Because of this, the lenses had to present the same geometry on their anterior surfaces. *Fritz* believed that the contact shells had to be in conformity with the moldings and not be altered. Consequently, a controversy followed that provided *Bonhomme* with the opportunity to describe his experiences with contact glasses. For this author, the positive in plaster (made from the Zelex mold) was forwarded to one of the manufacturers: *Raoul Fritz* in Belgium, *Thier* in the Netherlands (Utrecht), *Dallos* in the U K, *Dudragne* in France (the latter using no super-added intermediate liquid), *Obrig* in the USA.
The presentations by *Fritz* to the Belgian Society of Ophthalmology are often repeated with minor modifications at presentations in Paris. In the following years, *Fritz* suggested covering wounds, ectasias and other corneal lesions with sutured contact glasses. Later on, he participated in numerous discussions, particularly in regard to the correction of keratoconus. (52)

2.3 - Switzerland

2.3.1 - German-speaking Switzerland

Although remaining outside the world conflict, the German-speaking area of Switzerland maintained its relationship with German manufacturers and continued its tradition of glass contact shells. Thus it was that, in 1942, *Arthur Brückner*, in an appraisal of the situation in regard to glass contact lenses, gave only passing mention to plastics, mixing together Celluloid, Cellon and Plexiglass in the same group. (53)
Moreover, in 1946, *O. Knüsel* (Aarau), in a progress report, concluded that only *Müller-Welt*, *Müller-Wiesbaden* and *Zeiss* glass contact shells were available in Switzerland during that era. His assessment of these products was somewhat guarded: *Müller-Welt* contact shells often had poor optics, were thick and heavy, but, nevertheless, better tolerated than *Zeiss* contact glasses. According to the manufacturer, the contact shell had to touch the cornea; however, for an ophthalmologist, it is fundamental not to have any contact between cornea and contact lens. *Knüsel* described the clinical case of a patient who had developed corneal opacities as the result of such contact. The defect of the *Zeiss* contact shells was related to the sphericity of their haptic which is nowadays corrected by contact shells with molded haptic. The old-fashioned *Zeiss* contact shells stuck too tightly onto the globe of the eye. This was needed for the maintenance of the lachrymal meniscus. After carrying out numerous experiments to measure the surface of the globe in vivo, *Knüsel* reckoned that the vertical and horizontal meridians are different: they are not spherical, but parabaloid. He regretted that Switzerland did not have its own independent manufacturer and arranged to carry out some experiments with Plexiglass. However, once again, the Swiss manufacturer ran into production difficulties.
In the course of the following years *Knüsel* entered into a more in-depth research study beyond the optic to the sclera and introduced an instrument for the measurement of the curvatures of the ocular surface. Using thousands of measurements, he came to the conclusion that there existed several types of scleral curvatures, with regularly recurring examples. He continued, however, to have reservations because of the frequency of visual veils. After that, *Knüsel* continued with his experiments and presentations, until, after visiting the USA, he became one of the first to introduce corneal contact lenses. (54)

1948 was the year of publication of a treatise entitled, 'The Contact Glass as an Optical Instrument' (Das Haftglas als optisches Instrument) by *Ernest Bürki* (Basel). During the previous years, in evaluations of the treatment of keratoconus, the author had described contact glasses as an active orthopedic treatment for that condition. As proof, he had observed the disappearance of *Vogt*'s intracorneal lines and the stabilization or even regression of the cone. He cited *Strebel* as having associated instillations of almond oil with the lenses. In his treatise, *Bürki* classified corneo-scleral lenses of the era didactically into those with spherical and aspherical haptics, either blown or molded. He went into great detail on the disadvantages of plastic materials, but hoped for improvements in these. From amongst the glass contact shells with spherical haptics available in Switzerland, he listed those of *Zeiss-Sattler*, besides those of *Dixey*, *Obrig*, *Courtis* and *Hamblin*. The available aspheric contact shells were manufactured according to the most frequently occurring ocular moldings, namely *Hamblin-Dallos* glass contact shells, *Müller-Welt* plastic lenses, *Dudrange* lenses and *Feinbloom* lenses. In 1949, he redescribed the optical advantages of contact glasses as compared with spectacles. (55)

The third person to promote contact lenses in the German-speaking part of Switzerland was *Joseph Strebel* (Lucerne). After 1930, *Strebel* concerned himself with methods of orthokeratologic management of keratoconus, using contact shells. He also described, during the war years, a law of asymmetry of the anterior scleral cap in these patients. Thus, he recommended a modification of the keratometer measurements, which, since *Gullstrand*'s time, were based on the refractive index of aqueous (n=1.3375), when, in fact, it was necessary to take into account the corneal refractive index as well. (n=1.376).
In 1948, *Strebel* announced the production, on his own initiative, of the first contact shells made from plastic to be manufactured in Switzerland. The recommended fitting set was composed of 10 groups of 5 contact shells, one group with classical geometry, and the other more original. These had a total diameter of between 19 and 24 mm, a thickness between 0.30 and 0.40 mm and weighed only 0.19 and 0.22 grams. Corneal diameters between 6 and 14 mm were available with several degrees of elevation of the optical part for clearance like a 'bridge' over the cornea. The haptic could be provided with lachrymal gutters, transverse folds and a ventilation aperture. He also recommended contact shells of his own manufacture suited to contain therapeutic agents, as illustrated in two patients treated for lime burns. The shells could be painted or colored. He then described the logical development, according to his idea, of spherical to parabolic shells, and from there to new lenticular contact glasses, from which the scleral portions had been removed. However, for these new lenticular contact glasses, he recommended a total diameter of 12 mm. (56)

2.3.2 - French-speaking Switzerland

This part of Switzerland apparently adopted plastic materials more rapidly than its German-speaking counterpart. Already, by 1947 and following a presentation by *Knüsel* and *René Dufour* (Lausanne) explained how he had prescribed contact lenses made from plastic at the Lausanne ophthalmological clinic and used ocular molding with Negocoll with a view to the manufacture of *Dudragne* trial contact lenses. In 1949, he delivered his first results after two years using *Dudragne* contact glasses in spite of setbacks. A local technician assisted with scleral adjustments. Of 32 patients remaining in the series, 19 wore their contact lenses on a regular basis and five others tolerated them for only one or two hours. *Dufour* was to report later the use of contact shells in a patient with neuroparalytic keratitis where the use of the contact lens allowed a tarsorrhaphy to be opened. In one patient with albinism, *Dudragne* manufactured contact glasses with an opaque scleral portion and a painted representation of the iris surrounding a pupillary orifice 4 to 5 mm in diameter. (57)
In the following year (1947), *Maurice Girardet* (Lausanne) reported how he prescribed contact shells made from synthetic resin with which he corrected several unilaterally aphakic patients over a two year period. In the course of the discussion, *John D. Blum* was of the opinion that the individual ocular molding method was superior to other procedures, *Ernst Bürki* adding theoretical optical considerations. *Dufour* also described his success with unilateral aphakic correction using *Dudragne* contact shells. (58)
In 1949, *John D. Blum* (Geneva) reported the results of his first fittings, particularly high myopias, keratoconus patients and aphakic patients. In the 38 patients who remained in the series and were fit with *Dudragne* contact glasses, 33 were wearing their contact lenses for an average of 9 hours per day. During the discussion, *J. I. Pascal* (New York) explained that the fit is the basic problem and that, in the USA, contact shells with toric haptic were then being prescribed. In 1952, *Blum* reported further fitting successes in 9 patients with unilateral aphakia, including three children. In this group, 7 achieved binocularity and wore their lenses more than 10 hours a day. (59)

2.4 - France

Following the report and publications by *Emile Haas* in 1937, French fitters remained loyal to glass contact shells. That remained the standard of care for about 10 years. After the war plastic materials became the norm and the engineer, *Raymond-André Dudragne*, tried to adapt these materials to the manufacture of contact glasses. He already held several patents dealing with their manufacture and fitting. One of these concerned radial slits that opened and shut alternately depending on eye movements. *Dudragne* had developed trial lenses that were quite similar to those of *Hamblin-Dallos* and used an aspheric haptic constructed in accordance with his collection of the most frequently used moldings. The complete set comprised 60 to 80 trial contact shells. The corneal portion continued through a gentle transition towards the scleral portion that it widely encroached on, in order to avoid pressure on the limbus. The scleral portions possessed curvatures, shapes and very varied diameters. In their trial box, the shells did not have any systematic classification into different scleral shapes, but were indexed by two numbers, which is off-putting for the new fitter. With experience, however, one rapidly acquires a knack for making the correct choice. Furthermore, the beginner is recommended to choose the best lens, not according to random tries, but by successive placement of a trial lens over a positive mold of the anterior segment of the globe. Following the example of *Dudragne*, other opticians also specialized in the manufacture and fitting of contact lenses: notably *Rose* in Paris, *Cavalieri* in Lyon and *Mossé* in Marseille. (60)

In Paris, *Onfray* and his collaborators presented two keratoconus cases and one high hypermetropia patient fit with *Dudragne* contact glasses. Next, *A. Magitot* presented a paper on fitting, either by trial technique or molding. He believed that contact lenses were well tolerated, above all in keratoconus patients. The '*Fick* phenomenon' (attributed by some to a lack of corneal aeration) was due rather to a fault in tear circulation or secretion. *Maurice Lenoir* gave a detailed description of ocular molding, which he judged to be essential for the majority of cases. He abandoned Negocoll, but favored Moldite for molding because it could be used at room temperature. He collaborated with *Rose*, an optician, who devised an imprinted 'gate' with pneumatic suction device which, by forcing in or out by suction, allowed an even distribution of the molding paste. *Lenoir* became the defender of plastic contact shells, which he recommended as favoring tear circulation through irrigation channels hollowed out on the posterior surface of the scleral portion of the lens, especially for use in aphakia. In 1952, *Jean Sexe* published a new assessment of the development of contact lenses in France. (61)
In Lyon, *Louis Paufique* and *George Bonamour* (1947) together with *Cavalieri* (optician) determined that it is easier to give a patient perfect visual acuity than to guarantee perfect toleration of the contact lenses. These authors recommended the replacement of cobalt blue illumination with a 'Wood's Light' from the so-called black high-pressure mercury-vapor lamp (Mazda MA 300). This emitted ultraviolet rays without danger to the eye. They described an examination technique by introducing a model to inform the manufacturer where adjustments were required. Next, *Jacques Rougier* presented several publications on the indications and the results described following 300 fittings and also documented the first corneal contact lenses available in France. Also, in Marseille, *Albert Ourgaud* used *Mossé* contact lenses to reduce a dislocating corneal transplant. It is to be noted that *Jean Cabarrouy*, a pioneer of contact lenses, spent some time in Argentina, and then, after 1950, published his discovery in France. (62)
In most cases, it was the physician who determined the indication for contact lenses and was viewed as responsible for monitoring their tolerance by the patient. If he wanted to participate in fitting contact lenses, he had two choices: he could either use the contact shells provided by the manufacturer or he could carry out ocular molding. The adjustments and the trials of the provisional shell were confided to the technician, the physician being satisfied with his appreciation of the final tolerance. It is apparent that this procedure limited fitting to major indications for contact lenses, essentially keratoconus and unilateral aphakia. Already, the foundations for a conflict to decide on the roles, responsibilities and obligations of the participants were being laid. This conflict was become greater in the future.

2.5 - Other European Countries

Everybody knows that Germany suffered major destruction from World War II. It had been divided into two economic zones and *Zeiss* had been dismantled as a company. It was essentially *Müller-Welt* (Stuttgart) and *Müller-Wiesbaden* as accessory, who had taken over the watch. This situation remained unchanged until 1950. Thus, when the first Congress of Ophthalmology was authorized in the Soviet zone, *Wolfgang Bassenge* stated: "*The corneo-sclera shells of Müller-Welt are considered to be the best at the present time. (...)*

Corneal metabolism is only assured when the liquid between the contact glass and the cornea does not stagnate; this continuous exchange of liquid is most advantageously produced when the space between the cornea and the lens is the smallest possible and when tiny movements of the glass favor the capillary attraction of the lachrymal liquid." (63)

During the period of German reconstruction, several authors reported the existence of contact shells and their use. Trials of grinding plastic contact shells for the correction of his own refractive error by *Heinrich Wöhlk* in Kiel were cited. In Berlin, *Marzok* and *Peter Abel* also tried grinding contact shells that included bifocals. In the literature, it was reported that the trials by *Zeiss* to use resins had not given the expected results. When they were launched onto the market in 1952, *Zeiss* proposed to provide these shells with three perforations, each of 1 mm in diameter and placed one mm from the limbus. Because of the economic situation, the principal indications for contact lens prescription were mainly limited to therapeutic: unilateral aphakia, keratoconus, and corneal affections. Also used were the specialized *Müller-Welt* contact shells for albinos, per-operatory corneal occlusion, and as part of a telescopic Galilean system in which a contact lens was associated with a spectacle lens. (64)
Heinrich Wöhlk was himself and engineer and a hyperope of 8 diopters. At the age of 23 years, *Heine* had fit him with *Zeiss* shells. These were too heavy to be worn with comfort. He was employed by the Kiel firm *Anschutz & Company*, who used Plexiglass for the manufacture of gyrocompasses. *Wöhlk* was allowed to appropriate samples of pmma for his own use for trials in the manufacture of contact shells. Thus he prepared and tried out various shell models, making use of molds in wood and plaster. Starting with wax, moldings from his own eyes, he would have succeeded in manufacturing and wearing a contact shell fit in the scleral portion, however deprived of the optic portion. After the war ended, *Wöhlk* restarted his experiments and, in 1947, with the agreement of Professor *Meesman* of the Kiel Ophthalmology Clinic, he took ocular moldings in wax, which he used to model the haptic portion of a series of annular scleral shells. *Wöhlk* attempted to provide these haptic portions with an interchangeable ground optic. However the junction proved delicate and poorly tolerated and could not be marketed. As his next approach, *Wöhlk* pursued his experiments on his own eyes and on those of his entourage, abandoning scleral fitting and using only the optical portion, thus shifting development in the direction of corneal lenses. (65)

After 1947, in the Netherlands, *A. Bakker* became interested in corneal respiration, and concluded: "*It could be determined that the so-called selective permeation of carbon dioxide through the cornea is not probable. Absence of oxygen in the surrounding atmosphere does not inhibit normal life of the cornea.*"

In the same year, *A.C. Copper* reported to the Netherlands Ophthalmological Society the case of a sailor afflicted by keratitis. The keratitis was due to his having worn plastic contact shells for 18 hours. During the discussion, *H. Fischer* reported experiments in which contact lenses made from plastic were implanted into the anterior chamber of rabbits' eyes demonstrating that, while plastics are toxic, glass is inert. (66)

In post-war Italy, the first publications were mostly devoted to historical memoirs and to the assessments of the evolution of contact lenses following the introduction of plastic materials. (67) Next *Mario Maione* and *Carlo Bottino* (Genoa) and others published clinical results of fittings in more difficult cases. *Strampelli* attached contact lenses to the rectus muscles in order to maintain and compress the cornea after lamellar and penetrating keratoplasty. (68)

In Greece, *J. Fronimopoulos*, who had used *Zeiss* contact glasses since 1937, noted that those of *Müller-Welt* allowed better tolerance and represented a significant advance, particularly in patients with keratoconus. In Czechoslovakia, *J. Teissler* recommenced his pre-war molding experiments using different celluloid and other plastic materials. *J. Vanysek* presented a plan for their dissemination. Similar presentations were also made in Poland by *Adam Klaczynski* who published a manual and manufactured, starting in 1948, contact shells and plastic contact lenses using a procedure of his own invention. In Russia, the publications of *D. Ishtvan* appeared, followed by those of *Sverdlov*, whilst *V. P. Pivorov* recommended the use of contact lenses while gas masks were being worn. (69)

3 - Pmma Contact Shells outside of the USA and Europe

3.1 - South America

In South America, Argentina had long been a leader in the field of glass contact shells and was quick to adopt the new 'made in America' plastic lenses. After 1945, *Baudrillo Courtis* (Buenos Aires) published with *Elola* and *Nunez* the first major Spanish language work dedicated exclusively to plastic contact lenses. The reception was very favorable: in the comments of *Bier*, the 26 chapters were 'tastefully produced with good photographs and some excellent colour drawings'. Under the initiative of *Courtis*, local production of contact lenses was successfully started. The *Courtis-Sais* set of trial lenses was relatively large, being inspired by those of *Obrig* and *Feinbloom*. They contained 30 contact shells of which the most commonly used ones were represented twice to allow binocular examinations.

Corneal radius	Scleral radius						
mm	11.50	11.70	12.00	12.20	12.50	12.70	13.00
8.00			1	1	2	1	2
7.50	1	1	2	2	2	1	1
7.00			2	1	2	1	1
6.50			1	1	2	1	1

Table 26-1
Courtis-Sais basic contact shell trial set.

One is reminded that *Eduardo Amoretti* (Cordoba) had submitted a contribution to the First National Contact Lens Meeting in Chicago. He continued with his publications and presentations on plastic contact lenses and molding methods. He was of the opinion that the advent of plastics was a major event equivalent to that of the replacement of Negocoll by Moldite. He obtained good results with spherical and toric contact lenses, but judged nevertheless that other investigations were still required in order to obtain the best results. Another Argentinean, *Enrique V. Bertotto* fit *Hamblin-Dallos* contact shells. He developed a method to replace molding using a stereographic study of the eye permitting him to calculate the curvatures of the anterior segment. (70)
The experiments of the above pioneers were repeated over many years in most countries of South America. The studies of *G. Iribas* included a detailed explanation of the mathematical data with advanced studies, and other in-depth studies were published by *Daniel Silva* (Mexico) The latter author described *Tuohy* contact glasses, but concluded that they could not be used in patients with very high refractive errors and in infections, where it was necessary to fit corneo-scleral lenses first. (71)

3.2 - Japan

According to Japanese Ophthalmology historian *Saïchi Mishima*, there was no local Japanese manufacturer or fitter at the era of the introduction of pmma. Towards 1943, the ophthalmologist *Yutaka Mizutani* (Nagoya) became interested in the clinical applications of contact lenses, but it was not until 1947 that he tried his experiments to manufacture contact lenses made from molded plastic based on an ocular impression. He thus fit a student affected by keratoconus and published encouraging results in March of the following year in three other patients. In May 1951, at the 21st Congress of the Kyushu Ophthalmological Society, Professor *Shigemi Tamura* presented his communication on contact lenses that he had manufactured himself. In the same year, *Matsiuo Kajiura* of Fukushima presented a communication on the present state of plastic contact lenses made. In 1952, Professor *Tsutomu Sato*, after a visit to *Mizutani*, charged *Hironubu Atsuzawa* with the manufacture of contact shells for his clinic of Juntendo University, where *Hisao Magatani* carried out the fittings of corneo-scleral shells after moldings. Although, during this era, there were no other manufacturers or fitters in Japan, those interested founded a study group, which met together at the time of the annual meeting of the Japanese Ophthalmological Society. After the trials of the corneal lenses by their pioneer, *Mizutani*, followed by their spectacular development under the influence of *Newton K. Wesley,* interest in corneo-scleral contact shells dropped significantly. (72)

3.3 - Australia and India

In Australia, *D. Williams* reported good results with new plastic contact lenses and *J. Hart* recommended the 'Tangent Cone Contact Lenses' of *Feinbloom*. In India, Major *M. M. A. Dubash* also published a very complete review of this topic. (73)

Conclusions

Between the years 1940 to 1950, the introduction of pmma caused the progressive abandonment of afocal corneo-scleral shells provided with a thick liquid precorneal film throughout the world. There were replaced by shells with a capillary precorneal space and ground anterior optic. The career of corneo-scleral contact shells continued thus up to the present era, benefiting from the advantages of gas permeable materials for the correction of patients with special problems, many of these having keratoconus. Scleral contact glasses with a thick layer of liquid between cornea and lens are, however, still used for some specific indications, e.g. for the maintenance of therapeutic agents in the precorneal space.

Notes in Chapter XXVI

1. Williamson-Noble and all. 1940.
2. Wingate G.H., 1937.
3. Bier N., 1945a.
4. Bier N., 1945b.
5. Bier N., 1947b.
6. Bier N., 1947a, 1947b.
7. Bier N., 1949b.
8. Bier N., 1950a.
9. Bier N., 1953b.
10. Duke-Elder S., 1953.
11. Bier N., 1957.
12. Dallos J., 1954.
13. Bier N., 1949a, 1954a, b, 1955, 1956a, b, c, 1967, 1969, 1970, 1979, 1982.
14. Cross A.G., 1949; Treissman H., Hirtenstein A., 1950; Choyce D.P., 1954; (See chapter 23, § 1.3: Dallos's Influence).
15. Dickinson F., 1945.
16. Clifford Hall K.G., 1946.
17. Dickinson F., Clifford Hall K.G., 1946.
18. Unfortunately, the following error occurs, repeated too often: “A Parisian optician Edouard Kalt ground a number of contact lenses.”
19. Dickinson F., 1953.
20. Ridley F., 1946.
21. Forknall A.J., 1946, 1947.
22. McKellen G.D., 1947, 1949.
23. Steele E., 1949, 1951.
24. Nissel G., 1939; Nissel G., Lambda W.P., 1945.
25. According to Bowden T.J., 2009, p 114.
26. Williamson-Noble F.A., 1944.
27. Ridley F., 1944 (Presentation at the meeting of the Royal Eye Hospital Society held January 14, 1944), 1946.
28. Treissman H., Plaice E.A., 1947.
29. Ridley F., 1948b.
30. Ridley F., 1949: Presentation at the 34th Annual Meeting, Oxford Ophthalmological Society Congress. 8-10th July 1948.
31. Ridley F., 1948a, 1956, 1958, 1961a, b, 1962, 1963a, b., 1964; Estevez J.M., Ridley F., 1966. (see chapter 28, § 2.1: The New Approach of Frederic Ridley)
32. R.A.F., 1943.
33. Dickinson F., Hall K.G., 1946. p. 14.
34. Briggs A.A., 1947.
35. Cross A.G., 1949.
36. Reiss J.L., 1946.
37. Sharp C.G.K., 1947; Bennet A.G., 1948.
38. Cross A.G., 1949; Choyce D.P., 1954.
39. Treissman H., 1949.

40. Györffy I.v., 1950.
41. Hirtenstein A., 1950; Irvine R., 1949; Sarwar M., 1954.
42. N.N., 1947; Benedict W.L., 1947.
43. Mann I., 1947.
44. Klein M., Saarkany J., 1938; Bakker A., 1947; Fischer F.P., 1931a, 1932.
45. Györffy I. v., 1940a, b, c, (see chapter 24, §3.4), 1941a, b, 1942a (presented at the Hungarian Ophthalmological Society May 28, 1941), 1942 b.
46. Györffy I. v., 1944a, b.
47. Györffy I v., 1948a, 1950, 1951a, 1955a, 1964a, b, 1972, 1980, 1982, 1984.
48. Györffy I.v., 1940a, b; Mihàlyhegyi G., 1940c (Hungarian Ophthalmological Society Oct. 7, 1939), 1940a, b, c, 1941a, b, c, d, e, f, 1942a, b.
49. Mihàlyhegyi G., 1947.
50. Mihàlyhegyi G., 1950, 1954.
51. Fritz A., Fritz R., 1945, 1946. (Presentation to the Belgian Society of Ophthalmology on 28th April 1946); Fischer F.P., 1930; Schepens C., 1946; Bonhomme F., 1946.
52. Fritz A., 1947a, b, c; Fritz A., Fritz R., 1948; Fritz A., 1949a, b, 1950a, b, 1951, 1962a, 1963a, b, 1966.
53. Brückner A., 1942.
54. Knüsel O., 1946, 1947, 1948, 1953a, b.
55. Bürki E., 1942, 1946, 1948a, 1949.
56. Strebel J., 1931, 1932, 1937, 1938, 1943, 1948a, b, c, 1949, 1950a, b, 1951.
57. Dufour R., 1947, 1949, 1952.
58. Girardet M., 1948. Followed by discussions of Blum J.D., Bürki E., Dufour R.
59. Blum J.D., 1949, 1952; Pascal J.I., 1949.
60. Haas E., 1937, 1938, 1948; Dudragne R.A., 1940, 1944a, b, c, 1946a, b, c, 1948, 1949a, b.
61. Onfray, Marmier, Dudragne R. A., 1945. (Presentation to the Paris Ophthalmological Society 20th January 1945); Magitot A., 1947; Lenoir M., Rose N., 1947; Lenoir M., 1947, 1948a, b, c, 1949, 1950; Sexe J., 1952.
62. Ourgaud A. G., 1949 (Presentation to the French Regional Society of Ophthalmology at Bordeaux in April 1949); Jayle G.R., Ourgaud A.G., 1953; Sedan J., Ourgaud A.C., Mossé P., 1956; Sedan J., 1957; Paufique L., Bonamour G., Cavalieri, 1947; Rougier J, 1954; Paufique M.L., Rougier J., 1954; Rougier L., Bongard, 1955; Cabarrouy J.E. 1951, 1952, 1980.
63. Bassenge W. I., 1948, 1949: " Die Korneal-Skleralschen MüllerWelt werden als die zur Zeit besten Haftgläser bezeichnet (...) Ein ungestörter Zellstoffswechsel der Hornhaut ist nur dann gewärleistet, wenn die Flüssigkeit zwischen den Haftglas und Hornhaut nicht stagniert, da sonst durch Anoxie und Kohlensäureüberladung Epitheltrübung und Epithelödem eintritt; dieser kontinuierliche Flüssigkeitersatz erfolgt dann am zuverlässigsten, wenn der Raum zwischen Hornhaut und Haftglas möglichst klein ist und wenn feine Bewegungen des Haftglases die Kapillarattraktion der Tränenflüssigkeit begunstigen."
64. Fuchs J., 1950; Gogler E., 1950; Sautter H., 1949a, b; Euler P., 1949; Streissle, 1949; Meesman, 1949; Noteboom, 1950; Obal, 1950; Starke, 1951; Wolffersborff H.v., 1952a, b; Schulte 1952a, b; Serr 1953; Schlosshardt H., 1952; Emmerich K., 1957.
65. Marketing by "Heinrich Wöhlk. Gewerbe zur Herstellung unsichtbarer Haftgläser" (Craft of Production of Invisible Contact Glasses) founded in April 1948.
66. Bakker A., 1947; Copper A.C., van Manen J.G., 1948; Copper A.C., 1948.
67. Pace C., 1947 ; Gabardi 1948 ; Maiore MM.,1949.
68. Pace C., 1947; Gabardi, 1948; Maiore M.M., 1949; Bottino C., 1950, 1952; Maione M., 1951a, b; Maggiore L., 1951; Strampelli, 1952a, b.
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71. Iribas G., 1947; Silva D., 1953.
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