CHAPTER XXV

Corneo-scleral Shells made from PMMA in the United States of America (1940-1950)

Introduction

After the first trials of plastic materials in America by pioneers *Feinbloom* and *Obrig*, [1] the majority of American manufacturers oriented themselves towards these products. However, they only published their results after they had obtained their patents. The competition thus created in the emerging market for contact shells made from pmma became quickly widespread, not only because of the availability of patents originating in Germany, but also because of new manufacturing methods: injection and polymerisation in the molds was added to molding and blowing; also grinding and polishing by lathe, plus combinations of these diverse techniques.

In order to make themselves known to prescribers as well as to the general public, manufacturers promoted their products by a campaign of demonstrations, using magazine articles as well as by publishing very detailed instruction manuals, such as those of *Feinbloom* and *Beacher*. In Minneapolis, *Anderson* complemented his manual with a movie. In California, *Greenspoon* made himself known by fitting Hollywood film stars with tinted contact shells, while *Braff* (Los Angeles) undertook an interesting analytical and scientific description of fitting, from the wearing of to complications resulting from contact shells.

In spite of all this and taking into account that the majority of contact shells used in America were of the 'fluid-lens' type, the wearing-time rarely exceeded 2 to 3 hours. It was often recommended only to wear one lens, alternatively in one eye then in the other in the course of the day. The fitters wondered about the origin of these intolerances and of the visual veil, which they generally attributed to modifications in the pH and osmotic pressure of the tears, caused by accumulation of CO2 emitted by the cornea. The recommended solution and that supported by the nascent pharmaceutical industry would likely be found in the use of appropriate solutions for contact shell insertion.

There were however certain pioneers who supported the concept that corneal anoxia would not be solely linked to the pH of the buffering solution, but could also be attributed to disturbances in tear exchange in the precorneal space.

The historian has several documents available that cover this period. These include treatises, manuals and journals of Optometry and Ophthalmology. For example, in 1941, Contact Lens Technique by *Lester Beacher*, [2] in 1942, Contact Lenses by *Theodor Obrig*, [3] and The Practice of Fitting Contact Lenses by *William M. Feinbloom* [4] and, in 1944, Technique of Fitting Contact Lenses by *Albert Lester Anderson* [5]. In 1944, the first congress dedicated exclusively to contact lenses was held in Chicago. The proceedings from this congress appeared one year later. [6]

We also have obtained a very interesting report published by *Norman Bier*, who had visited the main optometric offices that were fitting contact lenses. From his trip of exploration in 1947, he summarized the points that had impressed him most:

"*The speed at which everything was executed, including the dispensing of contact lenses, which was often achieved within a three-day service. (…) Several improvements which can be shown by American methods, to quote one example, for the insertion and removal of contact lenses. (…) The many examples of the unique characteristics of American design and characteristics and [the] advanced practical knowledge to further the wearing and comfort of contact lenses.*"[7]

This period closed with the introduction and marketing of contact lenses of corneal diameter from 1950. It provides us with the opportunity to take account of and evaluate the prospects for corneo-scleral contact shells.

1 - Contributions from Theodor Obrig and Associates

Introduction

It cannot be denied that *Theodor Ernst Obrig* was a pioneer of contact lenses in America. As an author of a work on modern procedures for making glasses and correcting refractive errors, he closely followed all of the innovations. In 1936, he had already visited *Dallos* in Budapest and had publicized Negocoll ocular molding in America, as well as visualization by fluorescein in cobalt blue light. He had collaborated with *Zeiss* in the development and use of glass contact shells with both ground optic and molded haptic, starting with moldings that he had undertaken. He had made it known that, contrary to current perceptions, the corneal diameter was oval in the majority of eyes, exceeding 12 mm: for good tolerance, corneo-scleral lenses had to take these findings into account. (8)
On the eve of World War II, *Obrig* broke his links with *Zeiss* and switched his attention to recently available transparent thermoplastic substances, particularly pmma. This seemed to him the most interesting of these substances. We described how it was when, in collaboration with *Mullen*, he had resolved most of the difficulties in the manufacture of corneo-scleral contact lenses made entirely from acrylics and how, in 1940, he started to market them in his facility that he established in New York City. (9)

Author	*Year*	*Suject*	*Remarks*
Obrig T.E	1935	Modern Ophthalmic Lenses and Optical Glass	First edition
Obrig T.E	1937	Fitting of Contact Lenses	Arch Ophthalmol.
Obrig T.E.	1938a	Molded Contact Lenses	Arch Ophthalmol
Obrig T.E.	1938b	A Cobalt Blue Filter	Arch Ophthalmol
Mullen J.E.	1939	Contact Lens and Method of Making the Same.	USP 2,237,744
Mullen J.E.	1940	Method of Making Contact Lenses	USP 2,230,837
Obrig T.E.	1942	Contact Lenses.	First edition
Obrig T.E.	1943	A new Ophthalmic Impression Material	Arch Ophthalmol
Salvatori & Oriani	1943	The Fitting of Contact lenses	Arch Ophthalmol
Obrig T.E.	1944	First National Contact Lens Conference	Chicago
Salvatori	1945	Proceedings of the Contact Lens Conference	New York
Oriani	1946	Plastics in the Manufacturer of Contact Lenses	Optical J R Optom
Obrig T.E.	1947a	Contact Lenses	Second edition
Obrig T.E.	1947b	Solutions Used with Contact Lenses	Arch Ophthalmol
Salvatori	1947	A Scientific Method of Fitting Contact Lenses	New York
Obrig T.E & Salvatori	1957	Contact Lenses.	Third edition

Table 25-1:
Chronology of the principal publications of Obrig and his close collaborators (1935-1957).

1.1. - Obrig's Manual 'Contact Lenses' (1942)

1.1.1 - The Manual

Obrig's fame was founded mainly on his publication, in 1942, of the first really complete and detailed manual 'Contact Lenses' dedicated to the manufacture and fitting of traditional corneo-scleral contact lenses and above all, those recent ones made entirely from plastic materials. (10)
Obrig's manual included detailed chapters on anatomy and ocular physiology, the underlying optical principles and the maneuvers associated with contact lenses, their indications and advantages. This applied particularly to keratoconus patients and those with high myopia. In the unanimous opinion, the history section is relatively one-sided, which can be explained by the lack of contact of the author with other regions of the world. *Obrig* provided numerous credits in that regard, whereas he devotes 18 pages to the history of his own invention without citing the European inventors. In later editions, these omissions were not corrected even after peace returned and the documents became available to him. (11)
The description of the technical aspects is of clarity without comparison in the epoch. In the full assurance of his collaboration and experiments with the *Zeiss Company*, then in conjunction with *John Mullen*, the

author developed a contact lens made from pmma. *Obrig* overcame the difficulty of fusing a glass corneal portion in a plastic scleral portion, like *Feinbloom*, by developing a technique for grinding the corneal portion out of the plastic material itself, which resulted in a one-piece wholly plastic lens.
Considerable space is devoted in the book to the description of the difficulties encountered in developing so-called 'molded plastic' lenses and the optical grind of the corneal part in the experimental laboratory that he had founded with *John Mullen* in Worcester, Massachusetts. Most of the early test lenses were supplied with too small a corneal area, which *Obrig* claimed should be elliptical in shape, not round as was originally assumed. By molding the scleral portion to fit the globe and allowing adequate clearance at the limbus, the usual difficulties are said to have been avoided. For these moldings, *Obrig* used the *Steven*'s technique with *Poller*'s hydrocolloid Negocoll. As local anesthetic, he preferred 0.5% pontocaine solution to cocaine solution, but he found that 2% pontocaine had unfavorable effects on the corneal epithelium. A positive mold in dental plaster is cast from the Negocoll negative and a semi-finished contact lens is made from them. The physical fit of the scleral part of the lens is monitored by means of direct observation using 1% fluorescein solution with a light passed through a cobalt-blue filter. The exact power is obtained by subjective refraction and is ground onto the corneal portion of the definitive lens. The means of making the contact glass conform to the mold, yet still include an optically ground corneal segment, is not divulged. *Obrig*, and others engaged in the manufacture of molded contact lenses, retained this detail as a trade secret. *Obrig* presented an excellent chapter on various contact lens solutions. He found no satisfactory or acceptable solutions in his search for an adequate buffer solution for the liquid lens because of its chemical composition, hydrogen ion concentration and osmotic pressure. The chief difficulties that were encountered concerned clouding and irritation after a few hours' wear and he concluded: "*considerable research needs to be done in order to overcome this problem*."

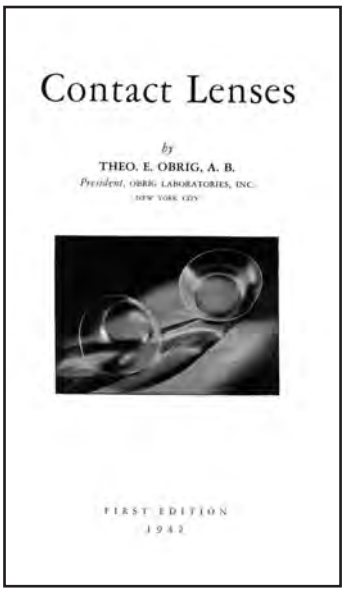


Figure 25-1
Obrig's manual 'Contact Lenses'. *Published in 1942, this work has 10 chapters and a total of 470 pages. It was the first in-depth treatise on contact lenses.*

Other commentators also describe this problem: thus, *Arthur B. Emmes* noted:

"*The chief difficulties that have been encountered concern clouding of the fluid and irritation after a few hours' wear. He reports the best results so far with the Feldman solution although considerably more research needs to be done to perfect this phase of the work. (...) Once the vexing problems of an adequate buffer solution are overcome, contact lenses of a molded plastic type will enjoy more widespread use*." [(12)]

The comments by *Harry S. Gradle* (ophthalmologist) also confirm these opinions:

"*The contact lens made entirely of plastic composition are more efficient even than glass and provides the patient with a feeling of relief in the knowledge that it is not breakable. (...) The type of contact lenses produced by Obrig leaves little to be desired in the physical fit of the lens, yet his experience, as that of others, has shown that too many patients respond poorly to the buffer solutions so far available*." [(13)]

In order to describe the merits of his own manufactured product, *Obrig* surveys in his manual the principle types of contact lenses available at this epoch [(14)]:
1/ Contact shells blown in glass of the type *Müller-Brothers* (Wiesbaden), often with an opaque scleral part and without an optical grind, are typical for the prosthesis glass blowers (foreign and American) during this epoch.
2/ Traditional *Zeiss* glass ground contact shells with spherical geometry, a standard overall diameter of 20 mm and a corneal diameter of 12 mm, from which comfort is rarely achieved.
3/ Contact shells of *Müller-Welt* (Stuttgart) type, of which the scleral part is blown in an aspheric toric mold. The corneal optical portion is ground and polished so that only a capillary tear layer separates it from corneal tissue.
4/ The various models of *Feinbloom*, some combined with plastic haptic and a removable glass corneal part, others imitating the principle of *Müller-Welt* contact shells, for which *Obrig* did not foresee any future.
5/ *Dallos* contact shells in glass, difficult to manufacture and heavy to wear.
6/ Finally others: glass *Zeiss* lenses with molded haptic and those of *Kollmorgen*, which were only pale imitations of the *Zeiss* and *Müller-Welt* contact shells.

1.1.2 - The Obrig 'All-Plastic Molded' Contact Lens

For *Obrig*, the all-plastic contact shells with molded scleral part and ground cornea of his own manufacture, have reached an almost perfect stage of development: (15)
- Their haptic portion conformed to ocular molding and the cornea is ground and polished according to the prescription.
- Their total diameter was ovoid, rounded nasally, thinned temporally, but could be executed in all possible dimensions, that of 23 mm x 25 mm being the most often used.
- Pmma is an excellent material: it is light, transparent and easy to grind. A prism or a cylinder of up to two diopters could be incorporated into it. Its corneal or scleral portion could be rendered colored or opaque.
The 'Obrig All-plastic Molded Contact Lenses' could be worn from 4 to 10 hours a day, but there existed considerable individual variability of the duration of wear of this lens that was impossible to predict.

1.1.3 - Obrig Technique for making Casts of the living Human Eye

A very long chapter, richly illustrated, is dedicated to the description of the ocular molding procedure with Negocoll following the procedures he had seen in 1936 at the time of his visit to *Dallos* in Budapest. He had tried this molding procedure on his return home, then modified and adapted it with the help of ophthalmologist *D.B Kirby*. At the present time, he had abandoned the taking of an implant using blown glass contact shells and was using instead, hollow-handled casting shells that were better suited to these procedures, following experiments he had done with ophthalmologist *Harry Eggers*. (16)
Then the manual described at great length the use and the special maneuvers required for taking the mold and the preparation of the dental stone cast. *Obrig* did not miss an opportunity to render homage to *Dallos*, whose work he greatly admired:

"*The original work of Dallos was the discovering and proving the use of Negocoll as a practical satisfactory medium for making accurate casts of the living human eye. He has done more than anyone else to make modern contact lenses a reality.*"

Then, *Obrig* also described the alternative molding techniques used by other fitters in 1942:

1/ The moldings of *Prister*: Dr. *Bruno Prister* of Trieste, Italy suggested the possibility of taking a mold of the anterior segment of the living human eye with dental wax in 1933.
He devised an instrument to carry a thin oval domed plate of dental wax. The eye is prepared by instillations of a local anesthetic to produce conjunctival and corneal anesthesia. Both lids are retracted and the oval wax plate is slipped under them and pressed gently on the globe. The wax is kept soft and molded to the surface by means of pads of cotton wool dipped into hot water and applied directly to the eye. When it is considered that a satisfactory and useful impression has been obtained, the wax is hardened by the application of cold swabs. The carrier and the wax mold are then carefully removed from the eye. From the negative thus obtained, a model of the mold is cast in plaster.

2/ The *Stevens* procedure of corneal moldings was not suited to the manufacture of corneo-scleral contact shells: "*While a most satisfactory casting of the cornea is obtained by this method, too little scleral tissue is molded to be of use for contact lenses. The speculum limits the size of the casting tube which can be used*."

3/ The moldings according to *Feinbloom*, who, since 1936 tried various diverse techniques, notably Negocoll and Dentocoll, but he preferred wax for making molds of the eye. *Obrig* made three criticisms of these methods: "*First, no detail of the size or form of the cornea is obtained. Second, no detail of the scleral surface is obtained, at best only an approximation of the actual surface is possible. Third, there is too much chance for a distortion of the molding during its removal from the eye and before it is actually cast*."

In subsequent editions of his manual he added that these failures are explained because *Feinbloom* wanted to give up anesthetic eye drops requiring the presence of a physician: "*However, without question, drugs must be used which necessitate that the work be done under the supervision of a physician*." (17)

4/ Moldings with Modeloid of *Leopold Dreifuss*, "*in which he uses a molding material of his own manufacture similar in many ways to Negocoll*."

1.1.4 - Fitting of 'All-Plastic Molded' Contact Lenses

In the following chapter, *Obrig* describes, in 60 pages, the procedure for fitting of the 'All-Plastic Molded Obrig Contact Lenses' in six sections: optical, physical, semi-finished, psychological, chemical and the finished fit. This part is very richly illustrated. *Obrig* describes the modifications in the pressure zones that have been diagnosed by means of 1% fluorescein solution under cobalt-blue illumination: "*The tight areas are relieved by grinding them down with a grit-impregnated point such as dentists use for touching up dentures*."
It is also possible to retouch the side of the contact shells by softening the plastic with a heated spatula. The corneal fit consists of eliminating all contact between the contact glass and the cornea by follow-up examination in all movements of the globe. *Obrig* gives great importance to 'psychological fit' for "*the conscious mind desires to learn, but subconsciously the patient is afraid of the lenses*"

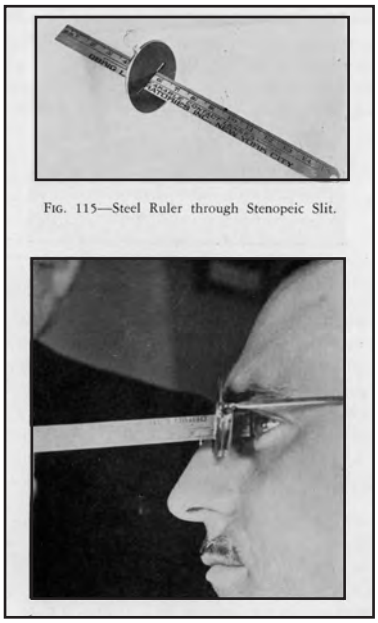


FIG. 115—Steel Ruler through Stenopeic Slit.

Figure 25-2
Measurement of vertex distance.
Measuring the vertex distance with a steel ruler through a stenopeic slit in the trial frame until it touches the contact lens. (Obrig 1942)

1.1.5 - Solutions used for the Liquid Lens

For *Obrig*, the correct choice of an adequate solution for contact lenses is the most critical part of the fitting procedure:

"*A number of difficulties, due entirely to the liquid lens, rapidly became apparent to anyone fitting contact lenses. (...) We have three variable factors, which can be controlled: the chemical composition, the pH and the osmotic pressure. (…)*
"In 1937, J.B. Feldman suggested the use of buffer solutions. During the last ten years a great many different solutions have been tried. (...) No one solution has been proved wholly successful in all cases."

Obrig listed 24 varieties of solution and products that he had tried out and cited those authors that had done the same. He found 14 causes of possible intolerance. To conclude:

"*It is possible and probable that the determining factor in the control of the clouding of the corneal epithelium is still to be discovered*."

Finally, he proposed to match the pH of the solutions to that of the tears and to vary it based on the observations of the patient. In order to increase the duration of the wearing time, he recommends:

"*If clouding takes place after the patient has worn his contact lenses for two to four hours, he should be advised to change the solution in his lenses about one half-hour before the clouding usually takes place. This most often results in another period of clear vision for two or three additional hours*"

1.1.6 - Contact Lens Patents and Bibliography

Finally, *Obrig* reproduced a selection of 20 patents published between 1903 and 1941 and presented a bibliography of 150 references.
The reception of *Obrig*'s work was very favorable. Commentators were in agreement in their recognition that this was the most complete work available and one that exposed the new techniques in the minutest detail and also showed the difficulties encountered. In certain aspects, however, comments from the medical profession were more nuanced:

"*The author loses no opportunity to commercialize on his own product, and describes the technique of modifying the trial lens on the patient. However, most oculists, familiar with the technical difficulties of modifying a contact glass, will agree that this is best done by the optician, under his direct supervision, and thus avoid a mail-order type of fitting as the author describes*." [18]

1.2 – Obrig's 'Moldite' molding Powder (1943)

In 1942, in the first edition of his manual, *Obrig* described in detail ocular molding with *Poller*'s Negocoll, in spite of the fact that he was already engaged in researches on other products intended for ocular molding. In 1943, he published one part of these trials using Moldite of his own manufacture. [19] He described this as "*an alginate gelling agent that reacts when mixed with distilled water*". This new product, specifically developed for ocular molding, represents, according to the author, an important step in the development of contact lenses. It is pointless to describe the inconveniences of Negocoll that had to be boiled for close to an hour before being brought down to human body temperature. During the whole of this time it has to be continuously worked with a spatula in order to be usable. In addition, it caused irritations. The researches of *Obrig* and Mrs *Gertrud Salvatori* and a team of chemists end after several years and numerous experiments in a suitable formula of alginate that, according to the author, was observed and studied under medical supervision in 500 patients before being placed on the market. Moldite is jellified when it is mixed with distilled water and worked with a spatula, at the same time leaving enough time for it to be placed in the eye with the molding shell. The use of warmer water accelerates jellification, while colder water slows the process. At ordinary temperatures Moldite remains liquid for 4 minutes, which is the time required to fill the casting shell and to put it in the correct position in the eye. At eye temperature, rapid and complete jellification is produced in 30 seconds. It should be noted that the article spells out the following comment in a footnote "*This is a product of secret composition; according to the author, the manufacturer refuses to provide the formula for it.*"

Obrig has also developed new molding shells more suited to the use of Moldite. They are made entirely of plastic, their cups have a total diameter between 24 and 27 mm, a depth of 19 mm and the shell is pierced with multiple perforations of 1 mm in diameter. A hollow handle is fixed at the center of the outer surface: this handle is 25 mm in length. The fact that the handle is hollow, with perforations in the shell, allows the removal of excess product. There are two marks on the nasal side: red for the right eye, green for the left eye, serving as reference points.

Even with this modified and simplified molding technique, *Obrig* recommended the presence of a medically qualified practitioner, especially for the four instillations of 0.5% pontocaine anesthesia and for removal of excess product. After its removal from the eye, the negative molding is filled with a fixing solution, then 'Castite' (hard dental stone) that hardens quickly and can be put to use after an hour.

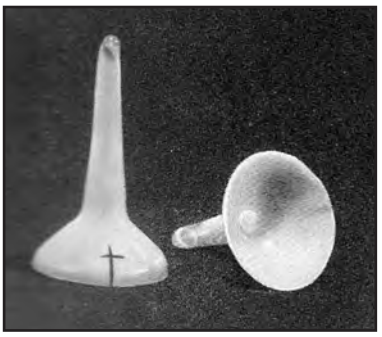
1.3 - The 'Science of Fitting' by Salvatori and Oriani (1943)

In the same year (1943), two *Obrig* collaborators, *Philip L. Salvatori* and *Americano Oriani*, published an article on the 'Scientific Method of Fitting Contact Lenses' in the Archives of Ophthalmology: "*Simple rules have been formulated which may be applied in every case. They eliminate guesswork and give complete assurance and confidence that the lenses will be fitted correctly and skillfully according to plan*." [20]

After having analyzed with *Obrig* nearly a thousand ocular moldings, the authors describe five stages and four rules of adaptation and draw the following conclusions from these:
1/ First of all, they confirm what *Obrig* had described in 1938, namely that the cornea is usually oval and that its diameter exceeds the traditionally believed 12 mm most of the time. Only 5% of eyes have this low diameter, whilst 38% attain or exceed 14 mm. The authors deduce from these findings that, in order to avoid the limbic irritation and maintain a large precorneal space, the diameter of the optic zone of the corneal shell must exceed by 1 mm the actual corneal diameter.
2/ The authors describe at length the procedure for examination with fluorescein. Using the fittings thousands of contact lenses as a basis, they developed a 'Science' of five steps and four rules for adapting these devices by retouching after eye examination. In the future, contact lenses must be comfortable to wear thanks to precise and controlled fitting. The haptic portion must provide good contact, without crushing or whitening of the conjunctiva, which demands a delicate balance between tightness and looseness. Using fluorescein, the practitioner has to verify the absence of contact with the cornea and be certain that the diameter is a hardly larger (1 mm at most) than the corneal diameter, but neither more nor less.
3/ The authors describe simple retouching of the haptic part. Their 'Science of Fitting' envisages the elimination by small retouches of both bubbles and froth and the opportunity to tighten a loose periphery with

heated spatula.
Numerous varieties of casting shell are noted: they should not be too large, or compress the tissues and should possess a flat hollow handle and multiple perforations in the shell, to allow the excess material to escape. It is sometimes advantageous to decenter the handle towards the temporal side.
Now that the topography and dimension of the cornea are known, the question of the size of the precorneal space remains, maybe even a discrete contact between the cornea and the lens. In actual fact, "*Some German authors claim that the lens should have some sort of contact with the cornea. In the US and for Obrig the lens should not touch any part of the cornea*." The lenses should be able to follow the ocular movements and not slide on the cornea.

Figure 25-3
Obrig's molding shell.



Upper figure:
Obrig's early round glass casting shells. This first glass casting shells with a handle were made 22 mm round.
(Obrig 1942)

Middle figure:
Obrig's early plastic molding shells, 24x27 mm in size. The handle is 25 mm long.
(Obrig 1942)

Lower figure:
In the new plastic casting shells the wall is pierced with multiple perforations about 1 mm in diameter. *These perforations, in conjunction with the hollow handle, allow the excess Moldite gel to escape.*
(Obrig T.E., Salvatori P.L., 1957)

Figure 25-4
Obrig's equipment for making molds of the eye with ophthalmic impression material.

Upper figure:
Early procedure with Negocoll (Stevens technique). *One can see distilled water, rubber bowl, spatulas, casting shells, fixing solution and the dental stone Castite*.
(Obrig 1942)

Lower figure:
Newer simplified procedure showing Obrig's molding powder 'Moldite' and the new casting shells. *One can see: anesthetic, Adrenaline, ophthalmic Moldite powder, distilled water, 10cc. graduated cylinder , 10 cc. wide mouthed graduated cylinder, stainless steel spatula, two small rubber plaster bowls, molding shells, muscle hook, gauze pads, Castite, irrigation bottle and syringe for washing eye.*
(Obrig T.E., Salvatori P.L., 1957)

1.4 – The First National Contact Lens Conference (1944)

In October 1944 *Obrig* and his associates *Philip L Salvatori* and *Americano Oriani*, plus their technicians, organized in Chicago the 'First National Contact Lens Conference'. [(21)] Attendees included a selection of physicians, optometrists, pharmacists and manufacturer, all of them more or less connected with the organizers.

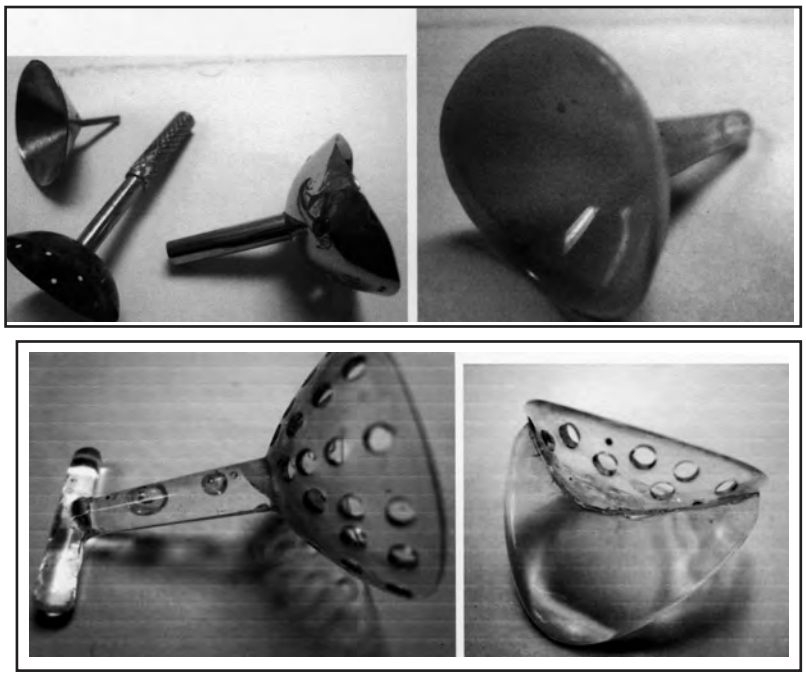


Figure 25-5
Development of molding shells.

Upper Row:
First models of casting shells made from glass and Bakelite respectively.

Lower Row:
Molding shells made from pmma with T-handle and flat-handle. (Private collection)

There followed exciting and impassioned discussions on the causes of intolerance. The participants were emphatic that, because of the intimate contact of the haptic with the conjunctiva and absence of corneal contact, the geometry and the nature of contact lenses could not be the cause. On the other hand, the intolerance was linked to the buffer solution of which pH, osmotic pressure and isotonicity were not compatible.
After introduction by Chairman *Obrig*, *Philip L Salvatori* Vice President of *Obrig Laboratories* listed the purpose of the meeting. This was to take account of the present state of contact lenses and establish a code of ethics for fitters. He promoted their education and certification by academic licensing bodies. *Salvatori* attributed the reservations in regard to the more widespread use of contact lenses to the lack of recognized education for fitters and technicians. He was critical of pseudo-education and certification after a one-day course lasting eight hours and administered by certain manufacturers and strongly recommended real educational training that must not be less than three months and which must be substantiated by a recognized diploma. He recalled that, according to American legislation, the presence of a physician remains indispensable for anesthesia and ocular molding, which seemed to curtail certain practices. (22)
Hugh L Hunter, president of *Belgard Spiro Company* of Chicago, who selected candidates suitable for fitting with contact lenses based on medical indications, illustrates this opinion. Such selection should be in the medical domain and is only acquired after long practical experience. (23)
During an interlude, *Albert L Anderson*, co-owner of Precision Contacts of Minneapolis, presented a movie illustrating the technique of molding an eye and fitting a contact lens. Like other manufacturers he had developed new molding shells, his own being provided with flat handles. (24)
The following speaker, *Alan Rosby* (ophthalmologist) presented his results from thousands of moldings, fittings and control examinations in which he had taken part with *Obrig*, and his associates and technicians. (25)
The following two contributions concerned contact lens solutions. These were the communication of *Robert J. Roth*, representing American Optical Company on physical and physiological chemistry and that of *Harry Hind*, a San Francisco pharmacist and specialist in ophthalmic solutions, on development of contact lens solutions.
Roth summarized the state of knowledge on the chemical and physical changes in tears at the time of wearing contact lenses and on-going research for a contact lens solution that would allow better tolerance. (26)
In the reading of his manuscript (because he could not attend this meeting personally), pharmacist *Harry Hind* compared the effect of saline solutions on the pH and the osmotic pressure of the tears. He compared eight buffer solutions recommended during the last years. He concluded that 'buffer solutions', especially alkaline buffer solutions, are to be preferred but he also admitted that the relationship between the pH of the tears and the intolerance to contact lenses remained unproven. The 'fogging' could be due to mechanical pressure in certain cases and to the secretion of tears, as well as their acidification due to accumulation of carbon dioxide.
These presentations raised numerous questions from the attendees of whom the majority remained convinced that acidification of the tears and 'fogging' could be eliminated by adequate contact lens solutions. (27) Thus chairman *Obrig* concluded that 98% of the intolerances are due, not to a poorly fitted and imperfect contact

shell, but to an unsatisfactory contact lens solution and that the chemists have yet to find the ideal contact lens solution. *Salvatori* and *Oriani* made the next presentations, but there was less discussion following these because they described the techniques of fitting and the recent innovations of *Obrig Laboratories*. The 'Science of fitting' would have reached a stage of quasi-perfection and would have found answers to the questions of how to eliminate air bubbles, to the problems of tightening of the contact shell edge and how to fit other difficult cases, e.g. aphakia, astigmatism, nystagmus, binocular vision. Then, a communication entitled 'Contact Lenses in Argentina' was read on behalf of the Argentinian ophthalmologist *Eduardo Amoretti*. (*Amoretti* himself did not attend the meeting) [28] *William Sneider* (St Louis, Missouri) pleaded for the need of unity among contact lens specialists in regard to the uniform handling of patients and a code of ethics between contact lens specialists and the ophthalmic profession. [29] At the end of the meeting, the participants elected a committee for the study and promotion of contact lenses.
One gathers from this meeting that, in 1944, the majority of fitters in America were convinced that intolerance was linked in almost all cases to 'buffer solutions' that were unsuitable and not to fitting problems. The fitting technique was considered perfect and the only recourse in the face of intolerance was therefore to be found in contact lens solutions. This was in spite of their disadvantages including the risk of contamination and the high cost of manufacture. *A.L. Anderson* (Minneapolis, Minnesota) describes:

"*I have frequently checked patients with perfect fitting lenses who could only get along but for a short period with one solution and have had them markedly increase their wearing time by prescription of another one.*" [30]

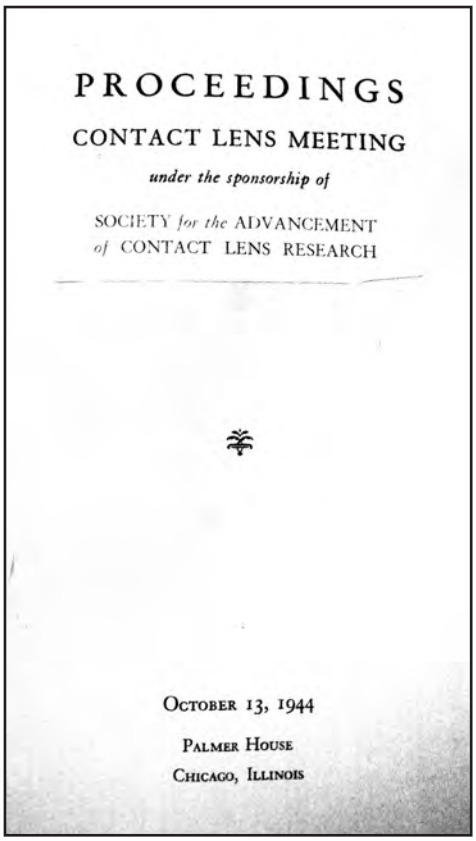

PROCEEDINGS
CONTACT LENS MEETING
under the sponsorship of
SOCIETY *for the* ADVANCEMENT
of CONTACT LENS RESEARCH
OCTOBER 13, 1944
PALMER HOUSE
CHICAGO, ILLINOIS

Figure 25-6
Front page of the Proceedings of the Chicago Contact Lens Meeting in 1944. *The Proceedings of the Contact Lens Meeting held in Chicago in 1944 were collected into a booklet of 54 pages in length, which was published by Obrig Laboratories. During this meeting, the participants decided to create a contact lens society.*

1.5 - The Impasse of Contact Lens Solutions (1947)

In 1946, *Oriani* published a technical article on the employment of plastic materials for the manufacture of contact lenses and, in 1947, *Obrig* published the second edition of his work 'Contact Lenses' enlarged by 76 pages dedicated essentially to the new techniques of molding and fitting. [31] He admits, however, that in spite of all the advances and the introduction of the limbic clearance on an enlarged corneal part, there persisted a limitation of the wearing time for which a cause could not be found, nor could this limitation be remedied. Clouding of the corneal epithelium occurred inexorably after several hours of wearing contact lenses.
Parallel to this, *Salvatori* published a manual called 'A Scientific Method of Fitting Contact Lenses' which received a less spectacular success, but allowed its author to assert himself relative to his associate. [32]

During the same year and in an article published in the Archives of Ophthalmology, *Obrig* reported that he had carried out experiments and measurements on his own eyes in his search to obtain more information concerning the causes and prevention of clouding of the corneal epithelium by means of solutions used with contact lenses. [33] He passed on the opinion of the manufacturers as a whole, who were convinced that their contact lenses were so perfect that they could not be causally implicated. He attributed clouding to the "*effects of carbon dioxide which passes through the cornea from the anterior chamber outward at the recorded rate of 0.05 cc. per hour and accumulates in the solution used with the contact lens and is responsible for, or is a contributory factor to, the clouding of the corneal epithelium*."

But the current opinion was following a false track in researching the buffer solution that would eliminate the acidification of the pre-corneal space. *Obrig* concluded: "*The addition of carbon dioxide or oxygen to the*

solution did not affect the time in which corneal clouding occurs; the osmotic pressure in solutions for use with contact lenses is important; the addition of amino acids or of methyl cellulose to solutions increases the time before clouding occurs."

At the time of his trip to America in 1947, *Norman Bier* visited *Obrig* and commented:

"*T.E. Obrig, of course, needs no introduction in this country since his textbook is well known to all who interest themselves in the field of contact lenses. He fits only the moulded plastic type of lenses, cleaning the limbal area fully and at all points and positions, although he likes to fit as near to the limbal sulcus as is possible. Both Messrs. Obrig and Oriani carry out constant research work in the contact lens field and at the moment are engaged in research on contact lens solutions*." (34)

Bier also visited the 'Obrig School for Contact Lens Technicians': "*I visited the Obrig School For Contact Lens Technicians where courses are conducted in the prescribing and fitting of contact lenses. Use is made of color films on contact lenses which give excellent instructions to the layman and practitioner students on the courses*."

Salvatori explained to him his most recent research on the molding technique:
"*Mr Salvatori explained the latest moulding technique to me. As is well known here, the present moulding methods are quite satisfactory in the hands of the experienced practitioner, but this new method by which the moulding material is injected through the handle of the shell by a syringe gives a resultant mould free of wrinkles and is most helpful to the newcomer. Obrig Laboratories are also experimenting on a new flexible scleral rim, which is so soft that when the corresponding haptic is produced from the mould, it takes up the correct contour without further modifications, as is so often necessary with present moulded lenses. A new moulding shell has also been produced which is suitable for ordinary methods of moulding as well as for the injection moulding method*."

1.6 - The 'Solutionless Lacrilens' Contact Lens (Salvatori)

In 1957, some five years later, *Obrig* shared the 3rd edition of his republished manual with *Philip L. Salvatori*. Previously, in 1951, *Salvatori* had presented his corneo-scleral shells, called 'Solutionless Lacrilens'. He will also guarantee the publication of this chapter of the manual, just as *Obrig* describes in the preface "*With his vast experience (...) in the fitting of the Lacrilens, a new chapter has been added covering this subject*."
The 'Lacrilens' is a lens which needs no solution other than the wearer's own tears. It is designed with a 4 mm 'lacrimal opening' and a 'channel' extending from the inferior edge to about 3 mm beyond the transition zone. The lenses are delivered without lachrymal opening nor channel. The fitter determined the position of these and, either places them himself, or he returns the lenses to the manufacturer for these added features.

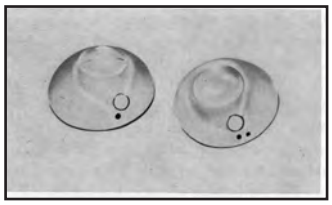


Figure 25-7
The 'Solutionless Lacrilens'.
Obrig's 'Lacrilens' is designed with a minimum of corneal clearance. The lens is made without a lachrymal opening or channel. The contact lens fitter must execute these features and other adjustments.
(Obrig T.E., Salvatori P.L., 1957)

Figure 25-8
Tools used in fitting the 'Solutionless Lacrilens'.
The lachrymal openings are drilled thought the lens with a dental burr. The position of the hole should be in line with the vertical center of the corneal potion. The channels are ground from the bottom of the lachrymal vent upward and flaring outward across the entire lower corneal junction. The broad junction along the lower corneal limbus must be carefully blended. If the situation demands, the lens must be reduced in size. (Obrig T.E., Salvatori P.L., 1957)

In spite of the fact that the 1957 edition was filled with the latest innovations in the contact lens field, there are some reservations in the critiques, such as in this book review, in which the following comments occur:

"*The early 170 pages of the book are copied slavishly from the 1942 edition; it is unbalanced, often misleading, and much is inevitably out of date. (...) The heart of the book lies between pages 175 and 400, (...) presenting the detailed work of fitting and moulding, the optics of the problem and the approach to the patient. Beyond this are not less than 305 pages devoted to a detailed reprint in English of perhaps all the contact lens patents that have been registered. The author suggests that the printing of this vast amount of material will enable the reader to trace the development of contact lenses from the beginning to the present time. (...) The bibliography of 28 pages of small print is exhaustive*." [35]

In 1952, *Obrig* retired from the NYC business, entrusting this to *Salvatori*. He was content to take charge of the branch in Sarasota. [36]

2 – The Contributions of William Feinbloom (1940-1950)

Introduction

The optometrist *William M. Feinbloom* is an almost mythical personage and, in any event, an integral part of the era of the pioneers of American contact lenses. He is the first optometrist to have become interested in contact lenses, as evidenced by his presentation of a report in 1930 to the American Academy of Optometry regarding the contact shells of *Zeiss*. [37] In 1932, he published a remarkable clarification of this report. [38] He is credited along with *Kohler* & *Danz* as being the first American manufacturer of contact lenses. For some time, he was fitting glass contact shells with spherical haptics, but, noting the inadequacy of their scleral part, he abandoned them in 1936 in favor of molded haptics from plastic material. It was then that he observed that a contact shell that fitted like a glove, with a haptic conforming to the mold was poorly tolerated, taking into consideration that such a shell is only a first approximation and that the pressures exerted by it have to be removed by painstaking retouching.
Feinbloom had anticipated the development of plastic materials, as had numerous forerunners, but suffered many disappointments. However, this did not stop him from pursuing his researches, often in an unfavorable commercial environment. We have described the circumstances in which he produced and sold combined contact lenses, with corneas made from glass and with a haptic made from molded plastic. [39] He pioneered various moldings with different alginates and, above all, with dental wax without anesthesia, that he carried out in his office at 138 East 36th Street, New York. By the same token, *Feinbloom* is also among the first to have conceived the idea of bifocal and multifocal contact lenses and to have used a telescopic system. [40]
After these pioneering and innovative activities as well as his involvement with his combined glass-bakelite contact shells, *Feinbloom* reserved these progressively, starting in 1940, to cases requiring a molding, then abandoned them totally in 1945 in favor of contact shells made entirely from pmma. Initially designated by '*Feinbloom Plastic Contact Lenses*' then, in the course of their development by '*Feincone Contact Lens*' and finally by '*Tangent Cone Contact Lens*' and '*Self-centring Contact Lenses*' these lenses experienced great commercial success.

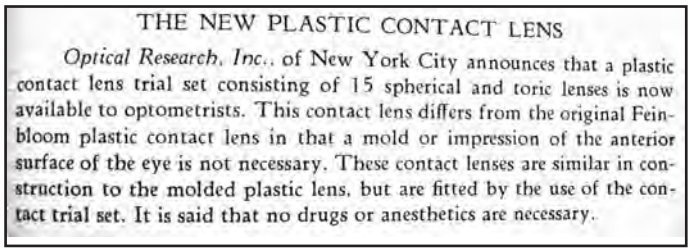
US Patent #	Filled	Title	Patented
2,129,304	June 4, 1936	Contact lens	Sept. 9, 1938
2,129,305	Aug. 21, 1936	Contact lens	Sept. 9, 1938
2,178,873	June 26, 1936	Method (...) of making contact lenses	Nov.7, 1939
2,196,066	March 2, 1938	Contact lens	Apr. 4, 1940
2,198,868	June 30, 1937	Contact lens	Apr. 30, 1940
2,477,689	March 4, 1946	Plastic contact lens forming plier	Aug. 2, 1949
2,438,743	Dec. 15, 1945	Tangent cone contact lens	March 30, 1948

Table 25-2
Principal patents registered by William Feinbloom concerning corneo-scleral contact lenses.

2.1 – The Feinbloom Plastic Contact Lenses

In 1940, "*Optical Research Inc. of NYC makers of the Feinbloom Plastic Contact Lenses announces that a plastic contact lens trial set consisting of 15 spherical and toric lenses is now available to optometrists*."
According to the author, these contact lenses do not require any ocular molding. They are similar to molded contact shells, but are fit with a trial set, without medications or anesthetic.
These new contact lenses are characterized by a spherical optic, a haptic cone-shape in section and a flange or radius section on the temporal side. They possess three variables: the angle of the cone of 42, 46 or 49 degrees, the scleral radius of curvature of 12 to 14.8 mm in steps of 0.2 mm and the radius of curvature of the temporal flange of 20, 26, 32 and 36 mm.
According to *Feinbloom*, their size allows fitting without the use of anesthetic.
The reception of these lenses by ophthalmologists was quite reserved, as *Harry S. Gradle* described it in 1942:

"*Oculists have not subscribed to this type of lens since it cannot compare favorably with the more accurate method of fabricating a lens to a mold of the eye.*" (41)



THE NEW PLASTIC CONTACT LENS

Optical Research, Inc., of New York City announces that a plastic contact lens trial set consisting of 15 spherical and toric lenses is now available to optometrists. This contact lens differs from the original Feinbloom plastic contact lens in that a mold or impression of the anterior surface of the eye is not necessary. These contact lenses are similar in construction to the molded plastic lens, but are fitted by the use of the contact trial set. It is said that no drugs or anesthetics are necessary.

Figure 25-9
Editorial on 'The New Plastic Contact Lens'.
For the new Feinbloom plastic contact lens a mold or impression of the anterior surface of the eye is not necessary. These contact lenses require neither molding nor anesthesia, but are fitted by the use of a trial set. (Editorial, 1939)

Figure 25-10
Advertising for Feinbloom's Plastic Contact Lenses (1939)
Beginning in 1939, Optical Research Inc., (Director: William Feinbloom) undertook an advertising campaign in journals intended to be read by optometrists.

2.2 – Absence of Drugs in Fitting Contact Lenses

The allusion to the fitting of contact lenses without the use of anesthetic agents or drugs will meet with an extremely interested reverberation as far as optometrists are concerned. According to *Feinbloom* the discomfort and irritation at the time of the fittings are due to the fact that the classical shells, of which the total diameter is roughly 20 mm, cannot be inserted without touching the cornea:
"*However, no anesthetic is necessary. The modern lenses are considerably larger than the older types, measuring from 23 to 25 mm. (...) The larger size of the newer style lenses makes it possible to insert them without touching the cornea at all. When the lens is inserted, the initial contact is with the portion of the sclera some distance above the cornea and no discomfort is experienced by the patient.*" (42)

Aside from the above, the new contact lenses with toric haptics and large diameters developed by *Feinbloom* suit the majority of eyes and are problem-free; these same eyes previously required molding. This is no longer necessary and fitting can occur without anesthesia: "*The use of the toric series of plastic contact lenses completely eliminates the necessity of anesthesia during the fitting process. No mold of the eye is needed and consequently no anesthesia to permit the taking of a mold.*"

On the other hand, neither saline solution nor fluoresceins are drugs: "*Neither the saline solution or the*

fluorescein is used for other than optical or mechanical reasons. They should not, therefore, be confused with any drugs used for anesthetic or therapeutic purposes. The modern type of contact lens can be prescribed and fitted without the use of any drug whatsoever."

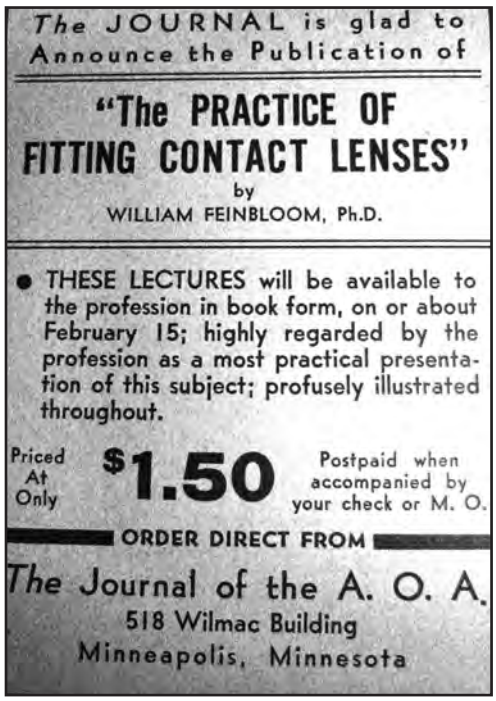
The proposition of *Feinbloom* of fitting without the use of anesthetic eye drops or other therapeutic products was most significant from the viewpoint of the optometrists. *Beacher* also adopted the idea for moldings in 1944, then *Nupuf* and *Braff* in 1945.

2.3 – The Practice of Fitting Contact Lenses (1940)

The marketing of *Feinbloom* contact lenses was an aggressive and effective promotion campaign in the form of advertisements, publications and practical courses. In 1940, he started a series of articles describing fitting in the form of monthly lessons. To each of these was devoted to a chapter, e.g. 'The Refraction Procedure in the Fitting of Contact Lenses', 'Myopia and Contact Lenses', 'Absence of Drugs in the Fitting of Contact Lenses', and so on. The twelve texts were brought together in a fascicule of 46 pages distributed by the American Optometric Association under the title of 'The Practice of Fitting Contact Lenses' of which sales were very successful. (43)

Starting in 1943, *Feinbloom* organized 'Practical Courses in the Prescribing and Fitting of the New Feinbloom Plastic Contact Lenses' to cover both the methods of molding and of trial case approximations:

"*In compliance with a large number of requests from optometrists, Dr. William Feinbloom is organizing a course in the fitting and prescribing of contact lenses. The instruction class will be held in his office at 138 East 36th Street, New York. (...) The latest developments in the fitting and prescribing of contact lenses will be presented at that time. The procedure is a strictly optometric one and the technique has been greatly simplified. The instruction for the most part will be by demonstrations and clinical practice to ensure that each optometrist will individually go through the practical steps of fitting plastic contact lenses. This course will enable the optometrist to begin contact lens work in his own practice. (...) The class will extend for fifteen hours. (...) The group will be limited to insure personal instruction.*" (44)


The JOURNAL is glad to Announce the Publication of

"The PRACTICE OF FITTING CONTACT LENSES"

by WILLIAM FEINBLOOM, Ph.D.

● THESE LECTURES will be available to the profession in book form, on or about February 15; highly regarded by the profession as a most practical presentation of this subject; profusely illustrated throughout.

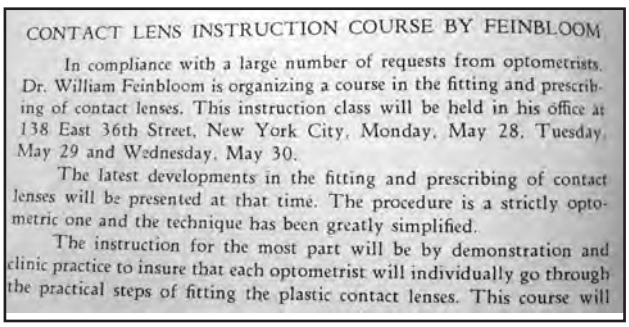
Priced At Only $1.50 Postpaid when accompanied by your check or M. O.

ORDER DIRECT FROM

The Journal of the A. O. A.
518 Wilmac Building
Minneapolis, Minnesota

Figure 25-11
Announcement of the publication of 'The Practice of Fitting Contact Lenses' by William Feinbloom. *This booklet includes the series of articles that appeared in the American Journal of Optometry and the Archives of the American Academy of Optometry.*
(Feinbloom W.M, 1940)

2.4–The 'Feincone' Contact Lenses


CONTACT LENS INSTRUCTION COURSE BY FEINBLOOM

In compliance with a large number of requests from optometrists, Dr. William Feinbloom is organizing a course in the fitting and prescribing of contact lenses. This instruction class will be held in his office at 138 East 36th Street, New York City, Monday, May 28, Tuesday, May 29 and Wednesday, May 30.

The latest developments in the fitting and prescribing of contact lenses will be presented at that time. The procedure is a strictly optometric one and the technique has been greatly simplified.

The instruction for the most part will be by demonstration and clinic practice to insure that each optometrist will individually go through the practical steps of fitting the plastic contact lenses. This course will

Figure 25-12
Course Announcement on 'Prescribing and Fitting Contact Lenses'. *The instruction courses 'Prescribing and Fitting Contact Lenses' in the North Eastern US are organized by W. Feinbloom in his office in NYC.*
(Feinbloom W.M., 1945c)

Spurred on by the success of these initiation sessions, *Feinbloom* undertook in the following years a major educative campaign across the North Eastern United States for the 'Feincone' contact lenses. He emphasized that these new lenses, reserved for optometrists, required neither ocular molding nor anesthetic. Fitting was performed with specific trial contact shells and the optical adaptation was started with trials using a contact shell of known corneal radius, keratometry and measurement of the distance from eye to lens.

FEINCONE CONTACT LENSES

TANGENT CONE SERIES — FITTED BY OPTOMETRIC TECHNIQUE

NO MOLDING • NO ANAESTHETIC

SCHEDULED INSTRUCTION COURSES IN FITTING TECHNIQUE

	Original Schedule—Registrations Closed	Additional Schedule
Chicago	March 3rd, 4th, 5th	March 6th, 7th, 8th
Omaha	March 10th, 11th, 12th	* * * *
St. Louis	March 17th, 18th, 19th	* * * *
Cincinnati	March 24th, 25th, 26th	March 27th, 28th, 29th
New York	March 24th, 25th, 26th	March 27th, 28th, 29th
Boston	April 7th, 8th, 9th	April 10th, 11th, 12th

The original instruction schedule in the left hand column above was recently announced and immediately filled. In order to take care of the over-registration, the additional schedule in the right hand column above has been established. There was also an excess registration at Omaha and St. Louis, but an instructor is not now available to give these additional courses.

Future instruction courses will be announced in these pages as they are scheduled. Both theory and clinical practice are covered in the course, the fee for which is $75.00.

FURTHER INFORMATION ON REQUEST

FEINBLOOM CONTACT LENSES, INC.

20 NORFOLK STREET — NEW YORK 2, N. Y.

Figure 25-13
Advertising for Feinbloom's 'Instruction Courses' in fitting technique. *Feinbloom's courses cover both theory and clinical practice. The fee is $75.00.*

Plastic CONTACT LENSES

INVISIBLE — NON-SHATTERABLE

are fitted

- By Optometric Trial Case Method.
- Without Drops—or anaesthetics.
- Without molds of eye.
- Start work with either a Trial Set of 3 lenses or a Master set of 15 lenses.
- All other necessary lenses on rental basis.

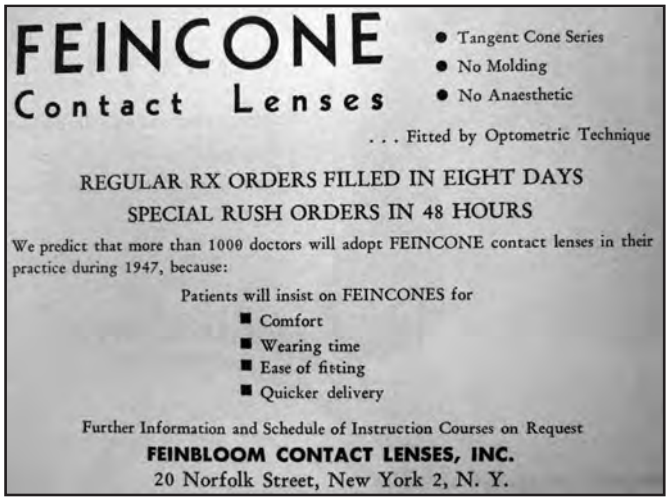
OPTICAL RESEARCH, INC.

Makers of the Feinbloom Plastic Contact Lenses

2214—40TH AVE. • LONG ISLAND CITY, N. Y.

★ Feinbloom Plastic Contact Lenses are now fitted in All Star States.

Figure 25-14
Advertising for Feinbloom's 'Plastic Contact Lens' (1939). *Advertisement of Optical Research Inc., makers of the 'Feinbloom Plastic Contact Lens'. Feinbloom's Plastic Contact Lenses were fit in the majority of US States.*



FEINCONE Contact Lenses

- Tangent Cone Series
- No Molding
- No Anaesthetic

. . . Fitted by Optometric Technique

REGULAR RX ORDERS FILLED IN EIGHT DAYS

SPECIAL RUSH ORDERS IN 48 HOURS

We predict that more than 1000 doctors will adopt FEINCONE contact lenses in their practice during 1947, because:

Patients will insist on FEINCONES for

- Comfort
- Wearing time
- Ease of fitting
- Quicker delivery

Further Information and Schedule of Instruction Courses on Request

FEINBLOOM CONTACT LENSES, INC.

20 Norfolk Street, New York 2, N. Y.

Figure 25-15
Advertising for 'Feincone Tangent Cone Contact Lenses' (1947). *The 'Feincone Tangent Cone' contact lenses experienced great success with optometrists. The manufacturer predicts a spectacular sales expansion. More than 1.000 doctors will adopt this lens in their practice during 1947.*

At the end of 1945, *Feinbloom* published 'Clinical Results with Feincone Contact Lens' in which he described 500 patients or 1000 eyes that had been followed by himself and by 26 of his optometric colleagues during a period of more than three months. [45]

In this era, four sections characterized the 'Feincone Contact Lens Series': corneal, cone, temporal radius and total diameter, of which the functions are described:

"*The function of the polished corneal section is to provide the necessary refractive correction. (…) The function of the cone or truncated section is to provide the bearing surface for the entire contact lens on the bulbar conjunctiva of the eye. The angle of the cone is the first variable and in the trial series is present as 43,46 and 49 degrees. (...) The function of the temporal radius is to reduce lid interference at the temporal side of the lens. The temporal section is a spherical section flowing from the cone on the temporal side. The radius of this spherical section is the second variable and in the trial set series varies as 12 mm, 12.6 mm, 13.2 mm and 33.8 mm. The contact lens is varied in a third manner, viz: by diameter or "Size Eye". The function of the "size eye" is to aid in reducing lid interference to a minimum and to aid in the cosmetic effect of the lenses. The lenses in the series are either Standard Size Eye, or -2 to +2 i.e 2 mm smaller, or 2 mm larger in overall diameter respectively.*"

Analysis of the frequency of use of the variables used at the time of these 1000 fittings shows that five trial contact lenses were used for the fitting of 57% of eyes, ten for 75% and twenty for 92%. Feinbloom concluded from those numbers that a trial lens case of 15 Feincone lenses is sufficient and suited to the most frequently occurring cases.

2.5 – The 'Tangent Cone' Contact Lens

Then, *Feinbloom* went on to develop a 'Tangent Cone' contact lens which had, in addition to the conical scleral rim and scleral flange, a complete continuity between the corneal section and the conical bearing section forming a limbal clearance. [46]

In the course of the years to follow, *Feinbloom* pu-

blished several articles with complimentary details and clarifications on the advantages of toric haptic contact lenses with limbal clearance, including fitting without anesthetic [47]:

"*The science of fitting contact lenses has been further advanced through the possibility of reducing pressure on the eye by using tangent contact on the sclera. The art of fitting contact lenses has been further advanced by (1) reducing the number of trial lenses required in the fitting, (2) reducing the number of visits required to secure a satisfactory fit, (3) increasing the wearing time of contact lenses, and (4) simplifying the fitting procedure*."

Several observations by fitters of Tangent Cone contact lenses appeared in the course of the following years. Thus, *C.J. Hellinger* proposed a plan to follow in order to complete the successive stages of fitting. [48]

At the time of his visit to America in 1947, *Norman Bier* gave an interesting if somewhat uncompromising report regarding the activity of *Feinbloom*:

"*Dr. W. Feinbloom and the Feinbloom Laboratories (New York). Quite a deal of publicity has been given to this type of trial fitting lens, but the following outstanding points of technical interest may be of some assistance. The lens is composed of a conical haptic with a spherical flange and optic. There are three distinct types: (a) round regular cone; (b) oval regular cone; (c) round or oval double- cone. The standard cones vary in angle from the steepest of 43° combined with an 8.5 mm corneal radius. This radius is constant for a 46° angle, but is decreased to 8 mm for a 49° cone angle. In the event of the standard corneal radii being too flat, they can be specially ordered and made to a shorter radius, usually 7.5 or 8 mm. The spherical flange has a variable radius from 12 to 13.8 mm. The third variable is the change in overall diameter of the standard lens. Corneal clearances should be fully obtained in the primary position, but in all cases observed, the cornea was grazed by the lens at the limbus at a 15° rotation from the primary position. Dr Feinbloom assured me that that this is of little consequence as long as the "touch" is for short duration and is of little force. Under observation, the fluorescein pool should extend for some 3 to 4 mm in all directions from the limbal region, with the standard-sized round lens of just under 23 mm in diameter. By virtue of its construction, the area of contact is reduced to a minimum and I observed that the edge tended to stand away slightly in well-fitted cases. The standard fitting set comprises 20 round lenses and, although this is adequate for many cases, much better results are obtained by utilizing a larger set, particularly one incorporating the newer number 3 oval lens and especially the double cone lens. Fewer instruments are necessary with the Feincone forceps when this large set is used. As with all other American types of contact lenses, prisms, cylinders and tints are being dispensed when required. These lenses are pressed from sheet plastic and only the optics are ground. Their construction is certainly revolutionary. Dr. Feinbloom is one of the pioneer contact practitioners and has had experience in the fitting of all types of contact lens. At one time, he produced a flexible "rubber" plastic contact lens which had the serious drawback in that it became tighter and tighter on the eye during the period worn. Dr. Feinbloom mentioned that 75 per cent of his patients wear their contact lenses 8 hours per day, i.e. two four-hour periods, and 20 per cent wear their lenses for just four hours. Five per cent of cases could only wear their contact lenses for less than four hours and were not considered suitable for contact lenses*." [49]

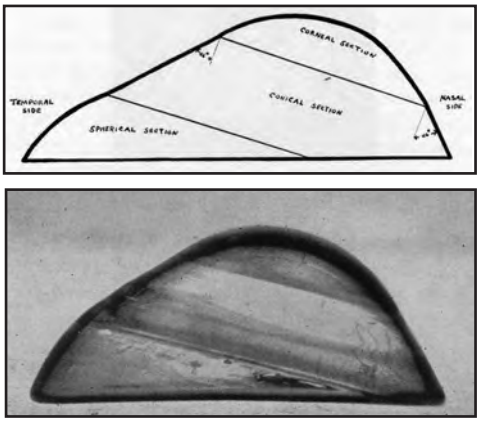


Figure 25-16
The 'Feincone' Tangent-Cone Contact Lens.
(Obrig T.E., Salvatori P.L., 1957 p. 109)

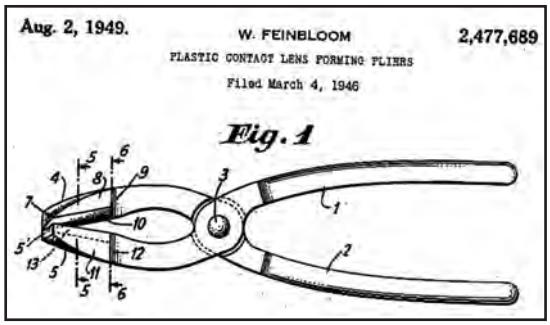


Figure 25-17
Plastic contact lens forming pliers patent.
Feinbloom's pliers adapted for blending a selected portion of a plastic contact lens. Pliers are provided with a jaw in each arm respectively.
(Feinbloom, W.M., 1946b)

From this nuanced report one will retain the comment that, in 1947, the wearing time for Feincone contact lenses rarely went beyond 4 hours at one time and that several problems remained to be resolved, such as the conjunctival contact at the margin of the contact shells for which *Feinbloom* used a pair of 'plastic contact lens forming pliers' of his own invention. [50]

2.6 - The Feinbloom 'Self-centering' Corneal Lens

In 1951, in an assessment entitled 'Contact Lens Fitting in The United States', *John Collins Neill*, Director of the Contact Lens Clinic of Pennsylvania State College of Optometry (Philadelphia) described the 'self-centering' corneal lenses of *Feinbloom* for which he indicated his preferences: [51]

"*Several years ago, Feinbloom introduced a new lens which he calls a "self-centering corneal lens". While this lens, like Feinbloom's older tangent cone lens, utilizes the principal of a cone, it is otherwise quite different. The new lens has a corneal diameter of 8 mm. The radius of the posterior surface of the corneal section is 7.4 mm. Surrounding this corneal section is a cone, which has an angle of 55°. Surrounding the cone section is an area, longer on the temporal edge and shorter on the nasal edge, which is available in a number of different spherical radii. These radii are designated as Alpha, A, B, C and D. Alpha is the shortest radius and D the longest. In fitting this lens, the clinician selects a radius, which fits the sclera in such a manner as to hold the cone in a position tangent to the cornea and in minimal clearance with it at the point of tangency. A small amount of contact lens fluid is required to fill the central 8 mm of the cornea and to fill the space over the limbus. The standard contact diameter of the self-centering lens is approximately 24 mm, although contour diameters of 22 mm and 26 mm are also available. For those cases, which do not permit the achievement of adequate minimal corneal clearance by variation of the scleral radius, the lens is also available with a one-half mm build-up between the spherical radius and the cone angle.*
The self-centering lens falls within the category of minimal clearance lenses. It generally affords longer haze-free wearing time than conventional lenses. Cosmetically it is far superior to those lenses. In most cases haze does occur sooner with these lenses than with the other types of minimal clearance lenses. This lens is quite comfortable to the average patient and can be worn for a number of hours on the first visit. Adjustments to the lens are quite simple and can be made by the thermal adjustment method."

In the same year, *Irving I. Vics*, optometrist at Albany, NY, published the case reports of 10 patients fit with *Feinbloom* 'self-centering' corneal lenses:

"*These 10 cases, taken as a group, present a much different aspect of contact lens fitting than heretofore experienced by the author, who has fitted many types of contact lenses in the past. With these new lenses, there were fewer deprecatory remarks from patients and the lenses seemed to come up to patients' expectations. All of the present groups of patients have continued to use their lenses which in itself is exceptional.*" [52]

Other testimonies on the use of *Feinbloom* conical contact lenses were published during the same epoch in the British Isles. In 1949, *Euin Steele* presented a complete review of fitting and prescription of these lenses. And, in the following year, at the time of an interesting comparison between the Pennsylvania State College of Optometry and the London Refraction Hospital [53], he reported that, when he visited the United States in 1947, *John C Neill* had shown him that *Feinbloom* contact lenses were the ones most commonly fit. He gathered, however, that fenestrations were not known in America. After that, *Kelvin Lenses Ltd* in Manchester (Lancs, U.K.) manufactured conical lenses. *McKellen* gave a very laudatory appreciation of these, with 50% of patients satisfied. [54] He praised the performance of *Feinbloom* whom he had visited with *Watson*: "*Dr. Feinbloom is an extremely able man. He has a fine brain, which he uses effectively and has as much experience behind him as anybody now in the contact lens field. He has 'been up all the streets', and has not feared to strike out along an entirely new road in his quest for a better lens*."

2.7 – Other Feinbloom Initiatives

Amongst *Feinbloom*'s other interesting innovations, one should first of all take note of bifocal, trifocal and multifocal corneo-scleral contact lenses. Also to be noted is 'The Miniscope'. This was a Galilean lens system constructed in the interior of a molded contact lens, 4.5 mm in thickness.[55]
When the vogue for corneal contact lenses pushed corneo-scleral contact shells into the background, *Feinbloom* pursued his researches. These included the gyroscopic corneal contact lens in 1956.

3 - Other Manufacturers and Fitters of Pmma corneo-scleral Contact Shells in the United States (1940-1950)

It would be unrealistic and misleading to make an exhaustive documentation of all the manufacturers and fitters of plastic corneo-scleral contact shells in North America during the years 1940 to 1950. A review of the literature allows one to list the principal manufacturers if we bear in mind that some will not be cited, principally because of the absence of bibliographical references. Thus, our alphabetical list is as follows:

3.1 - Ewing Adams, Detroit

In 1941, *Ewing Adams* (Detroit, Michigan) drew the attention of his optometric colleagues to unsightly eyes, i.e. eyes disfigured and blinded as well as the correction of eyes with astigmatism. He described the clinical history of a young patient whose right eye had been disfigured by scars and where molded contact shells were advantageously substituted for an unsightly ocular globe after enucleation or equally unsightly prosthesis. He described the psychological advantages for the patient and did not observe any signs of irritation. He thought that contact lenses represented the ideal form of correction for all degrees of astigmatism, but particularly when the astigmatism was high. He reported the case of a patient who had been wearing glasses containing -20.00 diopter cylinders, both of whose eyes were corrected by contact lenses obtained by ocular molding. Tolerance of the lenses was seven hours a day, even though the refractive correction was made solely by the tear meniscus.

In the following year, 1942, *Adams* recommended the fitting of contact lenses for the protection of the cornea in a patient with trichiasis. The contact shells were worn all day long while the solution was changed every four hours. *Adams* also dealt with strabismus using molded lenses and reestablished binocular vision in a patient who was hyperopic to the extent of +8 dioptres. This patient had previously undergone several operations on the extraocular muscles. After two months and several lens adjustments including the incorporation of a prism, the contact shells were worn for up to 8 hours a day. [56]

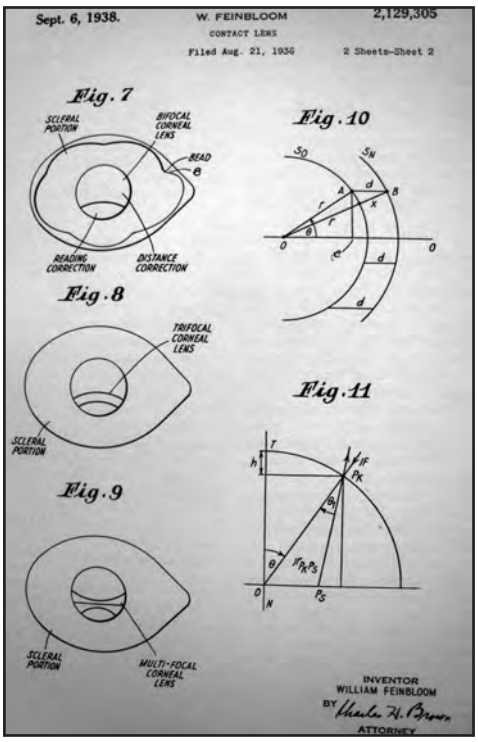


Figure 25-18
Feinbloom's bifocal, trifocal and multifocal contact lenses.
Illustrations taken from patent, describing contact lens, of which the corneal sections are made with two or more different refractive powers.
(Feinbloom M.W., 1936b)

3.2 - Edmond Alvis, St Louis

An interesting statistic regarding the number of contact lens fits in St Louis (Missouri) was made available in 1941 by the ophthalmologist *Edmond Alvis*: The numbers were 34 myopes, 8 keratoconus and 2 hyperopes. 24 were fit with 'stock lenses' of which 13 reached 4 hours of wearing-time per day. This achievement is considered to be a success. 19 patients were fit with molded contact lenses, of which 8 reached 4 hours of wearing time. The author considered that the major progress achieved resided in the possibility of adjusting the contact lenses after their delivery to the patient. During the discussion, *John Green* (NYC) reported that he had observed a severe keratitis with loss of vision following overwear of contact lenses. *William James* reported that he had fit seven patients one of whom had keratoconus. The latter had worn the contact lenses all day long. If glasses can satisfactorily correct the vision of a patient, he does not recommend contact lenses.

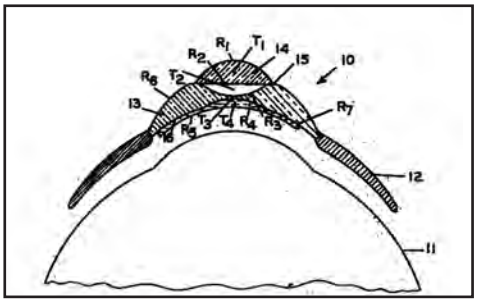


Figure 25-19
Feinbloom's Galilean telescopic contact lens.
Illustrations taken from Feinbloom's patent describing a telescopic contact lens comprising a corneal part, held in a scleral rim. The corneal part describes a glass body member having a negative central area. The corneal part comprises a positive lens carried on the anterior surface in axially placed area to form a Galilean telescope.
(Feinbloom W.M, 1937b)

Alvis replied that he had not observed any major complications in his series. However, there remained several unanswered questions, notably the choice of the total diameter for the contact shells. [57]

3.3 - Albert L. Anderson (Precision Contacts) Minneapolis

In 1944 *Albert L Anderson*, (Minneapolis Minnesota), owner of Precision Contacts in Minneapolis [58], (a subsidiary of N.P. Benson Optical Co. Inc.), made himself known by the publication of a clear and precise booklet describing the fitting of corneo-scleral contact lenses in plastic material. The title was 'Technique of Fitting Contact Lenses'. In this small volume, he gives a detailed prescription of the taking of ocular moldings, the fitting of semi-finished contact lenses and the choice of products available for the elimination of clouding. The work is beautifully illustrated and even includes a movie to be projected at evening information sessions for the general public. *Anderson* projected this same movie at the First Contact Lens Conference in Chicago. [59]

Anderson recommended that the practitioner determine the refraction first by using trial lenses with a diameter varying between 20 and 22 mm, with scleral radii of curvature from 11 mm to 13 mm in 0.25 mm steps and corneal radii of curvature from 6.5 to 8.5 mm in 0.5 mm steps. After that, one takes the vertex distance' through a stenopeic slit diaphragm placed in a trial frame. The ocular molding is performed using 0.5% topical Pontocaine anesthesia or 2% Butyn mixed with Adrenaline 1/2000. Moldite CLS is poured into specific molding shells. After the mold is taken, the imprint is placed in a fixing solution before taking from it a stone casting that is sent to the laboratory. The latter delivers a 'semi-finished' lens by return. This is fit under fluorescein control in a black chamber and examined with a 'General Electric Argon Glow Lamp'. For adjustments, *Anderson* proposed that a code be placed on the shell with a thick pencil. Practitioners were also able to equip themselves with carborundum or emery rasps impregnated in a rubber tip in order to be able to carry out minor adjustments themselves. After the adjustments and sometimes several rechecks by the manufacturer, the contact lens fitter received the finished contact lenses.

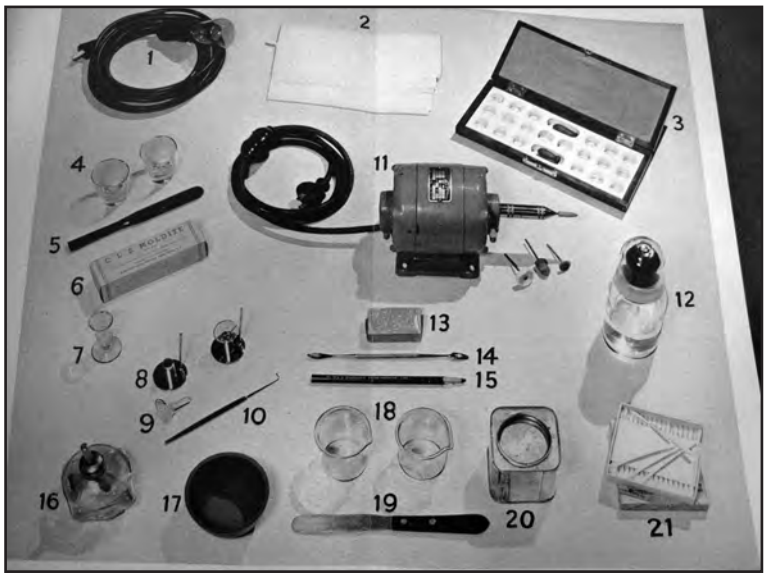


Figure 25-20
Anderson's proposal for contact lens fitting equipment.
The following items from the figure are needed, (1) Argon glow lamp with cord, (2) Dental trowel, (3) Contact lens trial set, (6) Moldite, (13) Bar of polishing compound, (16) Alcohol lamp, (20) Casting stone.
(Andersen A.L., 1944, fig. 5)

These 'permanent lenses' from Precision Contact are all plastic and their external diameter and radii of curvature are determined according to the casting from which the lens has been made. The corneal diameter is roughly 14 mm. Aside from exceptional cases the total diameter varies from 22 to 24 mm. During this era, the contact glasses of Precision Optical had generally a posterior corneal radius shorter than the corneal radius in order to avoid corneal contact and maintain a large liquid film for corneal clearance. The lenses thus induced a positive correction. The complementary refractive correction is ground onto the anterior corneal surface according to the measurements obtained from the semi-finished lens, taking account of the refractive error introduced by the lachrymal clearance. The most concerning problem remained that of clouding: "*If the lenses are so constructed that no abnormal pressures are created on any part of the eye, the problem of finding a satisfactory solution to eliminate the clouding of the vision is made relatively easier if it were possible to make a lens fit in such a manner that there would be a continuous "flow" of solution under the lens. This, however, is difficult to accomplish*."

Anderson recommended changing the buffer solution about 15 to 20 minutes before the usual time of occurrence of clouding and selecting solution depending on the pH according to the following guidelines: "*Four main types of solution are in use. (...) The patient will determine the maximum time the lenses may be worn*

before clouding occurs. The patient should then be instructed to change the solution about fifteen to twenty minutes before the known time that clouding occurs. Many patients obtain good results with 1.5% sodium bicarbonate solution and this is usually the solution given. (...) Clouding or dimming of vision after the lenses have been worn a certain length of time is the most frequent complaint."

Anderson explained the variations in the amount of corneal fluid as due to changes in osmotic pressure and the accumulation of carbon dioxide, tending to lower the pH of the fluid. According to *Anderson*, this was caused by the mechanical disturbance due to abnormal pressure on any part of the eye and by depositions of oily substances on the surface of the lens. For the care of all-plastic lenses, *Anderson* recommended washing with cold water and wiping with facial tissue. This guarantees unlimited use. The appearance of 'hair-line scratches' is not significant. It is possible to moisten the lenses with a drop of polyvinyl alcohol on the anterior surface and then rinse the lens in buffer solution before insertion. The lenses can also be asepticized with 1/1000 Merthiolate or 1/500 Metaphen.

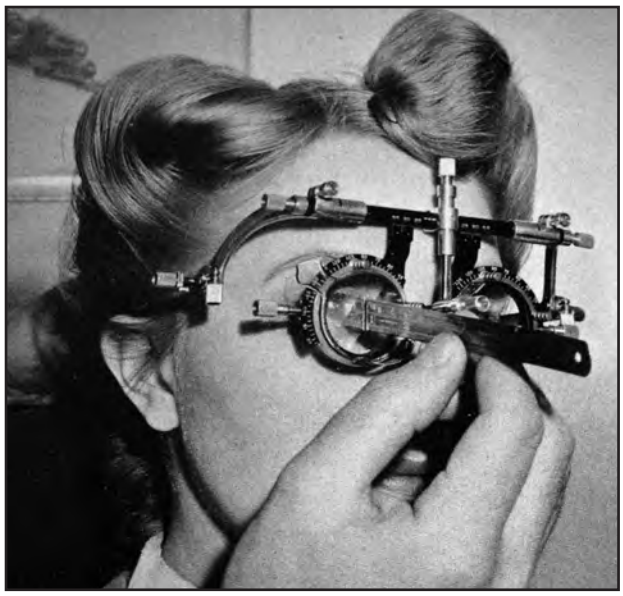


Figure 25-21
Measurer for vertex distance.
The measurement of vertex distance is performed with a steel rule and a stenopeic slit placed in the trial frame.
(Andersen A.L. 1944)

An interesting description from this era has come to us concerning contact lens fitting of a patient with high myopia by *Anderson*. He describes the fear and terror beforehand. Then follows the reassuring programmed initiation with anesthesia and molding: "*After a second application of pontocaine in my right eye, (...) the moldite was placed on my eyeball. Aside from a sensation of coolness akin to menthol on the skin, there was no feeling when the moldite was applied. The molding was accomplished so quickly and easily that I really had no time to become apprehensive. (...) After impressions were taken from both eyes, the excess moldite was removed.*"

Manufacturing and fitting took place on the premises:
"*In the large sixth floor laboratory of Precision Contacts my prescription began its journey from department to department. (...) Precision and perfection are the twin watchwords of every employee. But many of the 60 present employees needed no convincing that accuracy is of prime importance. Precision Contacts is noted for its willingness to employ handicapped persons. A total of thirty is now on the payroll. (...) Mr. Anderson, a quiet earnest man in his middle thirties, has devoted years of study towards improvement of ophthalmic lenses, contact lenses and artificial eyes. 'Wearing comfort of a contact lens is no longer a problem' asserts Mr. Anderson. 'The main thing that bothers a patient now is veiling or clouding, which cuts down wearing time'. "*

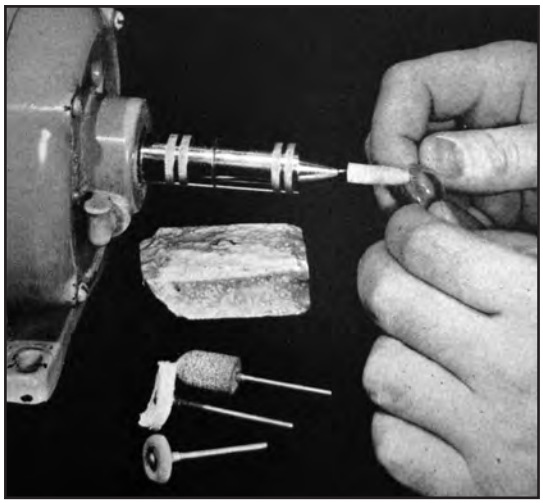


Figure 25-22
Method for relieving tight area.
Anderson's explanation:
Either a carborundum tip or an emery-impregnated rubber tip is used in an electric motor set-up. The tight portion of the lens in touched by the rotating rubber tip. The lens is never held still, thus a smoother surface results and the heat generated in the lens is not sufficient to be harmful. The lens must be tried on the patient's eye from time to time in order to determine whether the desired effect is being obtained. When sufficient material has been removed, the area is polished with a felt buff, which has been touched to polishing soap.
(Andersen A.L.1944b)

At the time of his trip to America, *Bier* also visited *Anderson* and commented as follows:

"*A. Anderson is associated with one of the largest contact lens manufacturing plants in the United States and he also lectures here to students on the practical aspects of contact lens fitting. From moulds taken by using his own developed moulding shells, very nice plastic lenses are produced. He has perfected a method by which cylinders can be ground on either the anterior or posterior surfaces of the optics and the obvious*

advantages of this do not have to be stressed.
A section of his plant has been set aside for research into the many problems involved in the production of contact lenses. Here he has developed his own type of rubber suction-holder. In addition to the normal contact lens, he is able to produce a cosmetic contact lens and he derives considerable assistance in their design from his artificial eye laboratory. As yet, he has not found a fitting trial set, which would, in his opinion, give complete satisfaction. At the moment, he is investigating this problem, but feels that an absolute minimum of 50 lenses will have to be employed to cover the majority of requirements." (60)

3.4 - E. Anderson, Canada

In 1941, a Canadian optometrist named *E. Anderson* described the psychological inhibition of subjects trying out contact lenses. Above all other concerns was their fears of pain and also of not being able to remove the contact shells. For some of these, he used '*Feinbloom* molded plastic contact lenses', each with a base to come into contact with the sclera while using glass of optical quality fused to that base in order to provide the refracting surface. For other patients, he used '*Obrig* contact lenses'. These were one-piece contact lenses made entirely from molded plastic plastic with anterior refractive surface ground to provide the needed optical correction. (61)

3.5 - Lawrence L. Beacher (Contact Lens Research Laboratory), New York

Lawrence Lester Beacher, owner of New York Contact Lens Research Laboratory (62) gained recognition by modifying ocular impression techniques using molds. In 1940, he begged the optometrists not to abandon molding under the pretext that the use of any form of anesthesia was restricted to physicians:

"*Optometrists might object to eye casting because medication is necessary during the procedure of taking these impressions. (...) That is no reason why contact lenses should be fitted poorly, and, furthermore, the objection is without foundation. (...) In this work, one cannot do it alone, an M.D. should assist us and at the same time administer the anesthetics.*" (63)
Beacher is the author of a simple yet comprehensive work entitled 'Contact Lens Technique. A Concise and Comprehensive Textbook for Practitioners'. In the next thirty years, there were to be several re-editions of this book. (64)
In the first editions, *Beacher* demands the presence of a physician for anesthesia with Pontocaine 0.5% or Butyn 2%. He soon changed his opinion and, in 1944, published a method of 'taking an impression without anesthetics'. He did this by covering the cornea with a mask during the taking of the molding. This was to be repeated in all his subsequent publications:

"*In recent years we have found that, except in very rare instances, there is no need for any anesthetics for inserting of contact lenses. There is no contact between the cornea and the lens, therefore there cannot be any pain whatsoever when they are inserted. We realize that the sclera is not very sensitive and does not require desensitization. The discomfort, if any, is indeed less than the usual dental treatment, for which the dentist does not administer medication.*" (65)

Figure 25-23
Beacher taking eye impression with anesthesia. *The physician, positioned at the patient's side, treats the patient's eye with drops of 0.5% Pontocaine. The fitter stands directly behind the patient.*
(Beacher L.L. 1944b)

This procedure is going to attract great interest and will be widely commented on, spread around and confirmed by other optometrists. In 1945, *Beacher* even proposed, following *Braff*, the taking of a molded imprint, in certain cases, without using a 'corneal cover':

"*I proceeded to take an impression of my own eye, eliminating the corneal covers and omitting medication. The sensation and the results were the same as if corneal cover were used; i.e. without discomfort*

or any after-effect whatsoever. Since then, I have repeated this procedure satisfactorily on about 50 pairs of eyes." (66)

Following the opinion of his era, blurring which appeared more or less right away after wearing of contact shells, was likely due to chemical changes in the solution used for their insertion. *Beacher* advised adapting the buffer solutions to the pH, recommending *Gifford*'s solution, *Feldman*'s solution, *Obrig*'s solution, or, more simply, just a 2% sodium bicarbonate solution. Eight hours of daily wearing-time is considered excellent. It is to be noted that, among the numerous initiatives of *Beacher*, is to be found a method of inserting contact shells with one hand only, while, at the same time, avoiding the inclusion of air bubbles. Several studies by *Beacher* address psychological problems associated with the wearing of contact lenses. (67)

At the time of his trip to America in 1947, *Bier* visited *Beacher* in New York and observed:

"*Dr. L. Beacher moulds exclusively and uses only plastic lenses. At his professional consulting rooms, he has the facilities for training several students who are specializing in contact lens fitting*." (68)

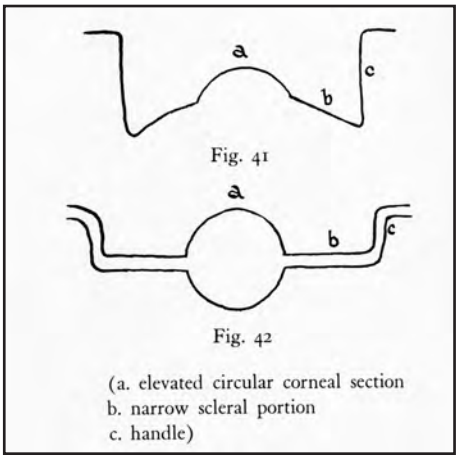


Figure 25-24
Cross-section of Beacher's 'corneal cover device' for eye impression without anesthesia. *A plastic device is placed over the eye in such a manner as to cover the cornea. According to Beacher, as long as the cornea is covered, no pain can result, because the impression mixture solidifies almost immediately and keeps the device in place. There will be no more discomfort to the patient than taking an impression of the teeth.* (Beacher L.L., 1944a)

3.6 - Solon M. Braff, Los Angeles

In 1944, *Solon M. Braff*, an optometrist in Los Angeles, made a complete, interesting, analytical and scientific description of fitting, wearing and complications of contact shells (in 21 pages): 'The Fitting of Contact Lenses by the Molding Technique'. (69)

Following a historical introduction in which he does not mention the American fitters prior to 1936 (which was the year in which the *Dallos* molding technique became known throughout the English–speaking world), he stated that pmma was established in *Obrig*'s hands as being most suited to Negocoll and that plastic lenses were found to be superior to glass lenses as previously used. In a long paragraph, he criticized physicians for having confirmed that the cornea was a round structure and that its diameter was less than 12 mm. This was the source of the errors by manufacturers of that era who, because they accepted the data provided by physicians, had prepared their lenses in accordance with a 12 mm corneal diameter. It is to the credit of *Obrig* that he developed the fluorescein test and demonstrated that, in the majority of his cases, the lenses were touching the cornea. The 1000 moldings of *Obrig* showed "*that the cornea was, in fact, oval and that the average size was 12 mm x 13.6 mm. Only 5% showed a horizontal diameter of 12 mm or less, while 38% were 14 mm or more*".

After this highly critical preamble, *Braff* proposed a scientific protocol for the fitting of contact lenses. He divided this into 5 steps:

1/ The optical fit: measurement of the patient's refraction with trial lenses inserted without topical anesthesia.
2/ The physical fit: ocular molding for which *Braff* had eliminated Negocoll because it was too irritating in favor of a more suitable molding agent. In any event, he advised the instillation of a pontocaine eye drop before molding and epinephrine at the end. This required the presence of a physician. Molding was followed by the preparation in dental stone of a positive cast of the negative impression.
3/ The semi-finished fit: with the new pmma contact lenses, it was possible to perform an adjustment when relief was required because of excessive size, scleral tightness, edge looseness or corneal touch: "*A properly fitted contact lens is one which rests evenly and without undue pressure on the sclera and arches over the limbus and cornea. There should be no tight areas as evidenced by vascular constriction and blanching, nor scleral looseness, which tends to cause corneal contact. These conditions are true both in direct fixation and in extreme rotation in the cardinal directions.*" Adjustments can be made directly with a "*dental lathe, small carborundum stone, grit-impregnated rubber tip, dental mandrel, felt polishing discs, dental polishing, wax*

spatula or dental trimmer." *Braff* gives a detailed explanation of how to do simple adjustments, document these in diagrammatic form and follow their effects on adaptation. After these adjustments have been performed, one proceeds to perform a repeat and more accurate refraction.
4/ The finished fit is concerned with a final check of the lens and instruction to the patient in the insertion, removal and care of the lenses. At the end of the fourth week, the patient is to return for a progress report,
5/ The chemical fit is concerned with the choice of an acceptable buffer solution. According to *Braff*: "*Much time has been expended, many solutions have been tried, many theories as to the reasons for non-acceptability have been evolved. (...) At present, the most satisfactory solution is that of sodium bicarbonate*."

The most common complaints are the following:
1/ seeing through a haze or fog (dry lens, thick secretions, corneal infiltration), 2/ visualization of rainbows associated with corneal haze, 3/ photophobia (overcorrection of myopia, light dispersion by buffer solution), 4/ burning, tearing, conjunctival injection (depending on the buffer solution), 5/ vision looking through water.

Finally *Braff* rendered homage to *Obrig* and *Salvatori*, with whom he had spent time in 1941 and who had done so much work in the molding technique. It is to be noted that, in this remarkable work, *Braff* recommended optical correction by lachrymal meniscus and did not mention the possibility of grinding an anterior refractive correction on the lens.

In 1945, *Braff* changed his opinion in an article that strikes an important echo: '*Eye Impression without Anesthesia*'. After referring to experiments carried out by *Beacher*, he describes his and his optometric colleague *Edward I. Goodlaw*'s experiments carried out on their own eyes. These consisted of taking molds of contact glasses without the use of anesthetics. The insertion of contact glasses by trial and error can be performed provided the shells do not touch the cornea. This is because the sclera is not particularly sensitive. The experiments also showed that the insertion and removal of a casting shell does not provoke discomfort, blinking or a defense reaction. Furthermore, the replacement of Negocoll by a compatible and more fluid molding material makes the procedure pain-free and not irritating to the eye. (70)
In the course of the years that followed, *Braff* completed his research work with a clear and comprehensible description of the 'Optical Principles for Contact Lenses'. This described current fitting and it also included a more in-depth study of etiology, diagnosis and correction of keratoconus. (71)
Braff began fitting contact lenses in his practice and became one of the first optometrists to specialize exclusively in contact lens fitting. He was introduced by *Goodlaw* to *Xavier Villagran*, a contact lens technician, to see if the latter could make scleral lenses by his contact lens process using polymerization. In 1945, they formed Solex Laboratories, derived from their first names. They required a manager and invited *Kevin Tuohy* to join them as a third partner. *Tuohy* left his position with the Montreal branch of *Obrig Laboratories* and went to Los Angeles. When *Braff* joined the Southern California School of Optometry in 1948, he handed over his share to *Tuohy*. Thus it was that he participated in the success of the first corneal lenses, which he notably recommended should be used in persons with minor refractive errors and as requirements for certain occupations. (72)

When he travelled to the United States in 1947, *Norman Bier* visited *Braff* in Los Angeles and commented: "*Dr. Braff is, I am given to understand, the originator of the moulding technique which can be employed without an anesthetic and he practices this method exclusively. His contact lenses are constructed by polymerisation and he claims that, by this process, he obtains more satisfactory results than are obtained as compared with sheet-moulded lenses*." (73)

3.7 - Joseph J. Carlson and Mitchell Silbert, New York

The optometrists *Joseph J. Carlson* and *Mitchell Silbert* of NYC developed ground scleral contact lenses (trade-name: 'Scleraform') and described in 1946 their characteristics and method of fitting. (74) First, they chose the trial lens with the steepest radius. By inserting shells with progressively longer radii, they marked and noted on a chart the tight segments requiring correction. The definitive contact shell is manufactured according to the initial contact shell after correction of the parts marked as requiring adjustment. In general two such adjustments are required in order to obtain a satisfactory toroïdal scleral part.
According to a commentator in the journal Optometric Weekly: "*Early in January, at their office at 292 Madison Avenue, New York City, Drs Joseph J. Carlson and Mitchell Silbert are offering a ten-week course in the prescribing and fitting of contact lenses*."

On his trip to the United States in 1947, *Norman Bier* visited their office and expressed his admiration: "*The lenses developed by Dr Carlson are ground from a solid piece of plastic and their final thickness is 0.5 mm. They are thus, in all probability, the thinnest available in the USA. A set of 13 spherical lenses is employed to carry out a satisfactory fitting of any shape of eye. The standard decentred round lenses have a 22 mm overall diameter, 13.75 mm inside corneal diameter and 8 mm corneal radius, although any variation from this normal can be obtained. The corneal chord in these trial lenses is a constant of 3.91 mm so that the only variable factor is the scleral radius. It may be surprising that a diameter of 13.75 mm is employed: since, with an analogous British lens, this would give a marked "crescent" effect, but, by an ingenious device incorporated in the lens, this is overcome and the resultant lens has a pleasing cosmetic appearance.*
The 13 lenses in the fitting-set vary in scleral radius from 12 mm to 14.4 mm in 0.2 mm steps. On a conveniently constructed chart, the various scleral meridians are marked and the fit of the lens recorded at each and every meridian. The lens with the steepest scleral radius giving a satisfactory fit over a segment of the eyeball is considered the 'base curve'. Once this base curve has been determined other lenses are inserted with longer scleral radii and the chart is duly marked until all tight segments have been eliminated.
The finished lens is then constructed to the original base curve with toroidal grind-outs corresponding to the final chart diagram. In the majority of cases such grind-outs suffice, but as many as four may be necessary to obtain a very satisfactory fit. These grind-outs need not necessarily be at cardinal meridians.
These lenses have been the subjects of extensive research and many developments have gone into the design of the present lenses, which are yielding excellent results, and their popularity among practitioners in the United States is widely increasing. Not only can the lenses be dispensed from a pre-determined fitting method, but a recent achievement is the grinding of a lens from a solid block to correspond to any mould taken." (75)

3.8 - Harry W. Ewald Jr., Pittsburg

In 1940, the optometrist *Harry Ward Ewald* (Pittsburgh, Pennsylvania), with a rich experience of six years of fitting contact lenses for cases of subnormal vision, observed that there are nearly 10,000 patients so fitted in the United States. He proposed to his colleagues to adopt a scientific approach with 'fitting standards' and not to consider a fit successful unless the subject has worn contact lenses for "at least five hours on three consecutive days and that the particular appliance prescribed has a proper set of inner contact curves, to rest comfortably on the anterior surface of the eye for which it is intended." (76)

When he visited the U.S. in 1947, *Bier* observed: "*Ewald has in all probability one of the largest practices I have seen in the United States. This practice is divided into several departments, the main ones being general refraction. orthoptics and contact lenses. I was most interested to see the many orthoptic instruments in use, and to note in particular the extensive use made of projection in training of orthoptic cases. In the contact lens practice, he uses mostly Feincone lenses and those produced by the National Contact Lens Corporation.*" (77)

3.9 - Isodore S. Finkelstein, New York

At the School of Optometry at Columbia University in New York, *Isodore S. Finkelstein* has directed and published numerous in-depth studies on corneal scatter and diffraction of light induced by contact lenses. *Bier* visited *Isodore Finkelstein* in New York in 1947 and made the following comments: "*Dr Finkelstein uses Carlson, Feinbloom and the moulding methods according to their individual merits in his most extensive optometric practice. He is a lecturer at one of the leading optometric colleges and is also closely connected with the Optometric Foundation of New York, an academic body which has recently published a treatise on contact lenses based on papers read at some of the meetings.*" (78)

3.10 - Eugene and Milton Freeman (Freeman Laboratories), Chicago

In 1945, *Eugene Freeman* drew attention in an editorial on recent publications of *Nupuf* and *Braff* dedicated to ocular molding without anesthesia. Then, in 1946 the Freeman Laboratories announced the development of a 'New Improved Impression Molding Shell'. (79) "*The impression shells are so shaped as to minimize lid*

pressure during molding and to allow for free flow of impression material after insertion of the shell. The shell is decentered and designed like a contact lens, so that a better ratio of superior, temporal, inferior and nasal of the impression is obtained. The countersunk perforations in the shell minimize the possibility of the impression being pulled away from the shell and the flat tapered handle affords a firm grip."

In 1947, *Eugene* and *Milton Freeman* produced a more in-depth and important treatise entitled, '*The Optometric Impression Technique in the Fitting of Contact Lenses*'. They recommended a procedure for making eye impressions without anesthesia thanks to the molding shell that they had developed:

"*Equally significant is the Freeman simplification of the technique for making eye impressions without anesthesia. (...) Eye impressions are made using 'Moldite' in the conventional manner, except that anesthesia is not needed or used. No lid retractors are used*." (80)

The positive casting is performed with 'Diolite Impression Stone'. The semi-corrected lenses are adjusted under fluorescein control. The lenses provided are generally designed with as large an overall contour as the stone casting furnished normally permits. Consequently, the principal adjustments consist of reducing the contour size with a motorized laboratory lathe. The authors emphasized how simple these adjustments were to make and on the originality of their recommendations which were totally different from those of other manufacturers. Finally they referred to the research recently published by their British fellows *Frank Dickinson* and *Keith G Clifford Hall*. (81)

On his trip to America in 1947, *Norman Bier* visited *Eugene Freeman* in Chicago and made the following observations: "*Dr. Freeman's general practice, limited to contact lenses, has been extended to include a school for the training of technicians and his own laboratory where moulded contact lenses are exclusively dispensed. He fits moulded contact lenses only and, in the majority of cases, without employing a local anaesthetic. The particular feature of his method is that he fits his lenses with full corneal clearance and without tight or loose areas in the primary position and within a rotation of 30° from this plane. Dr. Freeman maintains that the fit cannot be controlled beyond that area in view of the fact that the shape of the eyeball changes too much during such a rotation and any modification at these extremities would unbalance the fit in the original primary position. The customary procedure is for the patient to make three visits. At the first visit, the mould is taken; at the second, the scleral fit is examined and all modifications are made when and where necessary; lastly, the optic is accurately centered after the contact lens has been 'fixed' in its position and the power specifications noted. Unlike the majority of methods, the above procedure differs in the important respect that the optic is centered after the scleral fit has been determined and not, as with most other techniques, where the converse is the case. The approach is analogous to the fitting set method as developed by Dr. Greenspoon in so far as the centring of the optic is concerned. Dr. Freeman's success in fitting these somewhat large lenses (23 x 25 and 25 x 27) can, in my opinion, be attributed to the use of a decentred moulding shell developed by his brother and himself, the construction of which I found quite unique, as distinct from the usual shell where true centration is present*." (82)

Eugene Freeman, named Dean of the Chicago College of Optometry, continued his research work there. Thus it was that he developed a pinhole contact lens for the difficult correction of albinism and dyscoria: "*If I may generalize from the very small number of cases which I have handled in pinhole contact lens cases, the recurrent delays which drag the case out, the novel problems which arise, the tantalizing misses which give promise of better results without achieving them, add the suspense to the case which seems to heighten and make richer the satisfaction which is achieved when the case is finally successful*."

Ultimately, he invented and had constructed instruments for the measurement of the curvatures of the contact lenses. (83)

3.11 - Reuben Greenspoon, Beverly Hills

Reuben Greenspoon, optometrist formerly in Beverly Hills (California), acquired a reputation for supplying cosmetic contact lenses for Hollywood film actors. The relationship between lens technology and the movie industry began when two patients, *Jerry Fairbanks* and *Bob Carlisle* produced and directed respectively a film series named 'Popular Science' (distributed by Paramount Pictures). They asked *Reuben Greenspoon*

to appear in a segment of the film that showed the procedures for making contact lenses from eye molds. The film was projected on 20th December 1940 and resulted in bringing contact lenses and special effects with contact lenses to the attention of the movie industry at Hollywood and, of course, the general public. (84)
The first motion picture in which cosmetic contact lenses were used to create a special eye effect was entitled 'Miracles for Sale' (1949). The story required the main character, played by *Henry Hull* to have light blue eyes and his natural brown eyes at different times. In effect, the principal personage, *Dave Duvallo*, a master of deception, created an alibi for himself by playing the role and disguising himself as Professor *Tauro*, in spite of the fact that he had already murdered him. To achieve this deception, the actor *Henry Hull* modified the color of his eyes: sometimes blue, sometimes brown. He was fit with classic glass *Zeiss* lenses. The color was fused to the outside of the corneal section with blue ceramic material. The fusing process was carried out in an oven at a Los Angeles bottle factory. The procedure and the special effect were highly successful.
In 1940, *Orson Wells* asked *Greenspoon* to fit him with contact shells and also to give the eyes of movie star *Joe Cotton* a more aged appearance for the movie 'Citizen Kane', distributed the following year by RKO Pictures:
"*The famous actor director was looking for someone to change his eyes from those of a youth to the gray, faded blood-shot eyes of an old man. Orson Wells was to take the lead in a picture where he is shown as a young man who lives to the age of eighty. (...) Prominent scleral veins were etched onto the scleral portion of the contact lenses. A faint milky solution was used in place of the saline solution. This caused the iris to look faded and aged. Several days later, actor Joe Cotton was sent to me to have his eyes aged. Mr. Cotton plays an important part with Mr. Wells in the R.K.O picture 'Citizen Kane' soon to be released.*" (85)

Figure 25-25
Contact lenses change actor's eye color. *Greenspoon has given brown eyes to blue-eyed actor Walter Hampden to play the part of the Indian Chief Big Bear in the first Technicolor movie 'North-West Mounted Police'.*
(Greenspoon R., 1945a)

In another 1940 movie, entitled 'North West Mounted Police' (*Cecil B. De Mille*'s first film in Technicolor), actor *Walter Hampden* once used contact lenses to change the color of his blue eyes to brown. This was in order to play the part of an American Indian named 'Big Bear'. *Hampden*'s make-up, like all of that applied to those actors playing Indians, including real Indians, was dark mahogany. However *Hampden*'s eyes were blue and Paramount Pictures said that they had to spend more than $500 in fitting this blue-eyed actor with the early day set of contact lenses in order to change the color of his eyes to brown.
In 1945, *Greenspoon* was to have the opportunity anew of fitting contact lenses for actor *Herbert Marshall* in order to give his eyes the appearance of blindness in the movie 'The Enchanted Cottage'. In this romantic film fantasy, *Marshall*, as Major *John Hillgrove* is a blinded veteran from World War I. He plays a piano concerto for the film and uses this as a tone poem to describe the story of the two protagonists to a gathering of people. *Marshall*, who had lost a leg in World War I, played the role of blind person with the help of special contact lenses.
Greenspoon made the following comment:
"*In this picture Herbert Marshall portrays the part of John Hillgrove, a pianist who was blinded in World War I. The story of how the blinded pianist helps Oliver Bradford (Robert Young) and Laura Pennington (Dorothy McGuire) find happiness presents a wonderful theme describing those who returned from World War II injured in mind and body. The philosophy of a blind man as given to Oliver Bradford,*

Figure 25-26
Contact Lenses enable actor to portray blind man. *The actor Herbert Marshall (left), acting as a blinded veteran from World War I, wearing contact lenses to make his eyes appear blind in the movie 'The Enchanted Cottage'. The picture was taken after Mr. Marshall had worn the lenses most of that day; Greenspoon (seen to the right) admires the splendid effect he created.*
(Greenspoon R., 1945a)

who was disfigured in a plane crash, makes the R.K.O picture 'The Enchanted Cottage' well worth seeing. Mr. Marshall was fitted with my trial contact lenses in 45 minutes. The finished lenses were ready the next day. This was possible because I maintain an experimental research laboratory where I can mold contact lenses. The lenses were checked on Mr. Marshall's eyes and they fitted perfectly." (86)

For these fittings, *Greenspoon* followed a five-step process that he described as follows:
1. Taking of an eye impression; 2. Pouring plastic into same to make eye molds; 3. Molded contact lens being fitted to eye model; 4. Contact lens being worn by actress; 5. Creating eye defects and aging eyes.
Greenspoon was more than happy to provide Hollywood stars with every kind of theatrical special effect lenses (rejuvenating, ageing or giving the impression of being blind) after molding and provided these were well tolerated:

"*Illusion of blindness, total or partial, cataract-dimmed eyes, eyes that result from a week of 'mornings-after' and the eyes of madness can be achieved by the simple device of slipping the made-to- order lenses under the lids*." (87)

Reuben Greenspoon had acquired tremendous experience in the fitting of contact lenses, which he had been doing since 1933 with the classical contact shells of *Zeiss*. In 1939, he proposed performing fitting checks using a mixture of 10% Neo Silvol and three drops of 2% fluorescein. From this time on, he affirmed what will become established fact in years to follow:

"*It is imperative that free circulation of lachrymal fluid be maintained. (...) Denied oxygen, the cornea becomes gray in one or two hours and the patient complains of hazy vision and colored halos around lights. The lachrymal fluid flowing freely beneath the contact lens supplies much needed oxygen. If the circulation is too slow because of the lens fitting too tightly at sclera or limbus, tolerance is materially reduced*." (88)

In 1943, *Greenspoon* presented a new trial set for fitting contact lenses issued, as a result of his collaboration with The Invisible Lens Inc. (NYC), by his friend *Emerich Rakos* for whom he had provided hundreds of ocular moldings over a two year period:

"*Several hundred eye impressions and models were made. From these, eighty-five composite trial lenses were formulated. None of the scleral portions were based on geometrical curves, but on actual eye curves. After fitting many patients with this large trial set, a careful check was made and it was found that 87% of the patients were fitted with twenty five lenses and a trial set based on these was devised. The other 13% required very odd-shaped lenses. Although the impression system was tried on these 13%, results were not good. This was due to the fact that some eyeballs were found to be soft and large and, therefore, lost their shape when the impression shell and material pressed on the eye. Also, too much error crept in because of the expansion and contraction of materials and the altering of the eye models by technicians to give corneal and limbal clearance. Usually, not enough scleral area is obtained in the impression to make possible good results*." (89)

The control of the fitting of these 'Rakos-Greenspoon contact lenses' was made by using fluorescein in cobalt blue or in 'Strobalite' light. This was to ensure ample corneal clearance 3 mm beyond the limbus without compressing the conjunctival vessels. Once the trial lens was chosen, the optic was marked in the center and the necessary alterations were documented on a mold forwarded to the laboratory that, in turn, also ground the optic portion. If required, other adjustments on the final lens could be made. These included tinting or painting. *Greenspoon* reported excellent results. He did not, however, cite clinical examples.

In the same year, *Greenspoon* reported the correction of a case of unilateral aphakia that allowed the patient to achieve binocularity then, in 1945, he refit a patient that he had followed for twelve years. The keratoconus of this patient had been fit in 1933 when he was 18 using classical ground glass *Zeiss* contact glasses. The patient was wearing these lenses for 16 hours a day. Similar lenses, then made from plastic, replaced them. Here follows evidence of patient satisfaction:

"*In January 1945, you fitted me with your latest type of plastic contact lenses. They are larger than the glass lenses, but they feel so much lighter. There is no pressure on the eyeball and no irritation. They feel soft and flexible.*" (90)
When he travelled to the United States in 1947, *Norman Bier* visited *Reuben Greenspoon* and noted:
"*Dr. Greenspoon's practice proved most interesting and remarkable for the many cases who consult him from the film studios. I have the utmost admiration for his skill in creating the ocular characterizations needed*

for film work, this in addition to his general contact lens practice.
Dr. Greenspoon has developed a very rapid method of fitting [by] employing seven pairs of trial contact lenses and one additional pair for keratoconus cases. These constitute a fitting set evolved from hundreds of moulds, their chief characteristics being the gradual sclero-corneal transition and the use of the same corneal base-curve for all lenses, giving a fairly deep fluid lens. The trial lenses are engraved with a horizontal line and a circular pattern for centration of the optic of the lens over the corneal apex. Usually, slight modifications have to be made after the lenses are returned from the laboratories and apart from the customary methods of tightening and loosening area. Dr. Greenspoon has evolved a very ingenious way of tightening a lens using a polishing buff alone. He maintains that, with this small set, one can fit any type of eye, once proficiency in its use has been established. My visit to Dr. Greenspoon will remain one of the most valuable and happy re-collections of my US trip and his assistance in experimenting upon my eyes in the mitigation of Sattler's veil until late into the night proved of the greatest value. The unusual nature of his practice gives him the widest experience end entitles him to a preeminent place in the contact lens field." (91)

3.12 - Arthur Hoare, Los Angeles

This recent British immigrant practices the molding technique and also the Feincone and *Carlson* fitting methods. In 1945, *Arthur Hoare* considered that the optometrists minimized the difficulties they encountered when fitting contact lenses. In any event, the technique could not be learned and mastered at the time of a course or a few hours of theoretical lessons. (92)
In the course of his 1947 American trip, *Bier* visited *Hoare* in Los Angeles:

"*Dr. Hoare was, at one time, a British subject and it was a comparative surprize to find a 'real image' of our own H. H. Emsley projected into the United States, Although Dr. Hoare's main interest lies in the field of instruction, tuition and work associated with academic bodies, he also strives constantly for contact lens fitting and optometry generally to be placed on a higher ethical plane. In his extensive optometric practice, he also carries out contact lens fitting. In this latter connection, he practises the moulding technique and also the Feincone and Carlson fitting methods. Dr. Hoare's practice is unique in that, so far as I have seen, he does not undertake dispensing of any description, but only provides professional optometric services.*" (93)

3.13 - Henry J. Hoff, New York

The optometrist *Henry J. Hoff* (New York) presented in 1940 'A New Contact Lens Fitting Chart' for the fitting of 'Feinbloom Plastic Contact Lenses'. This was a logical and rational approach that would be sustained by a roster of tests to be performed. (94)

3.14 - Hugh L. Hunter, Chicago

Hugh L Hunter was one of the first contact lens fitters. As director of the 'House of Vision' in Chicago, he had registered in 1939 a patent for "*a method of producing a concavo-convex contact lens ground along continuous plotted curves with annularly curvilinear parts to fit an irregular or astigmatic sclera*." That could be one of the first contact lens with a paraboloid peripheral zone. In 1944 he had attended the First National Contact Lens Conference of Chicago. There he presented his theme: 'Selection of Contact Lens Patients' and reported his experience:

"*The youngest patient that I have personally fitted was seven years old. (...) The oldest patient we have supplied lenses to with satisfactory results was a man eighty six years old*." (95)

In 1947, *Norman Bier* visited *Hugh Hunter* in Chicago and noted:

"*He is one of the early workers in this field and has by now seen many thousands of patients. He uses the moulding technique exclusively and has developed it to such a degree that he is now able to mould both eyes in nine minutes, aided by a special clock to coordinate his stages of fitting. Among his own developments are*

a special suction-holder, vertex-measuring instrument, moulding shell and moulding material. And will be appreciated from the speed at which he works, he is able to see a large number of patients daily and, over a period of several years, has been able to accumulate a vast experience in this field." (96)

3.15 - Frederick L. Kollmorgen (Kollmorgen Optical Co.), New York

The *Kollmorgen Optical Corporation* in New York is a company that possesses a great deal of technical experience in the grinding of glass lenses for optical instruments. In 1937 *Kollmorgen* manufactured and sold his first American-produced glass contact lenses. They were quite similar to the ground contact shells of *Zeiss* and had a total diameter of 20 mm, an optic of 12 mm and a transition zone at the level of the limbus. (97)

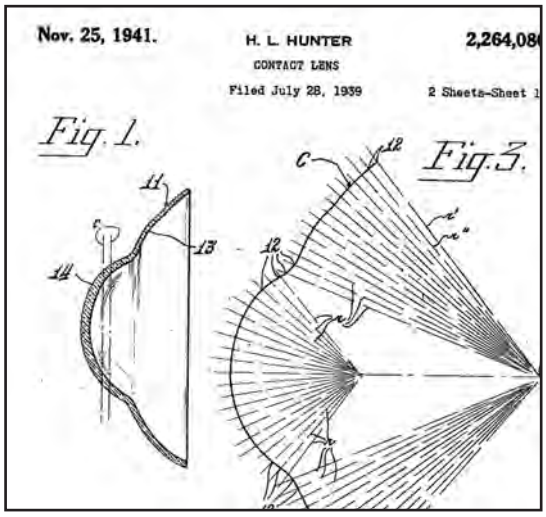


Figure 25-27
Hunter's diagram of the plotted meridional contour of the contact lens. *Hunter's patent described a method to providing a contact lens ground along a continuous plotted curve, to fit an irregular or astigmatic sclera and cornea. The contact lens may be ground curvilinear annularly and meridionally.* (Hunter H.L., 1939)

Next, *Kollmorgen* adapted to the new advances. He copied the contact shells of *Müller-Welt* and *Feinbloom* using ground contact shells with toric haptics and a difference of 0.6 mm between the radii of scleral curvature, as those recommended in cases of failure of standard contact shells. Then he also produced contact shells with haptics derived from moldings. These were similar to the molded haptic contact shells of *Zeiss*. In 1939, *Frederick L.G. Kollmorgen* had registered, in this regard, a patent application for a method of manufacturing dies for molding contact lenses and, more particularly, for making contact lenses with a haptic molded to the eyeball. (98) The procedure was intended "*to provide a contact lens which will not touch the sensitive parts of the eye including the cornea and limbus and which rests solely on the insensitive sclera of the eye*." *Obrig* criticized his competitor for manufacturing heavy contact shells that were fragile and difficult to adjust. (99) The vogue for plastic materials no longer matched the technical know-how of *Kollmorgen*, whose company was highly specialized in glass grinding and the manufacture of optical instruments. In 1942, he announced the cessation of manufacture of contact lenses in view of the current urgency for manufacturing periscopes, navigational and fire-control instruments.

3.16 - Adolf Mueller-Welt and Joseph L. Breger, Toronto and Detroit

In 1950, *Müller-Welt* fluidless contact lenses were introduced into the United States. Used since 1937 in Germany, these corneo-scleral contact shells experienced major advances during and after World War II because of the substitution of pmma for glass for which several patents had been registered. (100) *Adolph Müller-Welt* had set up a flourishing business in Stuttgart and counted on opening a branch in the USA with the collaboration of *Joseph L. Breger*. As he was unable to immigrate to the United States, he set up first in Toronto (Canada), while *Breger* managed the American side of the company from Detroit (Michigan).

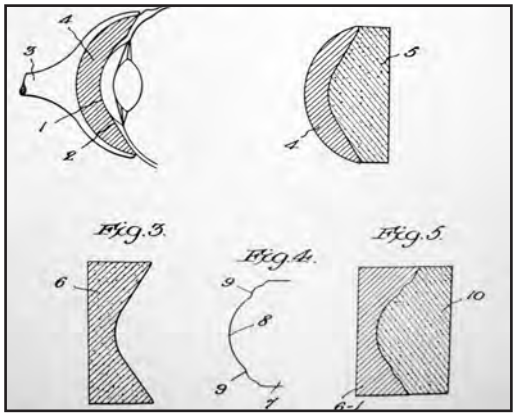


Figure 25-28
Kollmorgen's patent. *The patent describes the manufacture of a primary cast from the eyeball, then of two replicas and metallic reproductions forming dies adapted to mesh with each other for molding a contact lens.* (Kollmorgen F.L.G., 1939)

The interest in the introduction of *Müller-Welt* contact lenses into the USA resided essentially in the fact that these were the

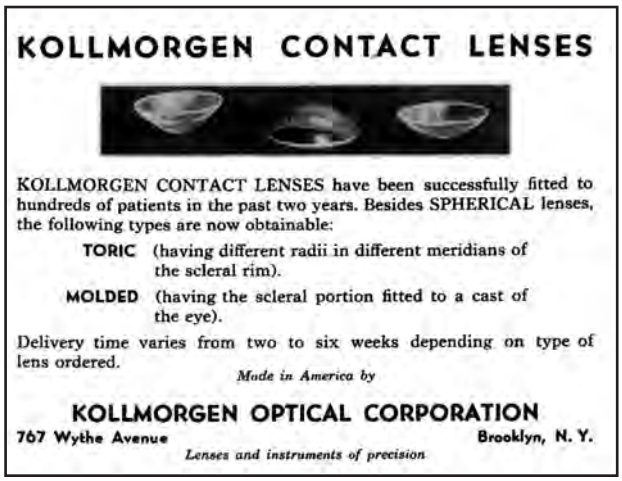


Figure 25-29
Advertising for Kollmorgen contact lenses (1940).
The advertising division of Kollmorgen Optical Company demonstrates the originality of contact lenses following the molding procedure for toric molded contact lenses.
(Optometry Weekly, 1940)

Figure 25-30
Announcement of Kollmorgen's cessation of manufacture contact lenses (1942).
In 1942, Kollmorgen Optical Company discontinued the manufacture of contact lenses in order to give priority to optical instruments for military use: periscopes, navigational and fire control instruments.
(Optometry Weekly, 1942)

first fluidless contact lenses on the American market. [101] They were provided with a loose corneal haptic, capillary corneal clearance and ventilation orifices at the limbus. All of this had the aim of favoring precorneal tear exchange, which was a concept practically unknown up to that time in America. The 'Preformed Scleral Contact Lenses' were presented, according to *Obrig*, in sets of 36 lenses: "*The Mueller-Welt fitting trial set consists of 36 lenses, 3 series of 12 each. The curves range from flat to [steep]. The N° 1 lens has the longest scleral radius and N° 12 has the sharpest scleral radius. The N° 5 lens is considered the normal radius. The trial lenses are made in three over-all diameters; a series of 12 lenses of 22 mm; the second series of 12 lenses of 23 mm; and a third series of 12 lenses of 24 mm. The three corneal curves are flat, normal, and sharp. If in fitting, the N°5 lens is tight and a flatter lens is required, a N° 3 would be flatter than the N° 5. If sharper lens is required, a N° 8 would be sharper than N°5.*"
For fitting, the corneal fit is chosen first: flat, normal or steep. A layer of tears about 0.1 to 0.3 mm thick has to be between the lens and the cornea. The scleral portion should be fit loosely. This allows the normal flow of tears to enter the corneal section and allows an air pocket to form under about one half of the scleral section. [102] In 1952, he refined the fitting procedure:
"*In the instruction manual we state to fit the lens as large and loose as possible. This is no longer advised. Fit the lens as large as possible, but fit the scleral flange so as to conform as closely to the sclera of the eye without cutting off all openings for interchange of lachrymal fluid. Do not accept extreme blanching of the sclera over a wide area. Do not accept extreme gapping of the scleral rim. Some gapping (looseness) of the scleral rim is acceptable - normal nasally; also superiorly and inferiorly in football-shaped eyes*." [103]

The introduction of 'fluidless lenses' resulted in putting into doubt the need of a voluminous precorneal space of stagnant liquid. But paradoxically, the idea of physico-chemical compatibility of liquids remained a fact of life and it was recommended to use a solution of sodium bicarbonate in distilled water for insertion of the lens. This was marketed as a capsule to be dissolved in an ounce (28.5 cc) of distilled water to which several drops of methylcellulose could be added to increase viscosity. [104]
Interest in *Müller-Welt* so-called 'fluidless lenses' was typical for the epoch. However the enthusiasm for these was stifled in the next stage (after 1950) when corneal lenses appeared. Corneo-scleral contact shells are still useful for certain pathological conditions. Thus, in 1953, *Joseph E. Birnbaum* reported "a case-history on the use of contact lenses in correcting keratoconus" with the 'New Mueller-Welt fluidless Contact Lens':

"*We chose and prepared a New Mueller-Welt fluidless lens from our trial case after a visual estimation of the shape, size and curvature of the globe and cornea was made. (...) The patient wears his lenses for thirteen hours a day, comfortably and without removing them. His vision became a constant and clear 20/50 as the excessive lacrimation every new wearer undergoes ceased. We believe, as does his ophthalmologist, that the lenses should act as a pressure bandage and, in that manner, possibly retard the progression of the ectasia.*" [105]

3.17 - John C. Neill, Philadelphia

In 1940, *John Collins Neill* (Philadelphia), optometrist, published a criticism of the methods of examination using fluorescein as described by *Obrig* in 1937. He criticized *Obrig* regarding the obligation to use concentrations of 1 or 2% fluorescein. This required a pH of 9 that was irritating to the eye. However:

"*A more serious objection to the use of a solution containing as much as 2 per cent of fluorescein is the deep orange yellow stain imparted to clothing, towel or any flesh which it comes in contact (...). These stains are particularly objectionable to feminine patients who resent the streaking of their face and make-up.*" (106)

He reported that he had experimented without success on more dilute solutions using an ordinary tungsten filament electric light. On the other hand, contrariwise, even the most dilute fluorescein solution illuminated in a beautiful green color if an ultraviolet light source is used. He was referring to 'Mercury Vapor Lamps' of a type that required a special transformer such as supplied by American Optical Company and had been recently described by *Hague* for the surgery of cataract. Taking into consideration that the amount of ultraviolet light required in contact lens fitting is relatively low, *Neill* found that an ordinary two-watt Argon gas-filled glow lamp was sufficient. Such were manufactured both by General Electric and Westinghouse. All that was required was to place the lamp in a reflector and to equip it with an ultraviolet filter in order to make the illumination less bright. Such a lamp had just been marketed. (107) In 1946, *Neill* reported his success in fitting a keratoconic aphakic patient and, most importantly, the reestablishment of binocular vision. This was achieved after fitting a molded all-plastic lens and orthoptic treatment. It was unusual for the optometrists of this era to report such a case. According to *Neill*, the reduction of aniseikonia associated with unilateral aphakia had been demonstrated mathematically by *Boeder* and the correction of the first case had been reported by *Greenspoon*. *Neill*'s patient was therefore the second case reported in the literature. (108)

In the following year (1947) *Neil* described optometric office minor adjustment procedures for plastic contact lenses as well as the deployment of contact lenses for occlusion purposes in a case of uncorrectable diplopia. In 1948, he extended himself at great length on the origin of 'Contact Lens Haze' and on contact lens solutions. (109) For this author, contact lenses had reached such a stage of perfection, above all because of the introduction of pmma, so much so "*that it is rather unusual to find a person who cannot be fitted comfortably with such lenses*." Nevertheless: "*Haze or fogging of vision is a phenomenon experienced by nearly every wearer of contact lenses. (...) Experiments have been cited which tend to support that corneal hazing a/ is not directly due to the osmotic power of the initial solution, b/ cannot be attributed directly to the retention of carbon dioxide by the cornea, c/ may be due to obstruction of the aqueous veins by hydrostatic pressure created by the contact lens, d/ may result from conjunctival irritation, Solutions and lenses which do not produce irritation are of paramount importance in our quest for the perfect contact lens*."

Figure 25-31
The Stroblite Ultraviolet Lamp. *In 1940, Neill declared his preference for an ultraviolet lamp, consisting of a two-Watt Argon glow lamp manufactured by both General Electric and Westinghouse. This lamp would fit any standard socket and had a three-inch reflector. The rays emitted were not completely dark, but could be made darker by enclosing the lamp in a reflector fit with an ultraviolet filter obtained from the Stroblite Company, 35 W 52 Street, NYC.* (Neill J.C., 1940)

When the Contact Lens Clinic was opened by the Pennsylvania State College of Optometry in March 1949, *John C Neill* became its director. In 1950, he published the result of fitting, under his direction, a cosmetic contact lens to correct a disfiguring scar of the eye. He did this with a trial case and a Feincone lens. A casting of the adjusted lens, with the appropriate color code, was sent to the *Policoff Laboratory.* (110)

After 1948, *Neill* drew attention to *Tuohy*'s corneal contact lens, then, in 1951, he published a detailed assessment of the types of contact lenses that existed at this epoch. (111) In the following years, he extended his efforts to microlenses and published an in-depth research project on slit-lamp examination for fitting and follow-up examinations as well as the fitting of aphakic patients. (112)

3.18 - Joseph S. Nupuf, Canton

In 1945, *Joseph S. Nupuf* (Canton, Ohio) presented a comparative study of the diverse plastic materials that could be used for the manufacture of contact lenses: this included manufacture by casting, shaping and molding. He concluded that casting and polymerization in molds were the best-suited procedures be-

cause they eliminated internal tensions and allowed the optical surfaces to be polished. The experiments that he had carried out during the two preceding years showed that custom-made 'Nupuf Lenses' that were manufactures starting from ocular moldings did not have any plastic memory. These lenses had appropriate corneal and limbal clearance and were from this fact well tolerated right away in 95% of cases. (113)
This presentation was the subject of commentary by *Eugene Freeman*:

"*Nupuf describes the characteristics of the new lens which he has developed and made available to the profession of optometry. One of the principal features is that his lens is made by a precision molding process, which results in two advantages. The first is that the lens will maintain its shape when placed in boiling water, the second is that the lens fits the cast so well that there are no loose or tight areas which need to be adjusted when the lens is being fitted to the eye*." (114)

After the era of the description of *Braff*'s procedure of molding without anesthesia, *Nupuf* and four other Ohio optometrists checked and confirmed the feasibility of this by experiments on their own eyes:

"*We conclude that, physiologically, accurate eye impressions are safely obtained with less irritation and discomfort to the patient, when no anesthetic or vasoconstricting drugs are used.*"
In 1966 and during the years that followed, Nupuf developed and patented instruments, which measured the meridians of a contact lens and of the eye." (115)

3.19 - Parson, San Francisco

Parson was one of the first contact lens pioneers, but he did not publish his observations. During his visit to America in 1947, *Norman Bier* visited him and made the following comments:

"*Dr. Parson is truly one of the 'back room boys' in American contact lens work and, during his 32 years in this field, he has acquired a vast practical experience; although one has yet to hear his name as a lecturer and author, I had the greatest pleasure in discussing the evolution of contact lenses with him and also the modern trends and developments in this field. He practices the moulding method exclusively and since he has now acquired control of the Kollmorgen Glass Lenses Company he is probably the only practitioner in the United States still in a position to supply glass lenses and replacements. In the main, he fits plastic contact lenses in common with the majority of U.S. practitioners and his practice also includes the fitting and making of artificial eyes and ophthalmic instruments. He also carries out extensive research work in his well-arranged laboratory*."

3.20 - Joseph I. Pascal, New York

Joseph Irving Pascal (New York) has a double diploma, i.e he is both an ophthalmologist and an optometrist. In 1952, he was the author of a treatise, 'Selected Studies in Visual Optics', but his unique place in American ophthalmology was determined by the fact that he remained an optometrist as well as an ophthalmologist all his life. He was quite a linguist, read, wrote and spoke Spanish, Italian French and German. He invented, developed or improved several instruments for examination of the eyes and he also was interested in the progress of knowledge in ocular geometry as shown by his publications as well as in the consequences of this for the manufacture and fitting of contact lenses. In 1947, he judged that the development of corneoscleral contact shells, first spherical shells as compared with molded shells, then the conical haptic type of shell, i.e. *Feinbloom*'s 'Tangent Cone Lens' represent a significant advance. On this lens, the haptic pressure is most comfortable when it is exerted over a small area of the eyeball. However, this principle of substituting a narrow tangential bearing surface to a wide 'glove fit' bearing surface does not solve all the problems in contact lens work. In his publications, *Pascal* also analyzed the forces of suction and adherence, the effect of precorneal centration of the lenses and the dioptric power of the lachrymal meniscus. He doubted, however, that contact lenses would ever displace glasses, but believed that they will, in time, attain a wide popularity as a supplementary to glasses in the quest to attain normal vision. (116)

3.21 - Emerich Rakos (The Invisible Lens Inc.), New York

After emigrating to the USA, *Emerich Rakos*, who held an Austrian patent for 'contact shells for individual fit and ground optic', founded in New York the 'The Invisible Lens Inc'. He readily adapted his observations, cognitions and patent that he had acquired in 1936 using glass, to plastic materials that were decidedly easier to work with.
The 'Invisible Lens Inc.,' and its president director *Emerich Rakos*, are cited numerous times for their innovations. This was particularly true when, in 1943, they presented their 'new trial set for fitting contact lenses', resulting from the collaboration with *Reuben Greenspoon* (Beverly Hills). (117)
The latter had produced hundreds of ocular moldings, starting from which, *Rakos* had derived 85 'composite trial lenses'. For usage, he confirmed that 87% of his patients could be fit with only 25 trial lenses and this constituted his trial set. For the remaining 13%, moldings did not give useful results, often because the globe was too soft, or a good scleral mold was not obtained, or for some other reason. For such cases, a special trial set was available:
"*This new trial set consists of twenty five plastic trial lenses. Six lenses are symmetrical, five lenses are asymmetrical, seven lenses have the shortest vertical radii and four lenses have the shortest horizontal radii. Also included is one cataract trial lens for aphakic cases; one conical corneal trial set and one very high minus trial set. To fit the 13%, a special trial set will later be available.*"

Inspection is made with fluorescein solution viewed with cobalt blue light from a Strobalite lamp in order to check if there is ample corneal clearance for 3.0 mm beyond the ocular limbus. The contact lens must not interfere with the conjunctival vessels; then the center of the lens is marked and the optic is then ground. It can even be tinted or painted. You can also produce a copy of it, made from plastic or glass.

3.22 - Samuel W. Silverstein, New York

In 1945, optometrist *Samuel W Silverstein*, who was an adept of *Feinbloom* contact lenses, found that making a mold of the eye was both unnecessary and undesirable. He found that the taking of a mold caused some discomfort to the patient, that there are too many variables that enter into the taking of a mold, that a lack of precision exists in the stone impression and that much time is lost in working with the semi-finished lenses. He suggested that optometrists should use stock lenses in average cases. He had also invented a projection method of checking the radii of curvature of lens surfaces with the aid of a 'delineoscope' and a special lens holder, which permits the examination of any meridian. (118)
During his trip to America in 1947, *Bier* visited *Silverstein* in New York and made the following comments:

"*Dr. S.W. Silverstein desires to introduce contact lenses so graded and calibrated in order that these can be provided from stock fittings. His lenses developed within the last 12 months are elliptically shaped and decentred in the long axis. He has a standard set of 11 stock lenses and, whenever repaired, these lenses can be ordered with decentred spherical scleral quadrants or toroïdal portions.* (119)
The method of fitting is, in brief, to find the sphere from the trial set, which gives the most satisfactory overall fit. Loose areas are then marked and, unlike in any other method practised, these portions are fitted with a decentred flatter scleral radius and not the customary steeper scleral radius. This is indeed a departure from the usual method. This decentration of radius confined to a local area on the contact lens can be in one or two quadrants or more if necessary. It should be noted, however, that the principal meridians are always at right angles to each other. Although the decentration of the localized flatter central radius has to be estimated, it is obtained in decentration steps of 2, 4 or 6 mm. The obvious advantage of this method is that loose areas are not eliminated by bending a localized point on the contact lens, but rather by giving a flatter decentred scleral radius in the area concerned.
With this method, however, tight areas have still to be relieved by bending or grinding and for this operation Dr. Silverstein has produced a 'vice' arrangement which holds the contact lens without distortion of the optic in any way. It should be appreciated that the 'stock lens' is the actual lens, which is used for the patient, and that the optic is ground for the patient's individual prescription. A replacement lens is then ordered for the fitting set from the laboratories. The thickness of the finished lens is 0.7 mm and they are produced by pressing from the plastic sheet.
The anterior surfaces are ground and polished. On the 11 stock lenses, the scleral radii vary from 12 to 14 mm in 0.2 mm steps, the elliptical overall diameter being 22 by 21 mm from 12 to 12.6 mm scleral radius,

23 by 22 mm from 12.6 to 13.6 mm scleral radius and 24 by 23 mm from 13.6 mm and over.
The standard corneal radius is 8.5 mm although any corneal radius may be incorporated when required.
The transition cone extending over an area of 3 mm gives a pleasing cosmetic appearance and from its nature of construction it will be appreciated how the name 'Transcone' was evolved."

In 1950, *Silverstein* applied for a patent to be assigned for a 'ventilated' corneo-scleral contact shell. He envisaged that the corneal part should be ground in such a manner as to create a large precorneal space. This space was intended to retain tears. The limbal part consisted of a widely- arched annular surface intended to create a pocket around the corneal section. This part should be provided with bored holes or channels for draining tears in the limbal space that would be filled with tears and partially with air bubbles. The inventor promised good lachrymal circulation at the limbal level and improved resulting tolerance. The patent also cites patents of *Dudragne*, because the latter had offered similar solutions intended to keep the limbus clear and drain the tears, thus improving lachrymal circulation. (120)

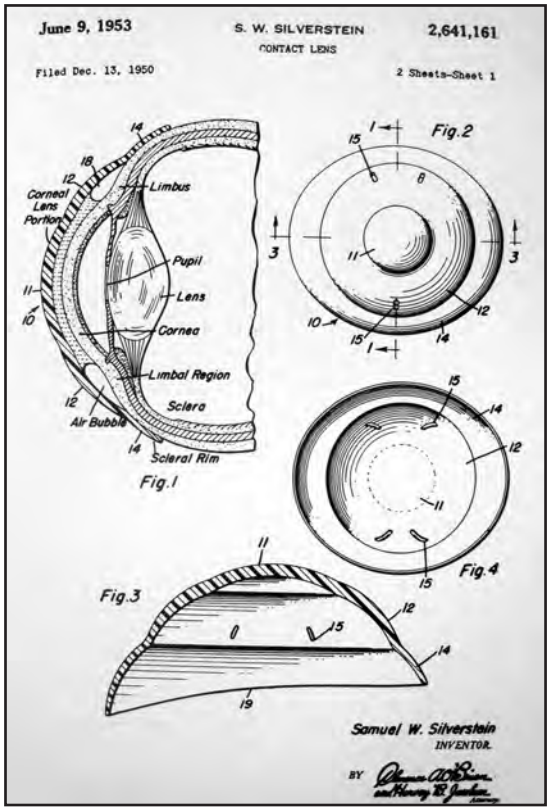


Figure 25-32
Silverstein's ventilated contact lens.
Silverstein's patent envisaged a corneo-scleral contact shell with large corneal clearance, and, most importantly, a 'ventilated' corneo-scleral junction zone. The limbal zone is a wide annular zone, the radius of curvature of which is highly arched, producing a large space drained by holes and channels. This area contains thin slivers of air and air bubbles that were felt to improve the oxygenation of ocular tissues.
(Silverstein S.W., 1950)

3.23 - Arno E. Town, New York

In 1939, *Arno E. Town*, ophthalmologist, presented a technique of ocular molding in which '*Kerr*'s dental wax of gage 20' was used to achieve the best scleral approximation. (121) The Negocoll-Hominit procedure remained the best for an impression of cornea and limbus. For using dental wax, the first step is to determine the approximate scleral curve by means of ground glass of known curvature. A piece of wax of 7.5 mm is cut and slowly molded over a hemisphere of the same radius of curvature as the ocular sclera. Using a punch with a 11 mm diameter, the center of the wax is punched out and a glass center of 12 mm diameter is placed over the hole. A convex glass of chosen size is then placed over the wax form. The latter is now available with the approximate scleral curvature. This is placed in ice water for five minutes. It is then put in the anesthetized eye for fifteen minutes. The form is then sprayed with ice water to harden it and removed. The positive form is made of dental stone. A skeleton glass is made from this form. After the fitting and correcting of the skeleton glass, a finished glass is made with the proper optical correction. For a good fitting, the contact glass must cover a large area without any pressure on the peripheral portion and it must not be in contact with the corneal or limbus. Air bubbles must not form under the glass It must be worn for four hour trial periods with comfort on two successive days.
Several months later, *Town* presented once again his technique for fitting and became the advocate for contact lens fitting to be performed exclusively by physicians:

"*Contact glass refraction is a part of ophthalmology and should be performed by oculists. The taking of impressions (...) should not be performed by an optician or technician.*" (122)

3.24 - Turner Veith (National Contact Lens Co.), New York

The company "The National Contact Lens Corporation" of *Turner Veith* (New York) was a serious competitor in the contact lens market as *Norman Bier* explains in 1947:

"*The chief feature of Dr. Veit's lenses is that they have a toroïdal haptic with a wide transition anteriorly and posteriorly. Dr. Veith contends that, for the satisfactory fitting of his lenses, the 'master' set of 225 lenses, of which only 12 optics are worked for measuring refraction, is necessary, although a satisfactory result can be achieved with the 'junior' set of 88 lenses, with only 6 optics. In his practice, Dr. Veith found that all but 2% of patients can be fitted with an 8.5 mm corneal radius with the particular construction of his lens although any radius from 7 to 9 mm corneal radius in 0.5 mm steps can be ordered if required. The overall diameter of his lenses is 24 by 23 mm with a 13 mm corneal diameter decentred 1.5 mm in the long axis. The final thickness of the lens is 0.8 mm and it is not unusual for 'spot' grinding and tightening of the lens to be performed in the final fit. The scleral radii vary from 12 to 14.8 mm in 0.2 mm steps in toroïdal form and in the 'junior set' some of these toroïdal differences are increased to 9.4 mm steps.*
The lenses are produced from sheet compressing, the inside curves being completed by this method and the outside curves remaining to be worked to the individual requirements and the sample showing each stage of production which Dr Veith was kind enough to give me, demonstrate the process admirably. I have found various practitioners all over the States using this technique." (123)

3.25 - Newton K. Wesley, George N. Jessen (Precision Plastic Contact Lens Company), Chicago

Optometrists *Newton K. Wesley* and *Georges N. Jessen* founded the 'Precision Plastic Contact Lens Company' in Chicago in 1949. This company's prime aim was research into the correction of keratoconus, with which *Wesley* was afflicted. From the moment of the appearance of corneal contact lenses, this company rapidly adapted to the new technology and achieved great success. (124)

3.26 - Other publications and noteworthy contributions (1940-1950)

In 1940, *Julian F. Chisholm*, ophthalmologist in Boston, Massachusetts, had just presented a demonstration on the present status of contact lenses. He went on to describe an adjustable fixation target with a muscle hook. (125) In the following year 1941, *David G. Cogan* observed in a study on the origin of bullous keratopathy that:

"*the corneal opacity which commonly occurs with the use of contact glasses is similar, due to a hypotonicity of the fluid used, and may be eliminated by the substitution of a 1.5% solution (or weaker) of sodium chloride.*" (126)

F.M. Lippmann, optometrist, thought that the molding or casting technique in making contact lenses presented no advantage over other techniques used. He pointed out that certain patients seemed to react better to the glass spherical type of contact lenses while others adapted better to the plastic and glass contact lens. (127)

In 1942, *J.W. McKinney* discussed contact lenses from the standpoint of historical background, indication, uses and the technique of fitting the molded lens. (128)

In 1943, the following year, *P.H. Boshoff* pointed ought the factors involved in making an impression from the cornea and sclera. The elasticity of the mold prevents permanent deformation of the impression when it is removed from the eye. (129)

In 1944, Canadian ophthalmologist, *L. Kazdan* (Toronto), reported the use of contact lenses in eyes, which had suffered traumatic aniridia and secondary cataract. After a contact lens with a +10 correction was made and was painted black except for a central pupillary area, the patient obtained excellent vision and a good visual field. In the same year he delivered a communication on the present status of contact lenses at the Academy of Medicine of Toronto *John H. Dunnington* and *Ludwig von Dallman* concluded from their work that corneal baths were of little avail. *Kenneth L. Roper* and *Robert E. Bannon* discussed the use of monocular occlusion to evaluate patients with heterophoria. The opaque contact glass had proved the most suc-

cessful from a therapeutic standpoint. Occlusion for less than two weeks is insufficient and annoying to the patient. [130] *Charles E Jaeckle* studied the use of contact glasses under low atmospheric pressures. He found that wearers of contact lenses may expect to have bubbles under the lenses, with constant diminution of vision when subjected to elevation of 18,000 feet or over. This study was undertaken because of its importance in military aviation. Bubble formation was noted at 5,400 meters of altitude but it was found that the length of time contact lenses were worn was not related to bubble formation: "*Can contact lenses be used practicably in planes at the altitudes commonly attained in modern warfare? The observations here reported were made in an attempt to answer this question. Numerous studies of ocular function have been made under conditions of low atmospheric pressure and, hence, low partial pressures of oxygen.*" [131]

In 1945, *H.T. Billger* presented two patients who had recovered their binocular vision using contact lenses to correct a pronounced anisometropia, due, in one case, to post-operative aphakia, in the other, to high unilateral myopia. In the same year, *Hugh A.G. Duncan* described a plastic contact lens that could be used for a constant bathing of the eye by attaching the set-up ordinarily used for constant intravenous infusion. Then, an ophthalmologist named *David Kadesky* presented his results obtained in prescribing contact lenses for 100 patients, of which 15 were keratoconus patients, 7 aphakic with the balance coming from myopic patients, many of whom had significant astigmatism. The author found the resulting visual acuity to be good. In his group, however, 2 were unable to wear the lenses, 48 could not wear them for more than four hours, 29 for not more than 6 hours and 21 for between 8 and 10 hours. [132]
In the same year, two ophthalmologists from Detroit Michigan, *Leon E. Firestone* and *Ernest M. Gaynes*, made an objective analysis of 'the construction of contact lenses relative to wearing time'. They came to the following conclusion, which was going to be applicable but was, at the time, unknown in the United States: "*Buffer solutions make the effective corneal clearance less than calculated as the lens is worn (and) making lenses with larger clearances than those usually supplied by the manufacturer increases the percentage of successes as measured. (...) The increased clearance allows the lens to rest further from the limbus and vascular plexus, resulting in less interference with corneal metabolism*." They pursued their meta-analyses of contact lens failures, using orthoptic examinations and came to the following conclusion in 1949: "*Induced prismatic effects are extremely common among contact lens wearers. These induced effects are often the cause of so-called contact lens failures*." Thus they supported the same conclusions that had already been published by *Freeman*. [133])

In 1946, *Gilbert C. Struble* and *John G. Bellows* found that the use of a contact cup for eye baths with solutions of penicillin had definite advantages and in the following year, *Robert Graham* described a series of experiments that he had carried out in order to evaluate contact lens fits and ocular mold-taking without anesthesia. He determined that patients did not feel any pain at the time of mold taking, whether this was with or without anesthesia, but, in the last situation, there was considerable apprehension. The optometrist has the advantage of not using an anesthetic agent, because the patient will subsequently point out to him the occurrence of any epithelial lesions. At the time of the fitting of the first corneal contact lenses, *Graham* published some remarkable descriptions of these. [134]

In the following years, *Irving P. Filderman* reported fitting an uniteral keratoglobus patient who also had strabismus. This individual wore contact lenses comfortably for the whole day by renewing his contact lens solution every 5 hours. *Howard F. Haines* reported the case of a monocular anterior corneal staphyloma corrected by contact lens with resultant binocular fusion.

Then *Russell S. Manwiller* described 12 consecutive cases taken from among the first 50 applicants to the Philadelphia Contact Lens Clinic. There were 6 myopes, 2 astigmatism patients, 1 keratoconus, one deformed cornea due to keratoconus and 1 with severe keratitis scarring. 2 patients could not be fit due to corneal or retinal lesions. According to *Manwiller*, the first free contact lens clinic in America was opened to the general public by the Pennsylvania State College of Optometry in Philadelphia on 15th March 1949, Since 1945, the College has been offering a postgraduate course in Contact Lens Fitting to the optometric profession. The Chief of the first Contact Lens Clinic was Dr. *John C. Neill*. The Contact Lens Clinic was situated in their main building of the College. It could accommodate 6 patients at a time with three students assigned to each patient. [135]

4 - Assessments and Perspectives (1940-1950)

The decade from 1940 to 1950 included World War II. It started in the USA with the introduction and utilization of pmma for the manufacture of corneo-scleral contact shells. Because of this, the facility and ease of transformations and touch-up of plastic materials led to the progressive abandonment of traditional contact shells made from glass with the correction by means of a more or less large precorneal space in favor of shells with a ground anterior optic. Nevertheless, the apprehension of certain contact lens fitters in regard to harmful corneal contact resulted in the maintenance of a protective space of 'apical clearance' at the origin of intolerances and symptoms attributable to liquids required to fill this space.
It is also necessary to record that the manufacturers of contact lenses at this period in history were relatively few in number and that they guarded jealously the finer secrets of their manufacturing methods. It was normal practice that each employee's working space was locked up a key and that that employee knew only the part of the manufacture that he did and was unaware of the activities of his fellow workers.
This ten-year period was closed by an event marking the presentation in June 1948 by *Maurice W. Nugent*. He was Professor of Ophthalmology at the College of Medical Evangelists in Los Angeles. His presentation was entitled, 'The Corneal Lens: a new type of Plastic Contact Lens'. It described the first 12 fittings of corneal diameter contact lenses by *Kevin M. Tuohy*, using lenses manufactured by Solex Laboratories of Los Angeles. [136] At the time of this historic landmark of the 1950s, several observers felt the need to reassess the state of contact lenses, of which the dissemination had been accelerated in the previous decade, but seemed now to be stagnating. From the point of view of the optometrists, the most interesting studies were those of *Koch*, *Bridgman*, *Zabner* and *Neill*. From the standpoint of the ophthalmologists, there were two assessments, the first by *Berens* under the aegis of professional regulations; the second was an independent assessment by *Abraham* and *Shameding*. However, the most significant document was Report Number 99 of the Army Medical Research Laboratory at Fort Knox, Kentucky, entitled 'Contact Lenses: An Evaluation Study'.

4.1 - The Opinion of the Optometrists

4.1.1 - Carel Christian Koch's Criticism

An influential member of the American Academy of Optometry, *Carel Christian Koch* (Minneapolis), who was co-editor of the American Journal of Optometry for more than 30 years, presented several interesting comments on interprofessional relations of his profession. In 1941, *Koch* had commented favorably on *Greenspoon*'s fittings of cosmetic contact lenses for actors at Hollywood, while, at the same time, regretting the lack of interest in contact lenses by his optometric colleagues: "*This is in part due to the former difficulties encountered in properly prescribing (...) and also to the normal professional inertia encountered in the development of new techniques which may in part supplant old ones*."

C.C. Koch wrote, in 1951, a critical assessment of the evolution of contact lenses by his colleagues: "*The majority of optometrists have had no training in this specialty. (...) It is evident that some practitioners refer contact lens cases to lay technicians instead of referring cases to optometrists who are better qualified to do this work than are lay technicians. (...) To refer the cases to lay technicians is to place this important professional technique in the hands of untrained lay persons who lack the proper educational background to handle this work*."

Koch's situation was an unusual one, because, in his Minneapolis office, he only did vision consultations. He did not dispense spectacles, but made referrals to dispensing opticians. He abhorred commercialism in optometry, such as advertising or promotion of optical devices. He was consistent with his notion of optometry as a profession that charged fees for services and did not profit from the sale of optical material. [137]

4.1.2 - Charles J. Bridgman's 'Opposed Viewpoints in Fitting'.

In 1948, *Charles S. Bridgeman* presented a 'Summary of Certain Opposed Viewpoints in fitting Contact Lenses'. According to him, the most important controversy and the one from which the majority of others result, is that of the nature of the transition zone at the corneo-scleral junction. Whether they be molded lenses or trial lenses, the design of the limbal section is either too abrupt or too gradual, whence an inade-

quate limbal clearance. This transition zone determines the pressure applied to the cornea or the conjunctiva and, therefore, the movement of the contact shell. One tries to limit these movements by modifying the overall size of the shell and its geometry, whether oval or egg-shaped. *Bridgman* wrote that he had no opinion on the apical contact recommended by *Dallos*. This seemed difficult to reproduce. On the other hand, apical clearance was preferable, provided one did not have too much. He concluded by recommending to fitters that they carry out small modifications of the contact lenses themselves (retouching). In that way, they were most likely to verify and comprehend the best method of achieving a successful fit. (138)

4.1.3 - Louis M. Zabner's 'Economics of Contact Lens Fitting'

The economic aspect of contact lens fitting was approached in 1953 by the optometrist *Louis M. Zabner* (Los Angeles), who stated:

"*In the young and unsettled world of contact lenses, relatively few men throughout the country have sufficient experience to make the fitting of contact lenses worthwhile. (...) The very development of contact lenses did not come from the practitioners, but rather from the early manufacturers who at that time did their own dispensing.*
The manufacturer is not only the principal instructor for the untrained optometrist, but he is also one of his principal competitors for patients. With one exception, all major manufacturers are in the field of fitting lenses. On the other hand, they advertise to the optometrists in our journals and, on the other, they advertise to the public in the daily press. (...)
Another most important economic unit in the field of contact lenses is the dispensing optician. A lesson of equal importance is the experience of the employee – the contact lens technician. Large dispensers throughout the country employ contact lens technicians with as long as 20 years' experience in contact lens works. We, as optometrists, (...) are losing another segment of our practice to both medical and lay practitioners." (139)

4.1.4 - John Collins Neill's Comment

In an editorial published in 1948, *John Collins Neill*, Director of the Contact Lens Clinic of the Pennsylvania State College of Optometry, had made some reservations in his opinion regarding the first corneal contact lenses of *Tuohy*. However, in 1951, in an assessment of available products, he observed that not one of the three types of contact lenses, namely, the conventional fluid-type lenses, the *Tuohy* corneal cap lens and the minimum clearance lenses seemed to respond to fitting attempts. (140)
In his opinion, traditional corneo-scleral lenses, be they preformed or molded, are seldom utilized. All lenses of this category require a fluid to fill the water lens chamber not one of which was found to be satisfactory. Most persons wearing this type of lens develop corneal edema within a few fours. Adjustments sometimes helped partially to resolve these problems. Such adjustments are however not possible with all types of lenses. Besides, impressions with alginates are not satisfactory. "*The conventional fluid lens is seldom used today because of its poor appearance and short wearing time*." On the other hand, the so-called minimum-clearance lenses have numerous disadvantages: "*One such lens is fitted so that the scleral limb lies rather loosely on the sclera and the corneal section is designed and adjusted so that its posterior surface lies nearly tangential to the anterior surface of the cornea. No accessory fluid is used with a lens so fitted. The limbal space fills with tears usually within a few minutes after insertion. Such lenses have been described by Bier, Müller-Welt and others. (...) Proper fitting of the minimal clearance lens requires painstaking and time-consuming work on the part of the clinician and usually requires many patient visits before the optimum clearance has been obtained. (...) The minimal clearance lens has a long wearing time and is comfortable, but it is difficult and time-consuming to fit*."
Finally, *Neill* admitted that the self-centering lens of *Feinbloom* is the most satisfactory lens "*The self-centering lens is readily fitted, is comfortable and has a longer wearing time than conventional lenses, but not usually so long a wearing-time as the minimal clearance type*."

4.2 - The Viewpoint of the Ophthalmologists

Two important assessments were presented during this era by ophthalmologists: the first by *Berens* under the aegis of professional organizations, the other by *Abraham* and *Shameding*.

4.2.1 - The 'Contact Lens Problem' by Conrad Berens

Under the title 'The Contact Lens Problem', *Conrad Berens* (New York) published in 1949 a memorandum widely disseminated and addressed to Government [141]. The 'American Committee of Optics and Visual Physiology', consisting of ophthalmologists from existing scientific societies, had elaborated the document. In it, *Berens* stated: "*Most ophthalmologists believe that the increased sales of contact lenses by lay persons not properly licensed by State Laws to care for ocular conditions, is dangerous to the public. Sensational advertising in the last few years has resulted in luring many persons into spending thousands of dollars in the hope of throwing away their glasses*."

The Committee had sent 2,000 questionnaires to the ophthalmic community and received 575 replies that he was able to use: "*162 have no experience with contact lenses or so little that they have no comments to offer, 373 prefer the molded plastic technique, 22 use the Feincone technique and 18 the trial or test plastic sets. (...) Many doctor prefer to have technicians fit the lenses and several specifically mentioned the Obrig trained technicians as being very satisfactory. (...) Practically all agreed that the patient deriving the greatest benefit from contact lenses are those suffering from keratoconus. Others report success with patients having monocular aphakia, younger patients following cataract operations and those with high astigmatism and aniridia. (...) Among the complaints concerning contact lenses, the most frequently mentioned were the following: limited time that most patients can tolerate. (...) The solution is unsatisfactory. Lenses are too expensive; there is too much commercialism and exploitation by manufacturers. It was agreed that the whole subject of contact lenses is still in a research period. The main problem at the present time, provided that the fitting of the lenses is correct, is that of hazy or cloudy vision.*
The public should be warned against those who advertise the superiority of their services or of any particular type of contact lenses."

4.2.2 - The 'Clinical Status of the Contact Lens' by Abraham and Shanedling

Independently of the questionnaire carried out by *Berens*, ophthalmologists *Samuel V. Abraham* and *Philip D. Shanedling* had also carried out their own questionnaire, the results of which were published in 1950. [142] The authors concluded that, at the present time, the literature has been concerned with technical aspects of the problem, but the problem of tolerance itself has not been solved: "*There have been several statements suggesting that the use of contact lenses is not generally as satisfactory as the literature and widespread publicity would seem to indicate.*" The authors sent questionnaires to 300 physicians and their patients. They obtained 59 usable replies from physicians and 1,407 from their patients. They questioned neither manufacturers nor dispensers, fearing that their replies might be distorted by reason of their lack of contact with dissatisfied patients. Amongst these responses, one was to note that the 59 responding physicians prescribed approximately 1,407 pairs of contact lenses in the course of the previous five years and most estimates that their activity in this field was decreasing. One comment seemed to summarize the medical point of view: *"I might say here that we accept no true cosmetic cases and are very particular in our screening as we feel that contact lenses are useless unless the patient gets considerable improvement in vision, comfort, or visual efficiency*."
Among the patients' replies, one notes that the majority of the subjects are aged between 20 and 30 years. A third of these are students, 66 patients have requested contact lenses for cosmetic reasons, 28 for improved vision and 7 for keratoconus or cataract. Only one third of the patients wear their contact lenses every day, a third have discontinued contact lens wear and the remainder states that they wear them occasionally. 78 patients complained of symptoms while wearing contact lenses, but about half of these wore them nevertheless. The authors concluded: "*The greater the need, the more likely is the patient to tolerate the contact lenses but, even in cases where the need is great, the wearing time is still too low in most cases. Until the problems connected with contact lenses are well appreciated and cared for, ophthalmologists would do well to discourage dispensers and manufacturers from over-enthusiastic exploitation. It would seem that contact lenses (…) require further research.*"

4.3 - The US Army Contact Lens Evaluation Study

In October 1952, the Army Medical Research Laboratory at Fort Knox KY concluded a report entitled 'Contact Lenses: an Evaluation Study' led by *James L. McGraw* and *Jay Michel Enoch*. Summaries by the same authors were to be published in the following year and extracts reproduced in various publications. [143] The

authors compared four types of contact lenses with glasses The contact lenses were fit by the most competent specialists: 1/ The conventional fluid-type plastic lenses fit by the molding technique at the Obrig laboratories in NYC; 2/ The corneal plastic lens fit by *Kevin Tuohy* of Solex Laboratories; 3/ The fluidless ventilated glass lens fit by *Dallos* in London; 4/ A fluidless ventilated plastic lens, Lacrilens, fit in the *Obrig* Laboratories.
The 61 pages of the document are very precise and report on the way in which the ten selected subjects were exposed to extreme conditions liable to occur during combat, along with every detail of significant investigation used to examine them. The authors concluded that, for army use, *Dallos* contact lenses and ventilated Lacrilens are superior to all other contact lenses: "*The overall performance of the Dallos and the Lacrilens was comparable. The Lacrilens, while its fitting period was prolonged took less time to fit than the Dallos. Furthermore, the Lacrilens being plastic is not so easily broken. The Dallos lens, on the other hand being made of glass requires no wetting agents and it is more easily duplicated. While the actual construction of the two lenses is quite different, it is felt that the principle of fitting that allows for aeration of the cornea and a constant flow of lacrimal fluid accounts for their superiority*."

The cost of the lenses and the necessary duration of time to fit limit their use at the present time. The lenses are however superior to glasses for many specific indications noted. The authors of this report state also that the number of fully qualified fitters is now grossly inadequate: "*The number of individuals skilled in the technique of fitting the newer types of contact lenses is extremely limited*."

4.4 - The Therapeutic 'Flush-fitting' Scleral Contact Lens in the U.S.

Scleral contact shells still followed a discrete career over the years in the form of therapeutic 'flush-fitting' contact shells. The principle consists essentially of manufacture of a corneo-scleral contact shell, which is a copy conforming to the impression of the ocular globe with corneal and scleral reliefs faithfully reproduced. The contact shell is separated from the corneal tissues and the scleral tissues by a capillary layer of tears, the renewal of which ensures both a regular supply and exchange of nutrients.
In 1959, *Albert D. Ruedemann* of Detroit had invited *Frederick Ridley* (of Moorfields Eye Hospital, High Holborn Branch, London) to present his experience with flush-fitting molded corneo-scleral contact shells. In return, *Ruedemann* paid a return visit to his invited guest in London in order to learn about *Ridley*'s new therapeutic approach that he then introduced to the USA. (144) Ten years later, he presented a synthesis of the joint project and enumerated his experience with several thousand fittings of scleral contact shells. He took imprints using Jeltrate and molded a plaque using pmma heated with compressed air above the stone mold. (145) The author thus fabricated 5 different types of contact shell, each with precise indications:
1. The refractive corneal contact shells that he recommended for certain patients with unilateral aphakia;
2. The 'fluid type' of scleral contact lenses, that constituted the treatment of choice in keratoconus;
3. The 'flush-fitting' scleral contact lenses, used with therapeutic aim in vascularizing keratitis, Stevens Johnson syndrome, ocular pemphigus, corneal burns, neuroparalytic keratitis, corneal abscesses, perforation and post-keratoplasty:"*In general terms, it is utilized to re-establish the integrity of the corneal and conjunctival surfaces and maintain the separation of palpebral and bulbar conjunctiva*."
4. The 'cosmetic cover shells', in flush fitting, with the iris painted on the posterior lens surface or as a cosmetic cover shell for microphthalmic or phthisical eyes.
5. The 'evisceration shells', in flush fitting, over an eviscerated eye with cornea preserved.
According to *Ruedemann*, the therapeutic success of flush-fitting shells provides equally well the protective effect against rubbing of the eye and the pressure on the lids from the continuous irrigation provided by regular replacement of the capillary tear layer. The treatment cannot be used where there is insufficiency of tears.
In the same year, *Seymour B. Goren* and *David Shoch* (Chicago) reported that they had successfully used 'flush-fitting' shells in 9 patients with severe neuro-paralytic keratitis after neurosurgical removal of acustic neuroma. They noted:

"*As the corneal lesion heals, a new shell is molded so as to maintain the flush-fitting nature of the prosthesis. As many as five shells have been required during the corneal healing process*." (146)

In 1964, *Girard*, *Soper* and *Sampson* described their interest in scleral corneal contact shells at the time of the evaluation report of the first 10 years. They admitted to having limited experience (147) :"*Corneal lenses were an outgrowth of the difficulties in fitting and the numerous failures of scleral contact lenses*."

But:

"*Fortunately, certain individuals, such as Frederick Ridley of London, Theodore Obrig and others in the United States did not lose confidence in the scleral lens when corneal lenses were introduced, but continued to work with and improve them. These improvements have resulted in a lens which is worn more successfully by a great number of patients. Ridley reports 80% of 200 wearers are able to wear scleral lenses 12 hours a day or more. (...) During the past two years, we have been favorably impressed with the results of the flush-fitting scleral lens in patients with corneal ulcers and corneal burns.*"[148]

Two years later, in 1966, they described flush-fitting scleral contact lenses of which they were to repeat the technique and the indications in their later publications. [149] Also in 1966, at the time of an International Congress on Corneal and Scleral Contact Lenses held in Houston, *Herbert L Gould* (Westchester, New York) presented the results of 592 fits of flush-fitting shells in his service at Manhattan Eye and Ear Hospital and *Ridley* delivered a magisterial presentation on the theory, practice and difficulties of scleral contact shells. For the author, the final proof of a good fit ('glove fit'), but with the absence of negative pressure and a free lacrimal circulation under the scleral shells is furnished by the 'Ridley Cling'. There followed an impassioned and highly informative round table discussion that contrasted the opposing techniques with *Ridley* acting as moderator along with *Wichterle* in their attempt to explain the complications and failures observed. [150]

However, the fitting of flush-fitting scleral contact lenses was too delicate for it become widespread in its use. In particular, as long as the shell remained in perfect position without exaggerated movements, it remained comfortable. However, when it was displaced, even by just a few millimeters, there occurred, where there were corneal irregularities, risks of erosion, ulcerations and serious secondary lesions at compression points. Flush-fitting contact shells were momentarily dethroned by epikeratoprostheses, then definitively by therapeutic hydrophilic lenses.

Notes in Chapter XXV

1. See Chapter 24.
2. Beacher L.L., 1941, 1944b. Several editions. Lester Beacher was owner of the firm New York Contact Lens Research Laboratories.
3. Obrig T.E., 1942. Second edition in 1947. Theodor Obrig was proprietor of Theodor Obrig Laboratories, Inc., New York.
4. Feinbloom W.M., 1942. This book had appeared in leaflet form under the same title in the American Journal of Optometry and Archives of the American Academy of Optometry between 1940 (volume 17) and 1942 (Volume 19). William Feinbloom was proprietor of the firm Optical Research, Inc., New York City later of Feincone Laboratories.
5. Anderson A.L, 1944. Anderson was owner of the firm Precision Contacts in Minneapolis.
6. Salvatori P.L., 1945. The First National Contact Lens Meeting organized by Theodor Obrig and his associate Philip L. Salvatori was held on 13th October 1944 at the Palmer House Hotel, Chicago.
7. Bier N., 1947.
8. Obrig T.E., 1935, 1938a, b.
9. See Chapter 24, § 3.3 - Obrig Laboratories Inc. 49 East 51st Street, New York, New York 22 New York.
10. Obrig T.E., 1942.
11. Obrig T.E., 1947a; Obrig T.E., Salvatori, P.L., 1957.
12. Emmes A.B., 1943.
13. Gradle H.S., 1942.
14. Obrig T.E., 1942, p. 131-142.
15. Obrig T.E., 1942, p. 185-201.
16. Eggers H., 1939a.
17. Obrig T.E., Salvatori P.L., 1957, p. 166.
18. Emmes A.B., 1942; Gradle H.S., 1942.
19. Obrig T.E., 1943.
20. Salvatori P.L., Oriani A., 1943.
21. Salvatori P.L., 1945a. The meeting was held on October 13, 1944 at the Palmer House Hotel Chicago Illinois.
22. Salvatori P.L., 1945b. Probable allusion to Feinbloom's Contact Lens Courses.
23. Hunter H.L., 1945.
24. Anderson A.L., 1945a.
25. Rosby A., 1945.
26. Roth R.J., 1945.
27. Hind H., 1945.
28. Amoretti E., 1945.
29. Sneider W., 1945.
30. Anderson A.L., 1945b, in discussion with Rossby A., 1955 p.14.
31. Obrig T.E., 1947a.
32. Salvatori P.L., 1947.
33. Obrig T.E., 1947b.
34. Bier N., 1947.
35. N., 1958.
36. Obrig is to manage this branch until the night before he died on 23 February 1967.
37. Feinbloom W.M., 1931, presented December 15, 1930 at the Ninth Annual Meeting of the American Academy of Optometry held at Omaha, Nebraska.
38. Feinbloom W.M., 1932.
39. See chapter 24, § 2.2.
40. Feinbloom W.M., 1936a, b, c, 1937a, b.
41. Gradle H.S., 1942.
42. Feinbloom W.M., 1941c.
43. Feinbloom W.M., 1940, 1941a, b, c.
44. Feinbloom W.M., 1945c.
45. Feinbloom W.M., 1946a. Read before the 22nd Annual Meeting of the American Academy of Optometry on December 19, 1945 at Columbus, Ohio.
46. Feinbloom W.M., 1945b.
47. Feinbloom W.M., 1945 a, b, 1946b.
48. Hellinger C.J., 1947.

49. Bier N., 1947.
50. Feinbloom W.M., 1946b.
51. Neill J.C., 1951.
52. Vics I.I., 1951. Read before the Annual Meeting of the American Academy of Optometry, Chicago, December 17, 1950.
53. Steele E., 1949, 1951.
54. McKellen G.D., 1947, 1949.
55. Feinbloom W.M., 1936b, 1937b.
56. Adams E., 1941a, b, 1942a, b. When Norman Bier wanted to visit Adams in 1947, he learned that the latter had just died.
57. Alvis E., 1942. Presentation to the St Louis Ophthalmological Society, March 28, 1941. The presentation was followed by discussions from John Green, William M. James and H.R. Hildreth.
58. Precision Contacts, 207-217 Sterling Building, 914 Marquette Avenue, Minneapolis 2, Minn.
59. Anderson A.L., 1944.
60. Bier N., 1947.
61. Anderson E., 1941a, b.
62. New York Contact Lens Research Laboratory, 33 West 42nd Street New York N.Y.
63. Beacher L.L., 1940.
64. Beacher L.L., 1941, 1944b, 1947, 1974.
65. Beacher L.L., 1944a, 1945.
66. Braff S.M., 1945; Beacher L.L., 1945.
67. Beacher L.L., 1942a, 1958, 1967.
68. Bier N., 1947.
69. Braff S.M., 1944.
70. Braff S.M., 1945.
71. Braff S.M., 1946, 1947.
72. Braff S.M., 1952.
73. Bier N., 1947.
74. Carlson J.J., Silbert M., 1946. Office: 292 Madison Avenue, New York City.
75. Bier N., 1947.
76. Ewald H.W., 1941.
77. Bier N., 1947.
78. Finkelstein I.S., 1952; Bier N., 1947.
79. Freeman E., 1945; Nupuf J.S., 1945a; Braff S.M., 1945. Freeman Lab., 1946. Freeman Laboratories Inc. 116 South Michigan Avenue, Chicago and Freeman Contact Lens Clinic.
80. Freeman E., Freeman M., 1947.
81. Dickinson F., Hall K.C., 1946.
82. Bier N., 1947.
83. Freeman E., 1952, 1965.
84. Popular Science by Jerry Fairbanks and Robert Carlisle in Magnacolor (December 20, 1940).
85. Greenspoon R., 1940.
86. Greenspoon R., 1945b.
87. Greenspoon R., 1940.
88. Greenspoon R., 1939. Lecture given before the Academy of Los Angeles County Association of Optometrists, April 20, 1939.
89. Greenspoon R., 1943a. See Emerich Rakos Chapter 21, §4 and Chapter 25, §3.21.
90. Greenspoon R., 1943b, 1945b.
91. Bier N., 1947.
92. Hoare A., 1945.
93. Bier N., 1947.
94. Hoff H.J., 1940. - Dr. Henry J. Hoff, 441 West End Avenue New York. N.Y.
95. Hunter H.L., 1944.
96. Bier N., 1947.
97. Kollmorgen Optical Corporation, 2 Franklin Avenue, Brooklyn 11, New York.
98. Kollmorgen F.L., 1939.
99. Obrig T.E., 1942; Obrig T.E., Salvatori P.L., 1957.
100. Mueller-Welt A., 1935b, 1936, 1949a, b, c, 1950a, 1951.
101. Mueller-Welt A., 1950; Long W.E., 1952.

102. Obrig T.E., Salvatori P.L., 1957 p. 371-373.
103. Leaflet Mueller-Welt International Lens Laboratories, 1952.
104. Long W.E., 1952, Neil J.C., 1951.
105. Birnbaum J.E., 1953.
106. Neill J.C., 1940; Obrig T.E., 1937.
107. Hague E.B., 1940. Stroblite Company, 35 W 52nd Street, New York City.
108. Neill J.C., 1946; Boeder P., 1938; Greenspoon R., 1943. Neill does not take account of numerous European publications.
109. Neill J.C., 1947a, b, 1948b.
110. Neill J.C. Described by Manswiller R.S., 1950; William W. Polikoff, Providence Wilkes Barre, Pennsylvania.
111. Neill J.C., 1948, 1951: Read before the International Optical Congress in London, July 1951.
112. Neill J.C., 1952, 1960, 1962.
113. Nupuf J.S., 1945b, 1946a: Read before the American Academy of Optometry on December 11, 1945.
114. Freeman E., 1945.
115. Nupuf S.J. et al., 1945.
116. Pascal J.I., 1947a, b. c, d, e, 1948a, b, 1951, 1952.
117. Rakos E., see chapter 21 § 4 - The Invisible Lens Inc., 501 Madison Avenue, New York City. Greenspoon R., 1943a.
118. Silverstein S.W., 1944, 1945, 1950.
119. Bier N., 1947.
120. Silverstein S.W., 1950, 1951.
121. Town A.E., 1939, 1940. Presentation at the 44th Annual convention of the American Academy of Ophthalmology and Otolaryngology, Chicago, October 10, 1939.
122. Town A.E., 1941. Presentation at New York Society for Clinical Ophthalmology, January 8, 1940.
123. Bier N., 1947.
124. Wesley N.K., 1988. See Chapter 27, §4.4.1.
125. Chisholm J.F., 1940, 1941. Presented to the New England Ophthalmological Society, April 16th, 1940.
126. Cogan D.G., 1941.
127. Lippmann F.M., 1941.
128. McKinney J.W., 1942.
129. Boshoff P.H. 1943.
130. Kazdan L., 1944a, b; Dunnington J.H., Sallmann v. L., 1944; Roper K.L., Bannon R.E., 1944.
131. Jaeckle Ch. E., 1944.
132. Billger H.T., 1945; Duncan H.A.G., 1945; Kadesky D., 1945.
133. Firestone L.E., Gaynes E.M. 1945, 1949; Freeman E. 1945.
134. Struble G.C., Bellows J.G., 1946; Graham R., 1947, 1949, 1952.
135. Filderman I.P., 1950; Haines H.F., 1950; Manwiller R.S., 1950.
136. Nugent M. W., 1948. Presentation to the Los Angeles Ophthalmological Society on 3rd June 1948.
137. Koch C.C., 1939, 1941, 1951.
138. Bridgman C.S., 1948.
139. Zabner L.M., 1953.
140. Neill J.C., 1948a; Nugent M. W., 1948; Neill J. C., 1951 (Read before the International Optical Congress in London July 1951).
141. Berens C., 1949.
142. Abraham S.V., Shanedling P.D., 1950.
143. McGraw J.L., Enoch J.M., 1952, 1954; Enoch J.M., McGraw J.L., 1954; McGraw J.L. 1954, 1957.
144. Ridley, F. Presentation on 8th October 1959 at the Detroit Ophthalmological Society. Ruedemann A.D., Jardon F., 1970. See more details in chapter 28, § 2.
145. Ruedemann A.D., 1970. Jeltrate manufactured by L.D. Calk, packed in a sterile vacuum can. The pmma press was designed by Mr. John Crawford of the American Optical Company.
146. Goren S.B., Shoch D., 1970.
147. Girard L., Soper J.W., Sampson W.G., 1964, p. 119.
148. Ridley F., 1962.
149. Girard L.J., Soper J.W., 1966.
150. International Congress on Corneal and Scleral Contact Lenses in Houston on March 20th to 24th 1966: Girard L.J., 1967a; Gould H.J., 1967a; Ridley F., 1967.