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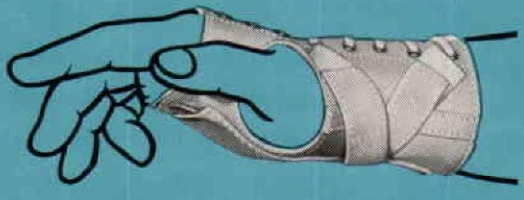

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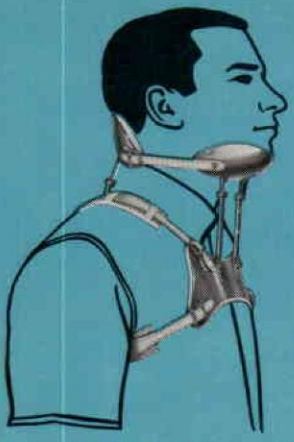

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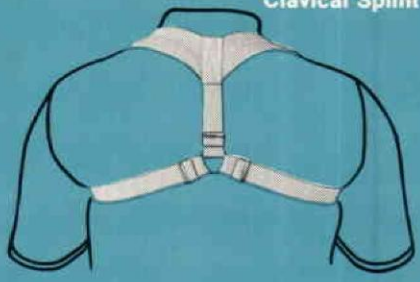

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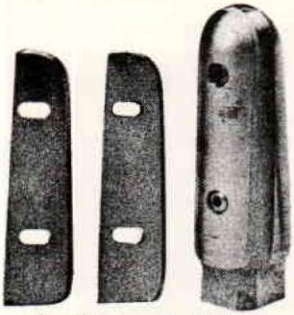

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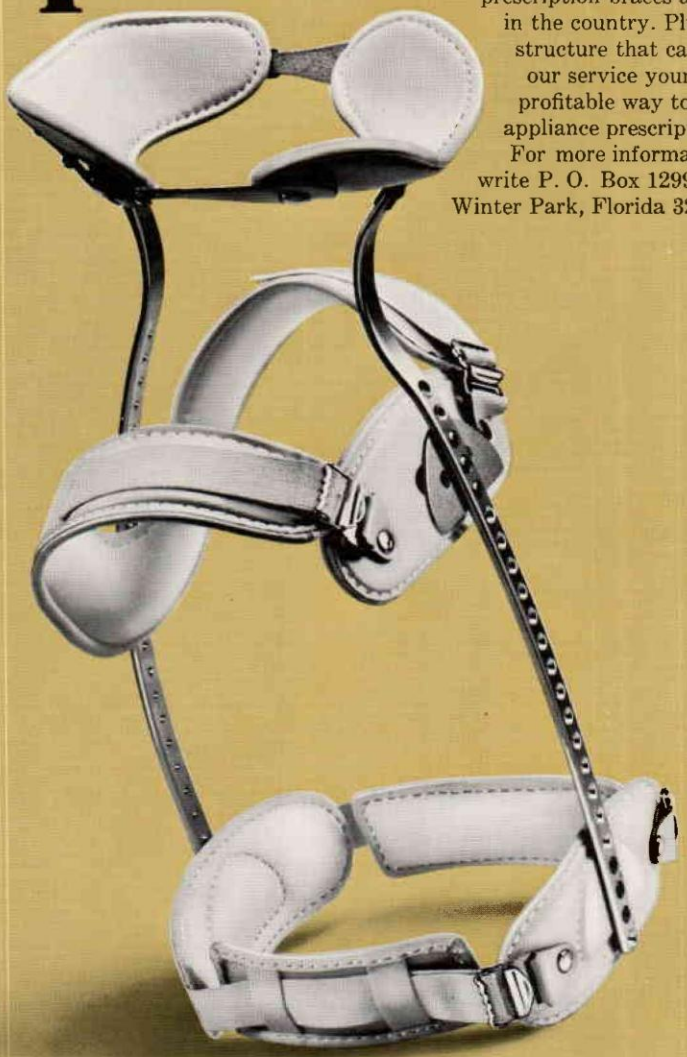

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Fabrication Technic for Inflatable Splints

by

Major Mary H. Yeakel, AMSC and Captain
Douglas K. Ousterhout, MC

INTRODUCTION

Inflatable appliances most frequently used for fracture immobilization of extremities, reduction of edema, and compression dressings have been commercially available for many years (1). Most of these appliances are in the form of an envelope which is wrapped about the limb to form a cylinder and fastened by means of a zipper, or Velcro. The cylinder is then inflated through a valve mounted on the outside wall of the envelope. These envelopes are usually fabricated from polyethylene sheeting or nylon fabric impregnated with Neoprene.

In this paper the three steps for fabrication of inflatable latex appliances are described. The illustrations and the various steps of the procedure describe the fabrication of an inflatable neck splint (figures 1A, 1B); the technic, however, is versatile and can be used in the fabrication of a variety of appliances.

FABRICATION OF DIPPING MODELS

Selection of the material (metal, plastic, dental stone) used for the dipping models will be determined by the configuration of the appliance. An aluminum dipping model was used for the inflatable neck splint (figure 2) because of the relatively flat contours which were required. In another use, Orthoplast might be chosen be-

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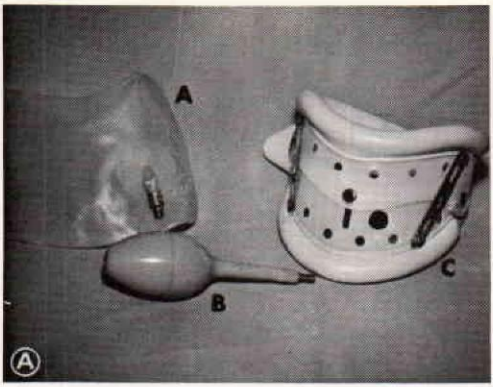

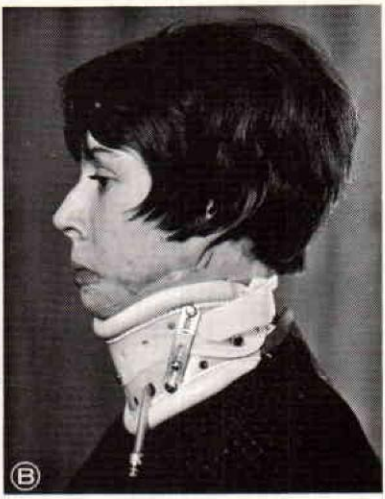

FIGURE 1A—Component parts of inflatable neck splint, (a) bladder, (b) atomizer bulb, (c) Myo Cervical Collar.

FIGURE 1B—Patient J. A. wearing inflatable neck splint following release of neck contracture requiring split thickness skin grafts.

FIGURE 2—Dipping models of (A) Aluminum, (B) Orthoplast and (C) Dental Stone.

cause of its elastomeric properties which allow the material to be stretched or drawn. More intricate models have been made in dental stone when adaptation of the appliance to the defect has been critical, as would be the case in the use of an inflatable obturator. After choosing the material for the dipping model, it is contoured to the shape of the finished appliance, taking into consideration the dimensional changes which will occur during bladder inflation.

A handle must be incorporated into the model for purposes of suspending it in the liquid latex and in the oven (figure 3A). The handle should be located on that portion of the model which will be least difficult to seal with a gusset. (This procedure is described in detail in the section on assembly.)

A dipping model is also needed for fabrication of the filling tube into which a metal air valve will be inserted (figure 3B). This model is made from a 1¼" diameter metal rod with a 1¾" diameter metal disc soldered to one end. The disc is necessary to create a collar on the filling tube for attaching it to the wall of the bladder. Since this dipping model will be used for fabricating all filling tubes, regardless of the type of inflatable appliance being constructed, the metal rod should be at least eight inches in length for universal use.

PREPARATION OF LATEX FILM PARTS

The latex material used to fabricate the inflatable appliances is one which was developed at this laboratory (2). This material is a latex dispersed synthetic elastomer: a terpolymer of butyl acrylate (90%), methyl methacrylate (7.5%) and methacrylamide (2.5%). The terpolymer is compounded with 37 parts of poly (ethyl methacrylate) as a reinforcing agent. In addition, 1.765 parts of formaldehyde, which acts as a crosslinking agent, are added during the compounding procedure. The compounding formula is represented below:

Material	Parts
Terpolymer latex	100.0
Poly (ethyl methacrylate)	37.00
Formaldehyde	1.765

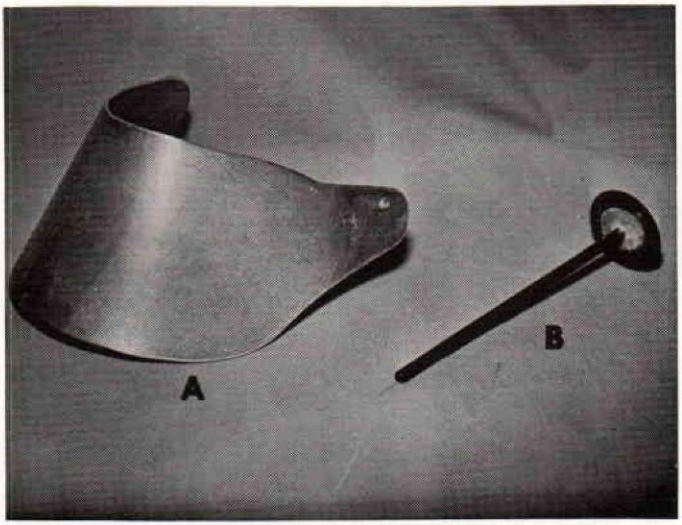

FIGURE 3—Dipping models for inflatable neck splint (A) bladder model with handle, (B) filling tube.

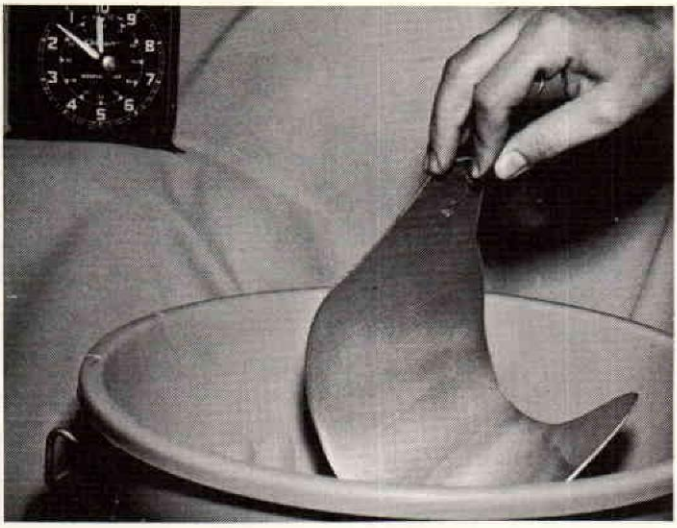

FIGURE 4—Dipping the model into the liquid terpolymer.

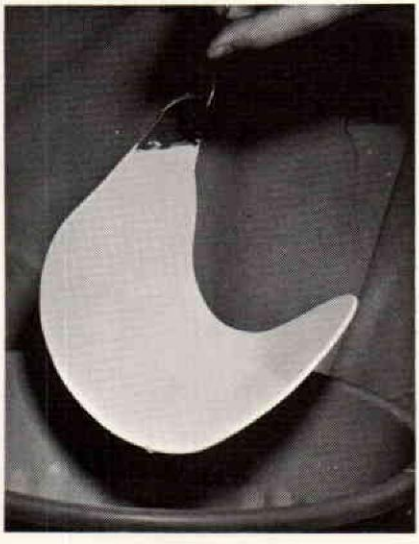

FIGURE 5—Terpolymer coated model. Note the milky opaque appearance.

When compounding this terpolymer latex, all calculations must be made on the basis of total *solids* of each material. (A detailed description of the compounding procedure, MR 6-68, can be obtained from this laboratory upon request.)

This material is essentially a chemically saturated elastomer which is inherently flexible without the addition of plasticizers. It shows excellent outdoor weathering, is oil resistant and can be steam autoclaved. The elastomer is crosslinked, dimensionally stable and compatible with body tissues. Another unique and very important feature of this particular material is the relative ease with which the latex film can be processed (3). The fabrication technic in this paper is dependent upon the use of this terpolymer, however, other dipping latices may be available which will provide satisfactory results.

A coagulant is necessary to prime the dipping model for deposition of the compounded latex. The coagulant solution is made by thoroughly mixing 20 gm of calcium nitrate with 80 gm of denatured alcohol.

After a generous application of a dry release agent (polytetrafluoroethylene spray) to the model,

it is immersed in the coagulant and air dried for several minutes to allow all excess coagulant to drip off. With a wire hook inserted into the handle, the model is slowly immersed in the liquid terpolymer where it is suspended for 90 seconds (figure 4). This dwell time will create a film thickness of 13 mils ± 2 mils; less dwell time will create a thinner film and vice versa. The terpolymer coated model (figure 5) is carefully removed and placed in a 60°C oven to cure for one hour. During the oven cure, care must be taken to be sure the model is freely suspended and will not touch any object. The same procedure is followed with the dipping model for the filling tube.

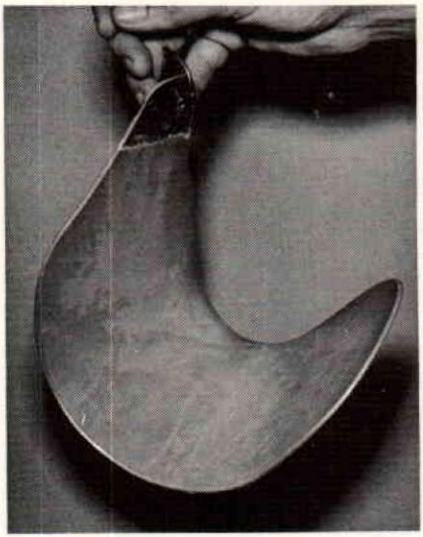

FIGURE 6—Translucent appearance of the terpolymer following the initial oven cure.

During the oven cure, the milky white appearance of the terpolymer will be lost and the film will become transluscent as the water is driven off (figure 6).

For ease in removing the film from the models, they should be immersed in water for approximately ten minutes. The water which is resorbed into the film will make the film softer and more pliable. The film is removed from the model by gently rolling or sliding it over itself, starting from the opening created by the handle

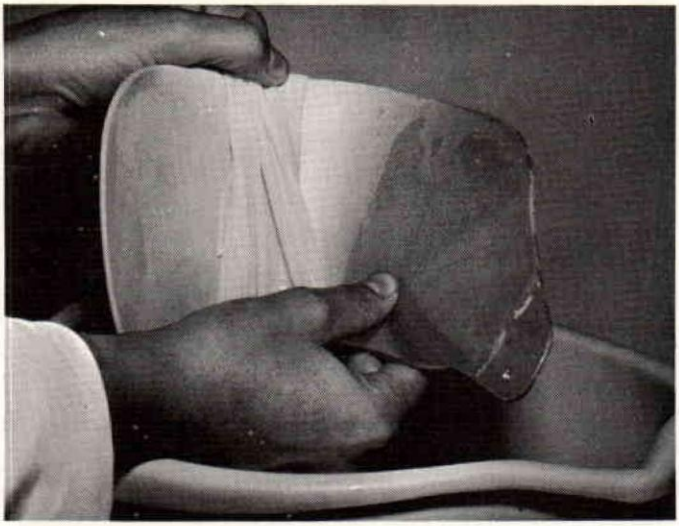

FIGURE 7—Removing the film from the model.

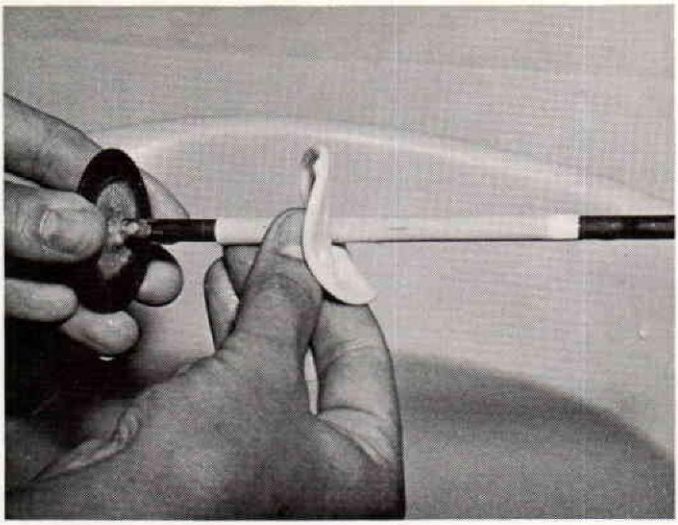

FIGURE 8—Removing the film from the filling tube dipping model.

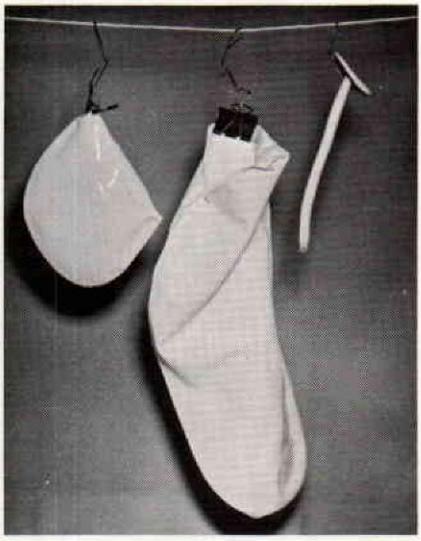

FIGURE 9—Air drying of the bladder components after they have been thoroughly leached.

(figure 7). Keeping the film wet during this procedure will prevent the film from sticking to itself. The film is then immersed in water for at least 18 hours to leach out the soap, coagulant, and any other impurities which might be present.

The open end of the bladder will eventually be sealed by adding a gusset. The gusset for the inflatable neck splint is formed on the same (or a duplicate) dipping model used to fabricate the main body of the appliance, however, the film is cast only on one half of the model.

The film is removed from the tube dipping model by cutting the film away from the bottom portion of the metal disc and then gently slipping the film over the end of the rod (figure 8).

After these three parts have been thoroughly washed of impurities, they are air dried for approximately one hour, or until they become transluscent once again. This can best be done by suspending them "clothesline fashion" (figure 9). The latex film is somewhat tacky at this stage and tends to adhere to itself quite tenaciously. To prevent this from occurring, an attempt should be made to prevent the films from touching

themselves or other objects. After this air cure, the three sections of the appliance—the bladder, gusset and filling tube—are placed in an air circulating oven at 100°C for the final thirty minute cure to complete the crosslinking or polymerization process. The parts are now ready to be assembled (figure 10).

ASSEMBLY OF THE APPLIANCE

To create a symmetrical appliance, the bladder is folded in half

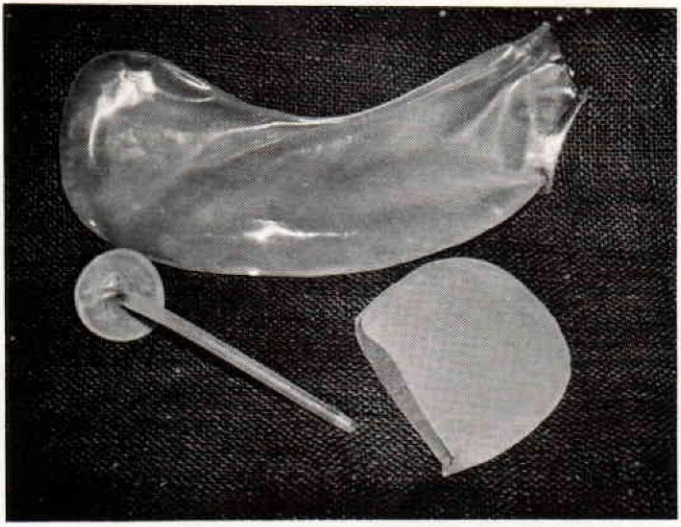

FIGURE 10—Three parts necessary for fabrication of the bladder following the final oven cure.

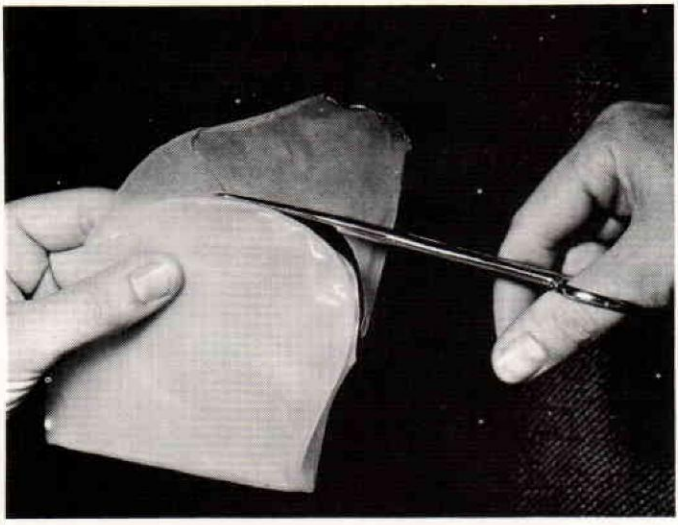

FIGURE 11—Cutting the open end of the bladder to create a symmetrical appliance.

FIGURE 12—Placement of the filling tube in the bladder.

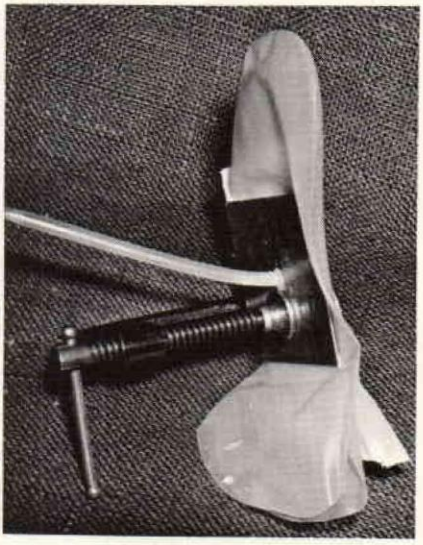

FIGURE 13—Gentle pressure applied with use of a "C" clamp to insure an adequate bond of the filling tube to the bladder.

and the open end is cut to match the closed end (figure 11).

To facilitate donning and inflating this appliance by the patient, the air inlet tube is positioned in the center of the anterior wall of the bladder and the tube is left at least four inches long. A $^{5}/_{16}$" hole is made in the bladder for the filling tube which will permit insertion of the filling tube without any creasing or binding at the base. A thin film of terpolymer is applied to the collar of the tube and it is drawn through the opening from the inside of the bladder to the outside (figure 12). A small piece of polyethylene film is placed between the collar of the tube and the inside posterior wall of the bladder to prevent the walls of the bladder from being accidentally glued to each other. Two three inch square aluminum plates, one with a $^{5}/_{16}$" diameter hole in its center through which the air tube is drawn, and the other padded with several thicknesses of gauze are placed in position on the bladder. Gentle pressure is applied to the plates for approximately four hours with a "C" clamp, lock grip pliers or vise (figure 13).

The gusset is cut from the half bladder so that when it is placed

inside the open end of the bladder it will extend ⅛″ beyond the bladder and approximately 1″ into the bladder (figure 14). A film of terpolymer is applied to the gusset. Polyethylene film, gauze padding and the metal plates are placed around the bladder and pressure applied.

A thin coat of liquid terpolymer is applied to the base of the metal air valve (figure 15). The air filling tube is stretched open with a suitable instrument and the valve is placed in position. A coat of terpolymer is applied to the filling tube around the base of the valve. Three individual pieces of thread

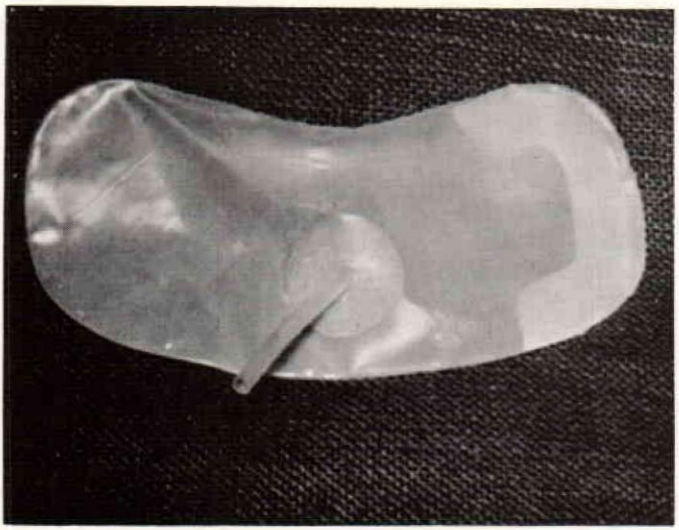

FIGURE 14—Placement of gusset to seal the open end of the bladder.

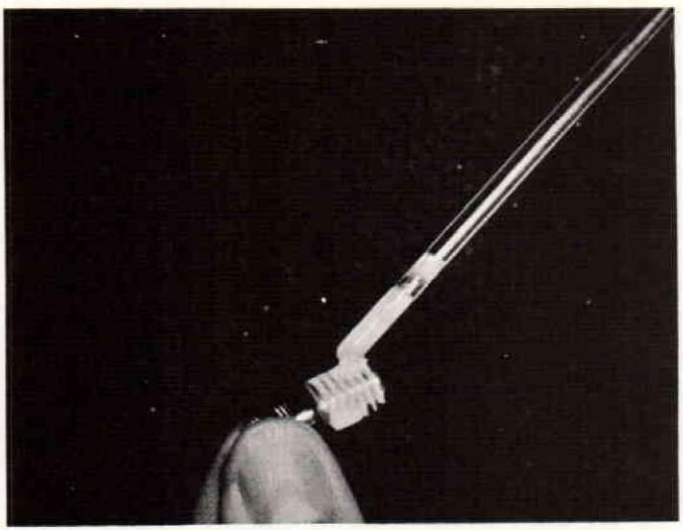

FIGURE 15—Applying a thin coat of liquid terpolymer to the base of the metal air valve.

are tied securely around the valve base and a second coat of terpolymer is applied. This will prevent accidental dislodgment of the valve from the filling tube and insure an air tight seal (figure 16).

After the metal plates are removed from the gusset area, it may be necessary to air cure the bladder for several hours to insure complete evaporation of the water from the terpolymer latex which was used as the adhesive. The adhesive bond will be quite weak until this occurs. However, at this time the bladder should be gently inflated and those parts of the bladder which may have adhered

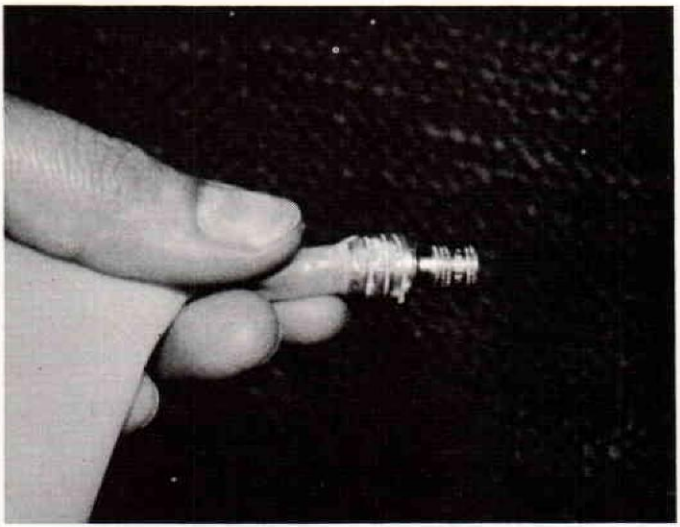

FIGURE 16—Thread tied securely about the filling tube and valve base.

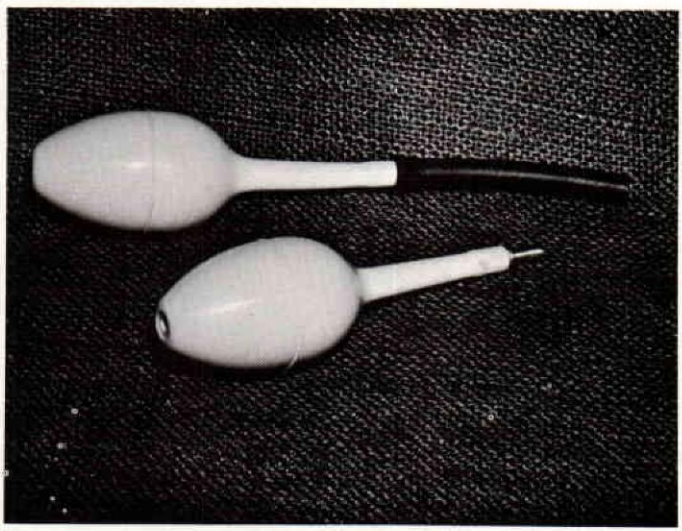

FIGURE 17—Atomizer bulbs adapted to fit the air valve.

to each other, due to some of the terpolymer having been forced into the bladder interior when pressure was applied to the gusset area, carefully separated. If there are any areas where a complete seal has not been obtained, a light application of the terpolymer latex should be applied. Air curing of the terpolymer latex will be complete when the milky white appearance has disappeared.

To be absolutely certain that the bladder is air tight, it should be inflated and held under water while gentle pressure is applied. Any tiny pinholes through which air is escaping must be sealed befor the final finishing steps.

The tacky feel of the bladder and its strong tendency to adhere to itself can be prevented by forcing talcum powder into the bladder. Excess material, such as droplets of terpolymer which may have formed during the dipping procedure, and all rough surfaces can be removed by gently sanding with rotary equipment using an arbor and fine grit band.

Inflation of the bladder is accomplished with a hand atomizer bulb adapted with a piece of flexible tubing which can be easily fitted over the valve stem or a threaded metal adaptor which can be screwed into the valve stem (figure 17).

DISCUSSION

The total fabrication time for this technic spans a period of two days, however, the initial steps of dipping, curing and removing the films from the models only require approximately 1½ hours and about 20 minutes of actual working time. The parts can be washed overnight and the remaining fabrication procedures completed the second day.

The latex material used is one which is both simple to manipulate and possesses excellent physical properties for this type of application. If a puncture should occur in the bladder, a small amount of the liquid terpolymer latex can be applied to the area which, after several hours of air curing, will provide an excellent seal.

If necessary, the bladders can be sterilized by standard autoclave procedures.

The materials used to compound the terpolymer latex are commercially available, but do require the final compounding procedure to be completed by the user.

SUMMARY

The technic for fabricating latex inflatable bladders has been described in detail. Although the appliance which is described has been designed for use with the commercially available Myo Cervical Collar as an adjunct to surgical prevention and treatment of cervical scar contracture (4), the fabrication technic is applicable to many inflatable bladder designs.

ACKNOWLEDGMENT

The authors wish to acknowledge the assistance of Mr. Alfonzo Spencer, photographer, U. S. Army Medical Biomechanical Research Laboratory.

REFERENCES

1. *Inflatable Splints*, **Drug Therapy Bulletin 4:** 87–8, 28 Oct 1966.
2. Leonard, F., Nelson, J., and Brandes, G., *Vulcanizable Saturated Acrylate Elastomers*, **Ind Eng Chem 50:** 1053–8, 1958.
3. Leonard, F. and Margetis, P. M., *Polymers in Dentistry and Medicine*, **SPE Journal 24:** #2, 60–3, Feb 1968.
4. Ousterhout, D. K., Yeakel, M. H., Lau, B. M., and Tumbusch, W. T., *Inflatable Splint: An Adjunct to Surgical Prevention of Cervical Scar Contractures*, Accepted for publication, **British Journal of Plastic Surgery.**

An Innovation in Symes Prosthetics

by

Herbert W. Marx, C.P.O.[1]

For many years, the prosthetist as well as the amputee were faced with the problems of low-level amputation. Many attempts have been made to provide the amputee on whom the Symes or other low-level amputation has been performed, with a suitable prosthetic device. Since early designers seemed to be concerned with replacement of lost motion rather than with intimacy of fit and restoration of cosmesis, the conventional Symes prosthesis left in most cases something to be desired. However, the introduction of plastic laminates to the prosthetic profession not only multiplied and improved the ways with which the prosthetist could accomplish more accuracy in fit, it also gave him the tool for improving the cosmesis without the addition of weight to the prosthesis. Even though the use of steel reinforcements in the construction of plastic prosthesis appeared to be of necessity at first, it was soon learned that the proper use of plastics would provide enough strength to replace all weight-adding steel reinforcements. The first all plastic Symes prosthesis which did not require any metal reinforcements, was the Canadian design, introduced in 1956. It is still the most widely accepted design for this level of amputation. However, the bulbousness of this type of prosthesis combined with the rather slim appearance in the calf region is objectionable, especially to the female patient. The unsatisfactory

[1] Assistant Research Scientist, N.Y.U. School of Medicine and Post Graduate Medical School and Supervisor, Orthotics and Prosthetics Laboratory, Institute of Rehabilitation Medicine, N.Y.U. Medical Center.

cosmesis as well as the posterior opening on this prosthetic device gave the initiative for the search of improvements. One of these improvements was the elimination of any opening, whether lacing or otherwise, in any region in the middle half of the socket. Since the nature of this type of amputation requires a wider socket diameter than stump diameter in the middle third of the shank, the fitting was based on total contact in distal and proximal weight-bearing areas only. An edema in the middle two thirds of the stump was frequently discovered. To eliminate this medical problem, an entirely new approach was necessary. A double-wall socket construction with a flexible inner shell seemed to be the most logical solution.

To improve cosmetic as well as functional characteristics of this type of prosthesis the following total contact Symes technique was developed:

CASTING

For casting, the use of elastic plaster bandages is of extreme importance because it assures the required even compression of redundant tissue, and, consequently, a more accurate cast.

The use of ⅛ inch adhesive felt patches applied to the bony prominences before casting appears to be superior to modifications made in these critical areas on the male mold. The measuring technique consists mainly of principles applied in casting a PTB prosthesis. In addition, peripheral measurements, starting at the patella-tendon level in two increments distally, should be taken. The length measurement, medial-tibial-plateau to end of stump is taken after the distal portion of the stump is wrapped and the bandage hardens under moderate weight bearing, thus establishing the fit of the distal portion in the final product. For this procedure, an adjustable height block similar to the one designed at the Prosthetic Service Center in Toronto is used, not only to maintain the patient in perfect balance but also to establish the amount of necessary elevation. Both the length measurement and the amount of elevation must be recorded. Applying the Patella Tendon Bearing principle in casting of the proximal two-thirds will satisfactorily distribute the weight between the distal and proximal portion.

Since the rubber-like properties of the material used for the construction of the flexible inner shell do not permit frictionless entry without a sock, the thickness of the sock to be worn by the patient is taken into consideration during casting.

To give additional assurance of accuracy of fit, a check-negative may be constructed. However, an opening should be provided in the medial, lateral or posterior mid-portion of this check-negative to provide ease of entry. The material which has been cut away to provide the opening should be reinserted after the patient has stepped into the socket. Insufficient contact or excessive pressure at any one point in the check-negative may be checked through ½ inch holes drilled through the

socket walls. To assure a good weight bearing distribution between the proximal and distal portions, the patient should stand with even weight bilaterally for approximately 15 minutes on this check-negative. If reference lines in the frontal and saggital planes were not established at the initial casting, they should be established now and used as alignment guides during static alignment. The negative might then be removed and the skin checked for indications of excessive pressure in either distal or proximal portions. Necessary adjustments, such as adding or removing material, can be done on this negative, which might then be used as form for a new positive mold.

LAMINATION OF THE DOUBLE-WALL SOCKET WITH FLEXIBLE INNER SHELL

After the vertical reference lines have been transferred from the check-negative to the male-mold and marked with roundhead screws or nails driven into the proximal and distal sections, the cast is sealed in the conventional manner with a PVA bag. For the fabrication of the inner shell, 4 layers of nylon stockinette are applied to the sealed cast. The PVA bag, which is then pulled over the work piece has to be taped distally and proximally as shown in figures 1 and 2. Taping off of these regions has been found necessary to prevent the flexible plastic which will be used in the center section from penetrating too far into them. (The distal and proximal sections will be laminated with rigid or semirigid plastic after the flexible part has cured.) The PVA covering in the center section is then removed. Care must be taken, that the layup is not cut during this procedure. A third PVA bag is pulled over the work piece. A mixture of silicone elastomer 384 and 385 in proportions 80 per cent to 20 per cent is used for the lamination of the center section. It is advisable, not to use more than 20 per cent of No. 385 silicone elastomer, because a higher percentage of this material will result in excessive foaming action, which will not only be hard to control, but it will also reduce durability of the center section in the final product. A higher percentage of silicone elastomer No. 384 is not desirable since expandability of this material will be reduced. After the flexible material has cured, the PVA covering is removed completely. Figures 3 and 4 illustrate the anterior and medial view of the flexible center section with the PVA covering removed. A new PVA bag is then applied and the distal and proximal portions laminated with a 75 per cent to 25 per cent mixture of 4110 and 4134 laminac or similar material. While laminating, all material has to be strung out of the flexible portion because any rigid plastic left in this area may decrease its durability.

Cosmesis and necessary rigidity of the prosthesis will depend on the outer shell which will be constructed in a similar fashion as is the outer shell of a double-wall socket of an upper extremity pros-

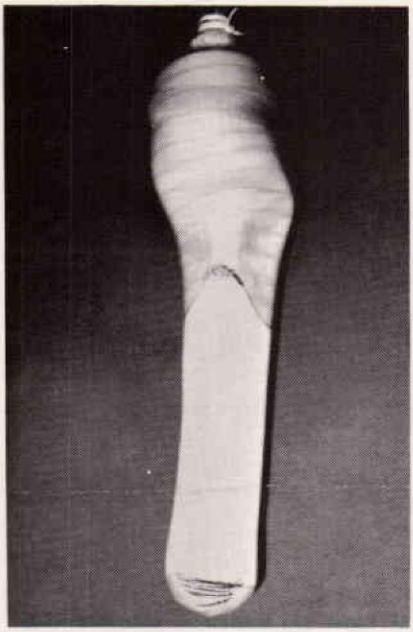

FIGURE 1

FIGURE 2

FIGURES 1 and 2—Preparation of first lay-up for silicone impregnation. (Anterior and lateral view).

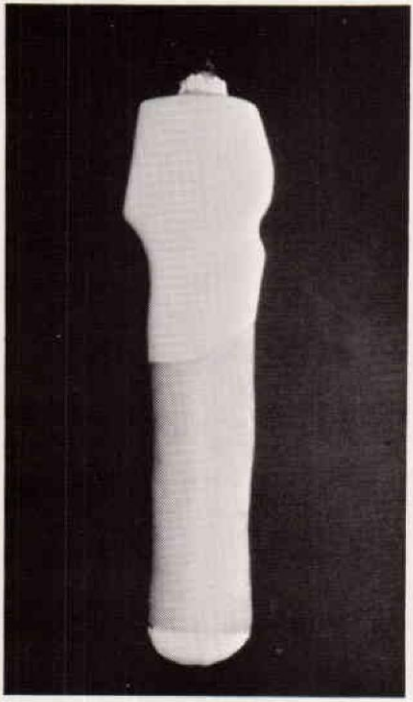

FIGURE 3

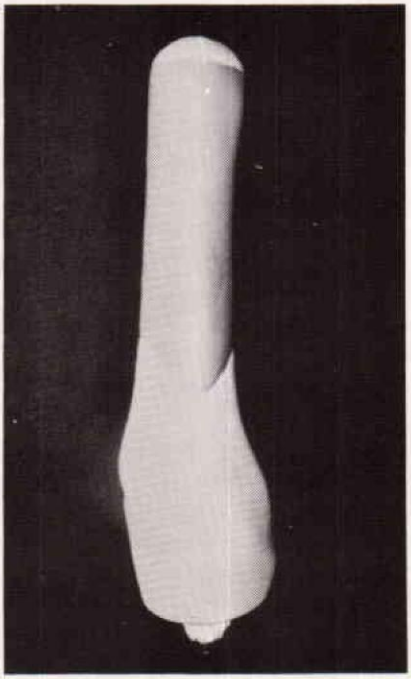

FIGURE 4

FIGURES 3 and 4—Flexible center section of inner shell with PVA covering removed.

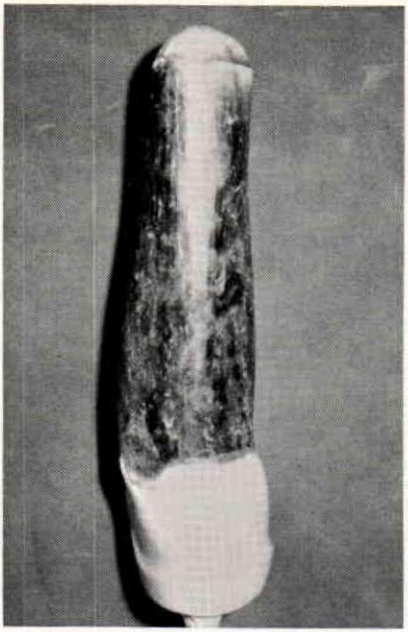

FIGURE 5

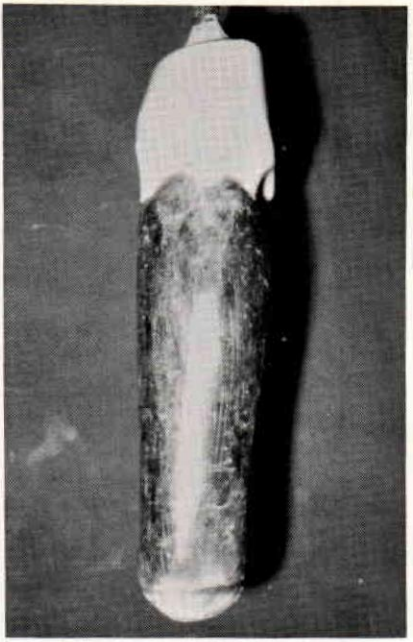

FIGURE 6

FIGURES 5 and 6—Wax built up over laminated inner socket.

thesis. A wax build up, as shown in figure 5 and 6 will give the necessary backing for the outer shell. It is of utmost importance to build a paper or celluloid sleeve around the work piece, into which the soft wax can be poured. We found, that if the cosmetic backing is built up with semi-soft wax, airpockets within the wax build up are usually unavoidable. While laminating the outer shell, these airpockets will fill up with plastic residue. Since these plastic accumulations can not be removed from between the two laminations, they will not only interfere with the expansion of the flexible inner shell but also introduce the possibility of discomfort for the patient.

After the wax has hardened it is shaped down to the necessary dimensions. The originally recorded dimensions of the sound leg should be reduced by 3/8 to 5/8 inches and then duplicated on the wax build up. To assure minimum weight and maximum strength of the final product, an epoxy lamination is preferable. Five layers of fiberglass, either tubing or matting, will provide sufficient strength. Before laminating the outer shell, it is advisable to roughen the distal and proximal portion of the first lamination to assure proper bond in these areas. To remove the wax build up, a 3/8 inch hole may be drilled through the outer shell in the lower popliteal area. The wax may be melted in an oven and drained through this hole. Because of the bulbousness of this type of amputation, we found it very difficult to re-

move the male mold from the laminated work piece. In most cases the cast has to be fractured and removed piece by piece. This should be done while the wax build up is still between the two laminations since it will provide a little more rigidity to the flexible middle section of the inner shell.

For length adjustment and easier alignment, a 3 inch wooden block is fitted and adhered to the distal portion of the laminated socket.

The base of this wood extension is removed as far as possible without disturbing the socket itself. Removal of this excess material should be done in consideration with the established flexion and adduction angle. Since only minor modifications in the angular relationship during dynamic alignment are possible, special attention should be given to this procedure.

SACH-FOOT MODIFICATIONS

Since the loss of length in a Symes amputation amounts to approximately three inches, it does not appear necessary to use a foot designed solely for the construction of this type of prosthesis. However, a standard SACH foot can be used. Figure 7 illustrates one way of utilizing the limited space available for SACH foot attachment.

The SACH-foot keel, weakened by the removal of material from its base, has to be reinforced. This is accomplished by means of a hardwood plug, in dimensions outlined in Figure 7, inserted from the

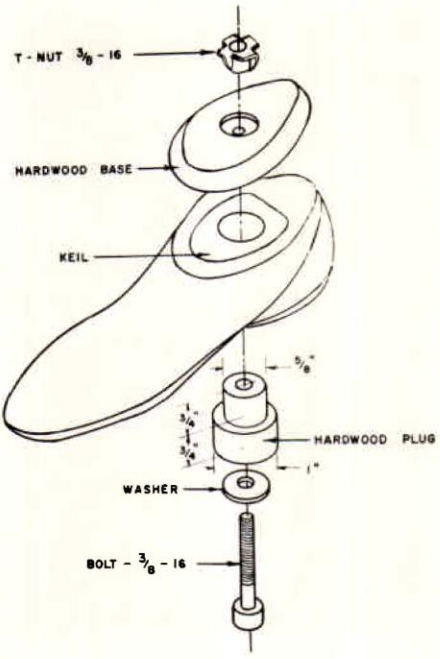

FIGURE 7—Exploded view of SACH foot modification for Symes adaptation.

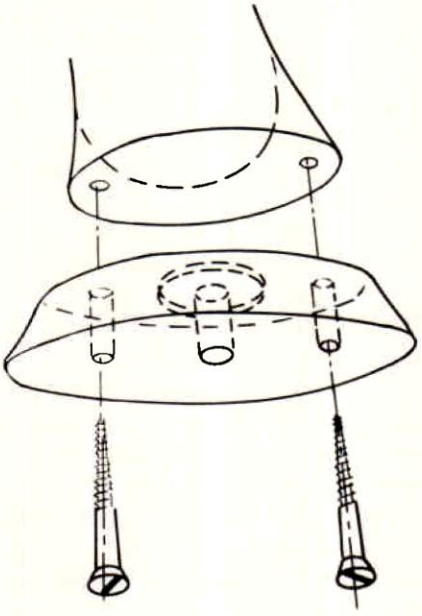

FIGURE 8—Attachment of hardwood base to socket base for dynamic alignment.

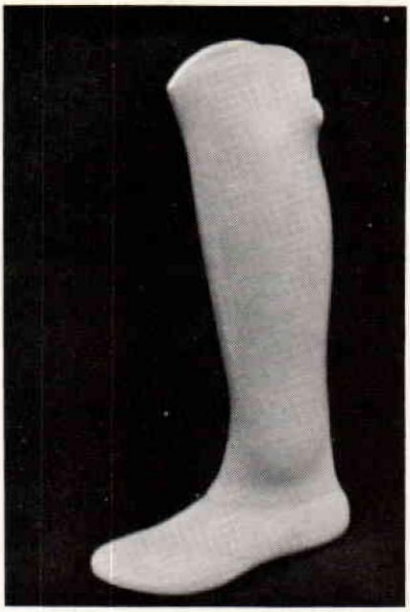

FIGURE 9

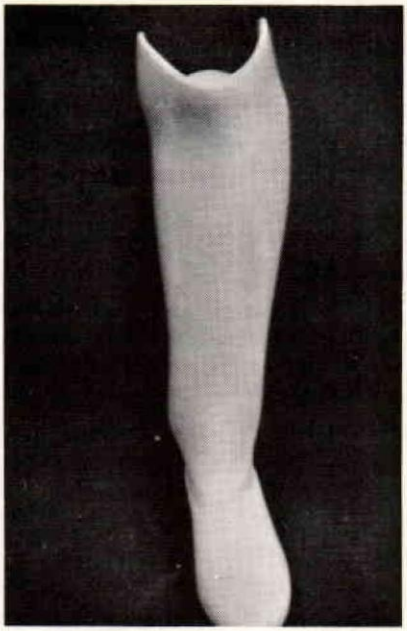

FIGURE 10

FIGURES 9 and 10—Finished Symes prosthesis.

underside into the foot. A hole is drilled into the center of this wood-plug to accommodate the foot attachment bolt.

Static alignment is done in the conventional manner. It is advisable to attach the hardwood ankle base with two wood screws No. 10–1¼ inch to the socket base (figure 8), since this arrangement allows easier alignment changes in the transverse plane. Alignment changes in flexion and extension as well as adduction and abduction angles should not be excessive if reference lines in the frontal and saggital planes have been established and transfered properly, and can be done at the socket base. Finishing the prosthesis after dynamic alignment is simply a matter of blending the ankle portion and applying the final lamination in the conventional manner. To improve the cosmesis, the medial and lateral apexes of the bulbous ankle area may be sanded down to paper thickness, before the final lamination is applied, since these areas are not under exessive stress during gait cycle, and consequently do not require as much reinforcement as the anterior and posterior sections.

SUMMARY

Limited expansion (approximately 1¼ to 1¾ inch, in the material required for a Symes prosthesis) of the silicone elastomer laminated inner shell, does not permit this technique to be used for all types of low-level amputations. The only three types of amputations for which this technique may possibly be used are

the Symes, Pyrogoff and Boyd amputations. However, different foot modifications are necessary on other than the Symes socket, because of difference in amputation level with its resulting length discrepancy also involves a difference in construction of the foot replacement. In general, the applicability of this technique depends largely on the dimensional difference between the distal circumferential measurement and any measurement more proximal to this point. It appears quite feasible to apply this type of TC construction in some cases of lower extremity congenital deformities or any amputation which results in distal scelettal bulbousness, as long as the maximum expandibility of the material is not overestimated.

A follow-up on patients provided with this type of prosthesis shows that the silicone elastomer used in proper proportions assures prolonged service. Inflating the air chamber between inner and outer shell was not found necessary. No material fatigue was found after the prosthesis has been actively used for more than 1½ years. According to patient reports, the cosmesis of this prosthesis is far superior to any other design, even though the bulbous ankle area could not be completely eliminated.

REFERENCES

1. American Academy of Orthopaedic Surgeons, Inc. (Editors), *Orthopaedic Appliances Atlas*, Volume 2, J. W. Edwards Company, Ann Arbor, Michigan, 1952.
2. Maset Jr., Robert, M.D.: *Symes Amputation, A Follow-up of Fifty-one Adults and Thirty-two Children*, **The Journal of Bone and Joint Surgery Volume 50: A:8,** December 1968
3. Wilson Jr., A. Bennett: *Prosthesis for Syme's Amputation*. **Artificial Limbs,** April 1961
4. Sarmiento, Augusto, Gibner, Jr., Raymond E., and Finnieston, Alan: *A New Surgical-Prosthetic Approach to the Syme's Amputation*, A Preliminary Report

A Rack and Pinion Cable Drive for Orthoses

by

Edwin M. Prentke, B.S.,[1] Barry A. Romich, B.S.[2] and Harry Derda[3]

We required an all-around reliable cable drive mechanism suitable for driving orthoses such as the Highland View Hospital flexor hinge hand splint and the Ampersand Powered Elbow Unit. The latter device provides elbow flexion assistance for patients with paralyzed elbows, especially if elbow stiffness is present.

Certain important features were required; the design shown in Fig. 1 has been adapted for use by several of our patients, as well as some patients in other cities. The requirements which have been met are:

1. Rapid and easy servicing of the motor and the cable attachment.
2. Freedom from cable problems such as the detachment or unraveling which occurs in reel windings.
3. Ease of removal and installation of longer or shorter cables.
4. Ability to use two racks, side by side, to drive two cables at once, in the same or different directions, by attaching them at the same or at opposite ends of the racks.
5. Length of cable travel to be varied by inserting a spacer at one end of the groove in which the rack slides.

All of these requirements have

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[2] Design Engineer, Engineering Design Center, Case Western Reserve University, Cleveland, Ohio 44106.

[3] Harry Derda, Instrument Maker Engineering Design Center, Case Western Reserve University, Cleveland, Ohio 44106.

been adequately provided in this device. Some of the details include the housing, machined from aluminum, two sets of set screws in the rack to securely anchor the cable, a taper pin driven through the gear hub and motor shaft to prevent slipping, and another set screw to anchor the cable housing where it enters the box.

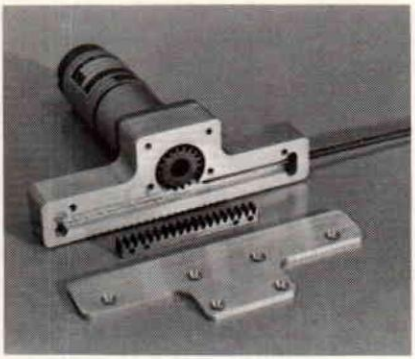
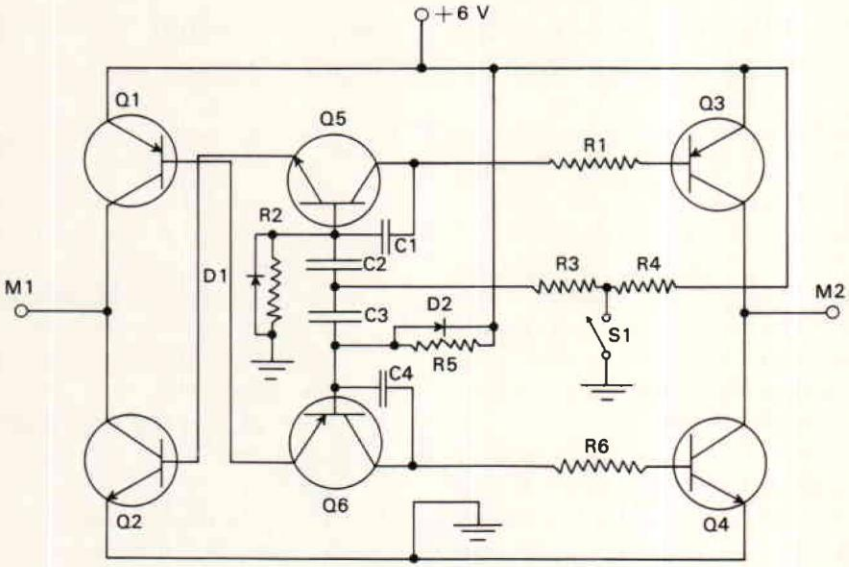


FIGURE 1.

We use a Globe 12 volt DC motor, No. 319A112-3, with 100:1 reduction gears, a speed of 90–110 R.P.M., and a torque of 77 ounce inches. The spur gear has a pitch diameter of .750", and a 24–14 ½ pitch. The rack is of steel, ¼" square, 24 pitch. For driving a flexor hinge hand splint, the unit provides a cable travel of 2⅛".

Since our devices are used mainly by patients in wheel chairs, the motor, gear box, and



Q1, Q3, 2N376A
Q2, Q4, 2N3055
Q5, 2N5183
Q6, 2N3638

R1, R6, 68 ohm 2 watt
R2, R4, R5, 1000 ohm ½ watt
R3 330 ohm ½ watt
D1, D2, 1N456A
C1, C4, 0.1 mfd
C2, C3, 500 mfd 15 volt
M1, M2, 12 volt d-c motor

POWERED ELBOW CONTROL
TMC-61-C 4-25-68

E. M. PRENTKE
BARRY A. ROMICH

FIG. 2

FIGURE 2.

the control device, such as our myoelectric control, are mounted behind the chair (1).

The Ampersand Powered Elbow Unit, also developed at Highland View Hospital, Department of Physical Medicine and Rehabilitation, was designed to enable quadriplegics with elbow contractures to feed themselves.

A motor with the above described rack and pinion drive is used to bring the hand splint close to the patient's mouth. Using a flexor hinge hand splint and a BFO, the patient can actively flex the arm by tilting a mercury switch attached to the radial side of the trough. When the hand is raised, by dropping the shoulder, the switch turns on and the motor driven cable pulls the hand towards the mouth. By lowering the hand the motor is reversed and the cable is extended, allowing the elbow to extend with gravity. A solid-state control circuit turns the motor clockwise when the switch closes, and counter-clockwise when the switch opens. Current is automatically cut off after the cable pulls all the way in or after it reaches the other position. This circuit is shown in Fig. 2.

The powered elbow control requires a longer cable travel than the hand splint. Our unit provides a travel of 2⅞" which is enough to permit the hand to move from the mouth to the front edge of the lapboard.

Power for the motor or motors is supplied either from the batteries of an electric wheel chair or from a Gould 12 volt nickel cadmium battery which can be recharged overnight.

Since November 1966, we have equipped thirteen people with rack and pinion cable drives, and five with powered elbow devices. All of these have been in constant use without major problems.

Blueprints of the motor housing and gear box shown in Fig. 1 are available without charge on request, and further information may be obtained from the authors.

REFERENCE

1. Trombly, Catherine A., Prentke, Edwin M. and Long, Charles, II: *Myo-Electrically Controlled Electric Torque Motor for the Flexor Hinge Hand Splint.* **Orthop. and Pros. Appl. J. 21:** 39-43, 1967.

Symposium on Below-Knee Prosthetics

Committee on Prosthetics Research and Development

December 16–18, 1968

Contents

This report was prepared as part of the work under Contract V1005M-1914 between the Veterans Administration and the National Academy of Sciences, and Contract No. SRS-69-12 between the Social and Rehabilitation Service, Department of Health, Education, and Welfare, and the National Academy of Sciences.

SUMMARY

A Symposium was held to assess the current status of below-knee prosthetics and make recommendations concerning future research and education programs in the on-going effort to improve

current practices. A review of current courses of instruction, current practice in clinical prosthetics, and current research projects was made.

It is the consensus that there now exists a body of knowledge that has been developed over the past few years and which is based on the concepts of the highly successful patellar-tendon-bearing (PTB) prosthesis that permits a significant improvement in present practice, and therefore it is recommended that special postgraduate, or continuing education, courses be made available for practicing clinic teams.

Also, it is the consensus that present research activities in the field of BK prosthetics are generally in the right direction. Increasing emphasis should be placed on the development of a truly refined theory of fitting.

SYMPOSIUM ON BELOW-KNEE PROSTHETICS

The Symposium was opened by Mr. Anthony Staros who, as Director of the Veterans Administration Prosthetics Center—the site of the meeting—welcomed the participants. As Chairman of the Subcommittee on Design and Development he recounted that the primary objective of the Symposium was to bring together all available information that might be helpful to the Prosthetics Education Program in bringing up to date their courses of instruction in below-knee prosthetics. He added that all research activities in below-knee prosthetics were to be reviewed also, and then turned the meeting over to the Chairman, Mr. James Foort, who followed the Schedule (Appendix A) which had been distributed previously.

A list of participants is included in this report as Appendix B.

I. Orientation

The Chairman reviewed the history leading to the Symposium noting that the so-called patellar-tendon-bearing prosthesis was developed at the University of California, selecting and synthesizing older ideas and providing rational biomechanical principles, as a result of a Symposium held there in April 1957 (*20*). Since its introduction in the United States about 1959, the use of the PTB prosthesis (Figs. 1 and 2) has spread throughout the world. Although the original PTB prosthesis has been phenomenally successful (*1*, *9*, *11*, *17*, *19*, *32*, *33*), a number of centers have, in recent years, introduced modifications in an effort to improve the technique even further. Unfortunately, some of these developments have been presented as though they were completely new types of below-knee prostheses, when in reality they are variations of the basic design.

At the Workshop Panel of Lower-Extremity Prosthetics Fitting held in January 1968, it became apparent that a number of innovations held considerable promise, and the Chairman was requested to organize a Symposium in order to elucidate the pertinent facts concerning improvements in prostheses for below-knee

patients. To do this he had visited virtually all of the research and education centers in the United States and Canada concerned with BK prosthetics, discussed experiences and current projects with the personnel involved, and developed the program as outlined by the agenda. He felt that the Symposium could be benificial to both the Education Program and the Research Program.

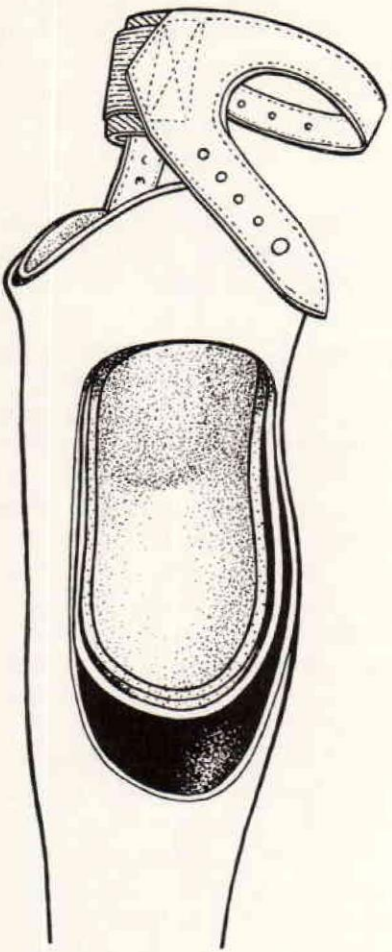


FIGURE 1—Cut-away view of original design of the patellar-tendon-bearing socket with soft insert and cuff suspension.

II. Review of Practices Presently Taught in University Programs

A. University of California, Los Angeles

Mr. Charles Scott, reporting in the absence of Mr. Bray who was ill, noted that the current instruction in below-knee prosthetics was oriented toward "certificate" students, a group which has had little or no previous training, and that five weeks are being devoted to the subject. He went on to report the following:

1. Both the hand-casting technique as described in the manual (*29*) and the Northwestern suspension-casting technique are taught.

2. Hard sockets with Silastic foam distal ends are taught as well as the Kemblo-backed insert-type of socket.

3. The use of synthetic balata (tubes formed from Polysar* X-414) for socket fabrication is demonstrated.

4. Modification of the male stump model is carried out in accordance with the BK manual (*29*).

5. Conventional cuff-suspension method is taught (*24*, *29*). Some trials of "PTS" (supracondylar-suprapatellar) (*22*, *23*) and supracondylar-wedge methods of suspension (*8*), as well as trials of the newly developed Hosmer suspension-strap-retainer locator have been made with inconclusive results. A lack of time has prevented the faculty from studying these

* Registered Trademark, Polymer Corp. Ltd., Sarnia, Ontario, Canada.

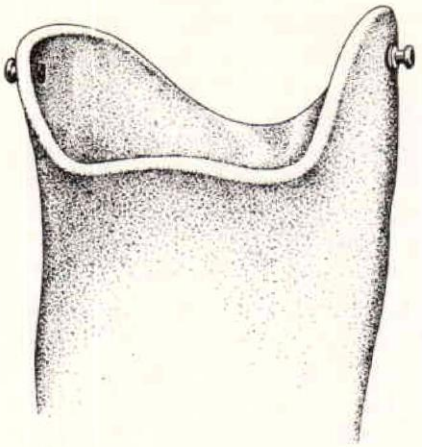


FIGURE 2—Posterior view of brim of original PTB socket.

techniques as closely as they would like.

6. Each student makes and fits four protheses.

B. New York University

Mr. Ivan Dillee reported as follows:

1. Texts used
   a. "The Patellar-Tendon-Bearing Prosthesis," C. W. Radcliffe and J. Foort (*29*).
   b. "VAPC Technique for Syme," 1959.
   c. "The Syme and Chopart Phosthesis," H. Blair Hanger.

(NYU is up-dating and reprinting the VAPC manual).

   d. Supplementary material:
      (1) Normal Human Locomotion
      (2) BK Alignment Jig —used in lieu of chapter in manual.
2. Types of Courses
   a. Short-term course taught in the Post-Graduate Medical School primarily for prosthetists with some experience. (Students are required to have two years' experience "in the field," but they are often poorly qualified as prosthetist students.)
   b. Degree Program for Prosthetists
3. Content of Course
   a. Basic instruction and laboratory exercises cenaround insert type socket with hand casting.
   b. NU suspension casting (*14*) demonstrated.
   c. Three sockets and two prostheses are fabricated.

C. Northwestern University

Mr. Blair Hanger noted that in recent years one short-term course in BK prosthetics has been offered every other year in August.

He reported that:

1. Four prostheses are made during the course.
   a. Hard socket with foam end; suspension casting of the stump.
   b. Insert-type socket; hand casting of the stump.
   c. PTS socket with insert as demonstrated by Robert Nitschke.
   d. Supracondylar wedge system with hard socket as demonstrated by Carlton Fillauer (first taught in 1968).

In addition, a lecture-demonstration of the air-cushion socket

(*31*) is given to acquaint the students with its possibilities.

2. Modifications to the male models are made in accordance with principles outlined in the BK manual.

3. In addition to the cuff, PTS (supracondylar-suprapatellar), and supracondylar-wedge methods of suspension, the method developed by Jack Caldwell is taught (*4*).

4. A lecture-demonstration on the carved-wood socket is included.

5. Included is an orientation session on immediate postsurgical fitting of prostheses.

In the discussion that followed, it was brought out that the major part of the teaching effort in reference to BK prosthetics at the three universities is devoted to the inexperienced students and most of the course content consists of the original methods given in the BK manual (*29*). Some time was devoted to advantages and disadvantages of various methods that might be used to keep practicing prosthetists up to date, but no concrete proposals were offered at this time, it being recognized that the selection of the most appropriate means must necessarily be related to the particular subject matter being offered.

III. New Practices

A. Socket Modification and Suspension Systems

Before calling upon Professor Charles Radcliffe and others to report on the air-cushion socket, the Chairman evoked a discussion in an effort to determine to what extent hard sockets are used in the PTB in reference to sockets with the inserts. It appeared that the hard socket with firm foamed-in-place Silicone rubber ends is the method of choice in the South, except for the fitting of bony, conical stumps but that this method was not being used as widely in other parts of the country. Mr. Muilenburg reported using mainly hard sockets with Silicone rubber ends as did Mr. Thranhardt. Mr. Fillauer said that approximately 95 per cent of new below-knee amputees now being fitted by him were provided sockets, foamed-in-place Silicone rubber ends, and the supracondylar wedge-suspension system.

Mr. Roy Snelson stated that very few liners were used by his group but that in difficult cases they were finding the air-cushion socket very useful. Mr. Foort related that approximately 200 patients have been fitted at his center over the past five years and the bulk of them are geriatric. They were all fitted with total-contact sockets without liners or foam in the ends. The Northwestern University suspension-casting technique has been used since its introduction. More recently, since introduction of the supracondylar-wedge-type suspension, amputees have been fitted with a high medial extension which clips over the medial femoral condyle. This medial extension is springy rather than rigid, so that entrance into the socket can be effected. Mr. Bert Titus reported that it was general practice at Duke University to provide hard sockets with hard ends and that every socket

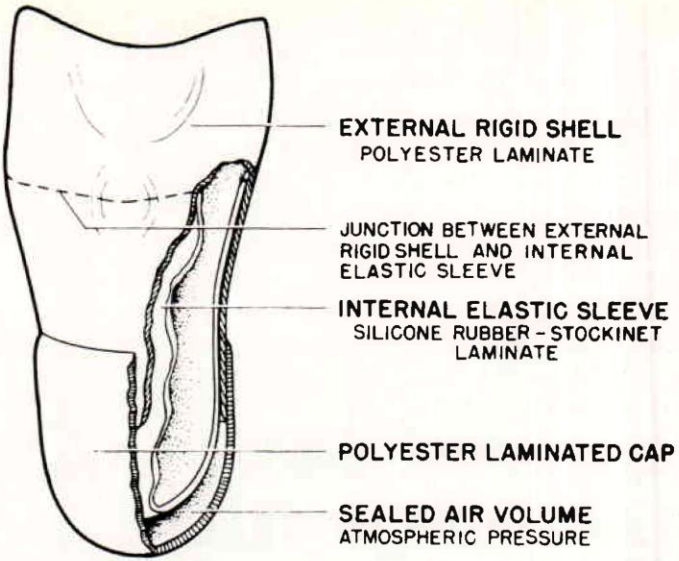


FIGURE 3—Cut-away view of the air-cushion socket.

was x-rayed to insure that total contact was being obtained. Mr. Nitschke reported that most of his patients received the "PTS"-type (supracondylar-suprapatellar) of socket which normally calls for a soft insert. In the immediate post-surgical fitting program in Seattle, Mr. Joseph Zettl said that the standard BK prosthesis has been the PTB with no liner.

1. Air-Cushion Socket (Fig. 3)

Professor Radcliffe distributed copies of the most recent VA manual covering the air-cushion socket has been designed to provide more "endbearing" than the original "total-contact" PTB. After relating experiences gained with the air-cushion socket in the Bay area, and describing certain key points in the fabricating and fitting procedures, he said that the group at the University of California are convinced that the technique has a rather widespread application and should not be limited to use in special cases for therapeutic value, even though a little more time is required to fabricate it. However, it is not recommended for use when rapid atrophy is anticipated.

Mr. Leigh Wilson described an alternate method that was finding favor in the Bay area for forming the outer shell over the RTV insert using wax as a mold. Prof. Radcliffe called attention to a report from the Orthopaedic Hospital, Copenhagen (Appendix C) and one from the Center for Prosthetics and Orthopaedics in Belgrade (Appendix D) which had been distributed to participants in advance of the Symposium. Both reports dealt with experience with the air-cushion socket and both were quite favorable. Prof. Radcliffe stated that he had received word from Sweden and Italy that experience in those

countries with the air-cushion socket had been most favorable also, and deplored the fact that the technique was not being used to any great extent in this country. Mr. Staros replied that the interim report on fittings being undertaken in the Bay area under the auspices of the VA showed favorable results, that a number of problem cases had been satisfied, but that it was clear that success is quite dependent upon application strictly according to the manual.

Mr. Snelson, with projection slides, reported on five successful problem cases that had been

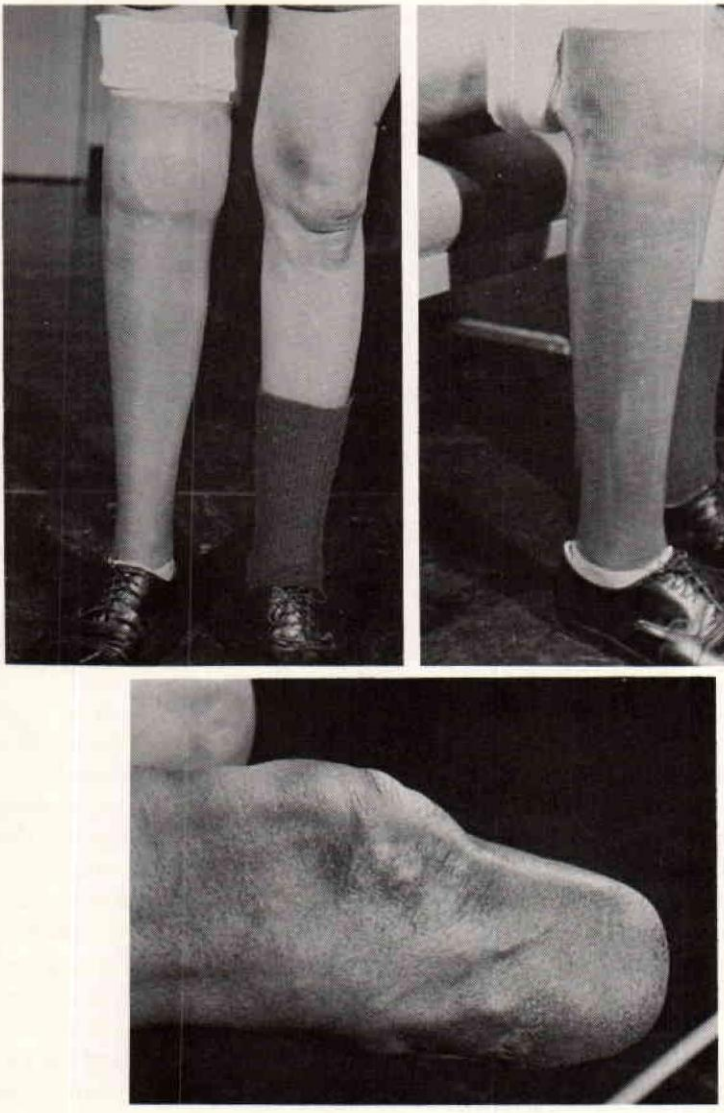


FIGURE 4—The PTS socket.

TABLE 1. Distribution of Cases Fitted with "PTS" Socket by Robert Nitschke.

Age	New	Old	Total	
		Unilateral		
1–20	7	9	16	
20–40	4	12	16	
40–60	11	18	29	
Over 60	26	14	40	101
		Double (All BK)		
1–20	0	0	0	
20–40	0	0	0	
40–60	4	1	5 + 5	
Over 60	2	2	4 + 4	18
		Double (AK and BK)		
1–20	0	1	1	1
				120

fitted with the air-cushion socket.

Prof. Radcliffe felt that the main difficulty with air-cushion sockets was in the fabrication technique. It was suggested that perhaps a central fabrication facility should be set up so that prosthetists could send their corrected casts to a certified center for fabrication of the socket. The central fabrication scheme could also be applied to the clear vinyl sockets developed by Mr. Snelson.

2. PTS-type Socket (Fig. 4)

Mr. Nitschke stated that during the last two years of the 158 BK prostheses he had fitted, 120 (76 per cent) had been of the PTS type, more or less as developed by Mr. Fajal (*25, 26, 27*). Distribution by age, and whether "old" or "new" patients, is given in Table 1.

Of these 120 sockets, three were converted to standard PTB and five were converted to PTB-type with sidebars and thigh lacers. In the PTS, a Kemblo insert with leather liner impregnated with paraffin is generally used and in most cases a wedge is used between the insert and socket to aid suspension. In about half of the cases, a wedge is used on both medial and lateral aspects of the socket. The insert is used primarily to make later adjustments easier. Mr. Nitschke felt that the advantages of the PTS were a reduction in piston action of the stump, the elimination of the cuff-suspension strap, improved cosmetic appearance, good mediolateral stability at the knee joint, and prevention of hyperextension of the knee, but that anteroposterior motion about the knee joint is restricted somewhat. When complete freedom of the knee joint is required, he fits the conventional PTB prosthesis. He

feels that the PTS has definite advantages for patients with short stumps and for geriatric patients. Mr. Nitschke showed motion pictures of a number of cases, and described in detail various steps in fabrication and fitting.

A number of the participants objected to the name "PTS" because it does not adequately describe the socket. Prof. Radcliffe pointed out that PTS had been derived from the initials of the name originally given by Mr. Fajal, prothese-tibiale-supracondylien. It was suggested that a supracondylar-suprapatellar brim" might be a more functional name.

3. Supracondylar - Wedge - Type socket (Fig. 5).

Mr. Fillauer recalled how in 1967 he had been introduced in Muenster to the concept of achieving suspension by introducing a wedge-shaped object between the stump and socket on the medial side of the socket just above the femoral condyle (*16*). Upon his return to the United States, he attempted to duplicate the work he had seen in Muenster, and after a number of trials had worked out a successful technique which he had published in the June 1968 issue of *Orthotics and Prosthetics* (*8*). Virtually all "new" amputees seen by Mr. Fillauer are provided with the supracondylar-wedge-type socket. Mr. Fillauer, using projection slides, described fabrication and fitting procedures, noting that development of the male model is the same as described in the manual (*29*). No liner is used. The higher brim on the medial and lateral aspects impart some stability but not to the same degree

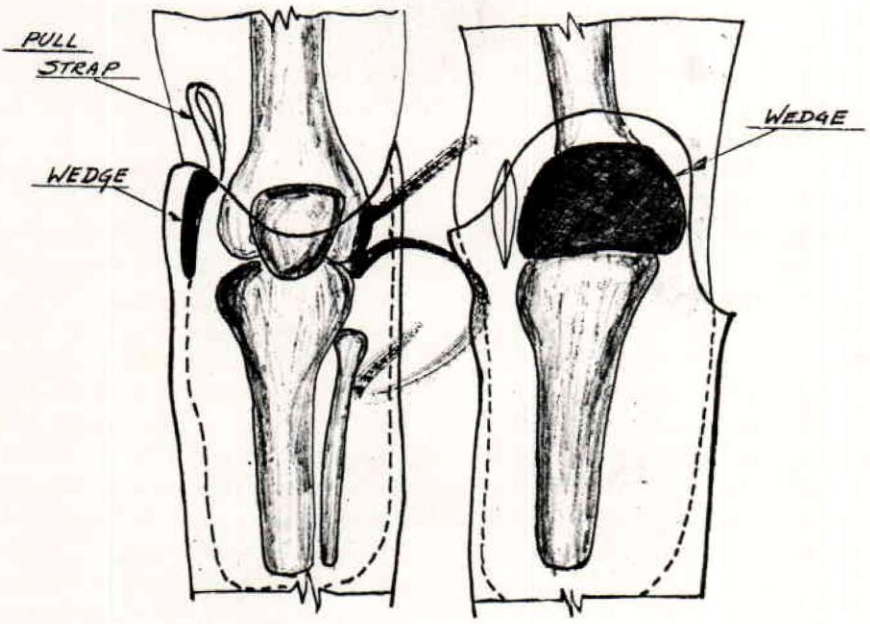


FIGURE 5—The supracondylar-wedge suspension method.

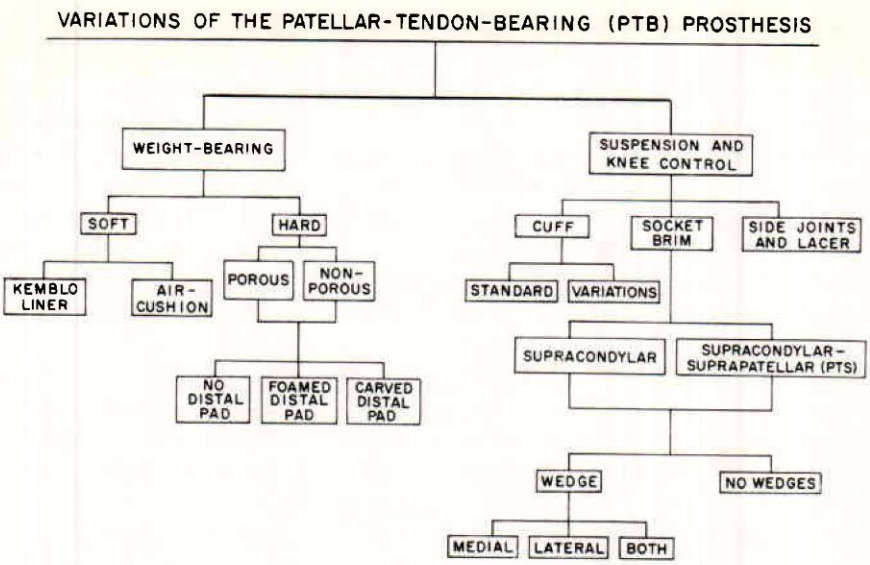


CHART 1.

as that provided by the PTS type. Three sizes of wedge seem to be sufficient, but there is some argument for adding a fourth size.

Mr. Hanger reported on the experience at Northwestern University when a number of students were taught under the direction of Mr. Fillauer. He felt that the students were fairly successful, but location of the wedge is very critical in achieving a correct fit. NU hopes to continue to offer instruction in this technique in the future.

Mr. Joseph Zettl described a technique he had developed independently of others but which is essentially the same as the supracondylar-wedge system described and used by Mr. Fillauer.

In the general discussion that followed, it was clearly the consensus that all of the innovations that had been reported upon had a valid place in the management of the below-knee amputee. Many of the innovations are not mutually exclusive and, therefore, clinic teams have at their disposal a number of combinations that can be used to satisfy the particular patient.

As a result of a suggestion by Prof. Radcliffe, a chart based on functional characteristics of a below-knee socket was developed (Chart 1).

Further discussion followed. It was the consensus that:

1. The various versions of the PTB as shown on the chart should be introduced into the field as soon as possible.

2. These techniques should be included in the Associate of Arts and Bachelor of Arts and other long-term courses.

3. Some provisions should be made to get the information to practicing prosthetists. Ideally, UCLA, NYU, and NU should offer postgraduate (continuing education) courses, if possible. (Other

suggestions including instruction at AOPA regional and national meetings were discussed, but no consensus was established. This approach is limited by the impracticality of providing laboratory practice.)

4. Detailed manuals are needed in addition to the one on the air-cushion socket.

Mrs. Friz invited the participants to consider how the Committee on Prosthetic-Orthotic Education could help. (Since the meeting, CPOE has taken steps to form an *ad hoc* committee to review publications and other educational material, identify current needs, and develop recommendations for action to meet these needs.)

B. Socket Materials and Fabrication

1. Pneumatic Casting of Sockets using Synthetic Balata (Polysar X-414)

Noting that the Polysar X-414 is a synthetic balata that can be molded at a temperature that is comfortable to the skin yet stable enough at temperatures slightly above normal body temperature to serve as a socket material, Mr. Henry Gardner described a technique that had been developed by VAPC to form a hard but flexible PTB-type socket directly over the stump using a pneumatic pressure sleeve (Fig. 6) (*30*). Suspension in this design is usually obtained by connecting the medial and lateral "ears" of the socket brim with an elastic strap. This method is feasible because of the flexibility of the socket material. The socket is usually mounted on a pylon. A technique to achieve good cosmetic appearance using a plastic foam, Goodrich "Spongex," was described. The draft manual was currently being revised to incorporate the latest changes. Mr. Gardner reported that trials at VAPC over the past two years had been very successful and that the technique was being used routinely at the VA Brooklyn Hospital to provide immediate postsurgically fitted patients with interim prostheses until they could be fitted by commercial shops.

Mr. A. Bennett Wilson, Jr., reported that under the CPRD Clinical Evaluation Program, six prosthetists had been trained at VAPC, November 6–8, 1968, and that each will report on at least five patients fitted under clinical conditions. At the conclusion of the course all of the prosthetists felt that the technique definitely had merit for fabrication of interim prostheses.

In the discussion that followed it was recommended that the manual be completed as soon as possible and that consideration be given to using the synthetic balata sockets in conjunction with the receptacle system developed at Winnipeg in order to effect even more saving in time. Furthermore, the receptacles may offer the reinforcement that seems to be necessary for some types of patients.

It was also suggested that, using the standard size information already developed at Winnipeg, synthetic balata sockets for BK patients be made up in a series of

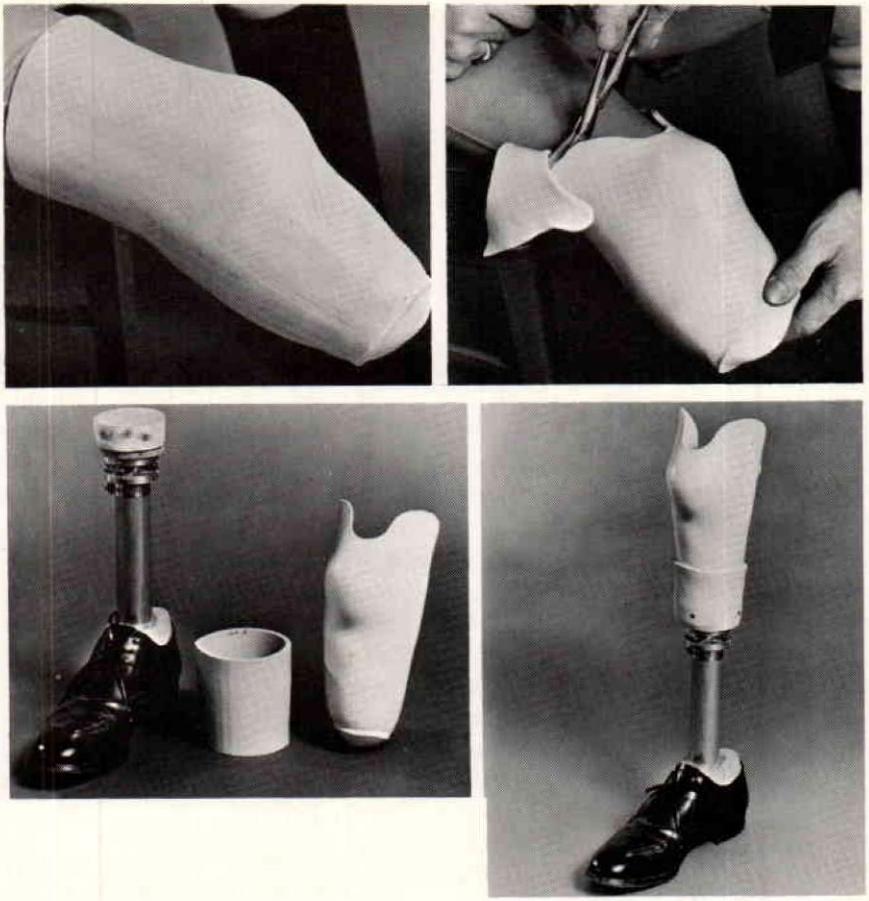


FIGURE 6—Some steps in direct forming of a socket using synthetic balata and air pressure.

standard pre-forms (*10*). These pre-formed sockets could then be fitted to the patient by heating in the usual manner and shaped to the individual stump using the NU Suspension Casting Technique. Changes in the patellar shelf and other minor adjustments could be carried out subsequently. It was felt that this method will be much quicker than the method demonstrated and proposed by Mr. Gardner.

2. Transparent Sockets

Mr. Ronald Lipskin reported on recent developments at NYU concerning transparent sockets and called attention to their technical report "The Development of the NYU Transparent Socket Fabrication Technique" (*18*). It was the consensus that the transparent socket in this form offered an excellent research tool for further study of socket design, fitting, and alignment. As an example, it would seem quite feasible to fit a PTS-type transparent socket, record relative motion between stump and socket, trim var-

ious portions of the proximal section away, record the relative motion, and compare this with the the original records. From these comparisons, some very interesting information may develop.

Mr. Lipskin pointed out that the transparent sockets may lend themselves for use in determining stress patterns by techniques involving polarized light and photoelasticity. He was encouraged to continue his investigation in this area.

Mr. Snelson reported that his group was trying to develop a transparent socket that would be inexpensive enough to serve as a check socket or part of a temporary prosthesis. If it were strong enough, it could, of course, be used as part of the permanent prosthesis. Encouraging results were being obtained by using fiberglass and epoxy with essentially the same refractive index. His plan includes the use of a stump sock.

Mr. Snelson also showed a transparent socket made from vinyl sheet formed by drape and pressure-forming over the cast. The socket was beautifully clear but Mr. Snelson reported that the manufacturing process was alien to standard prosthetic procedures, although he had encountered no difficulty in the technique.

It was recommended that all of this work be continued and some thought be given to the development of special stump socks that, when compressed, might give a better idea of the distribution of forces and pressures.

3. Porous laminates

Mr. Clyde M. E. Dolan reviewed the history of porous plastic laminates (*6*) and cited the pertinent findings of the NYU field study concerning the usefulness of the AMBRL technique for below-knee sockets. The test sockets, when fabricated strictly according to the manual (*15*, *28*), provided improved ventilation, were 30 per cent lighter, but still withstood hard wear. Slightly more time is required in fabrication, and keeping the pores clean requires diligence on the part of the patient. In summary, the results of the field tests were positive and it is the feeling of NYU that more patients should be receiving porous sockets than is presently the case. In this the group concurred.

IV. Proper Application of Sach Foot

Prof. Radcliffe reported that the Biomechanics Laboratory was working with VA and with manufacturers to modify the shape slightly in order to improve function. It is his belief that two forms of the SACH foot should be available; one for below-knee prostheses, the other for above-knee prostheses.

V. Stump-Socket Relationship

A. NYU Distal-Contact Regulator

Mr. Thomas Grille described the pneumatic distal-contact regulator (Fig. 7) which has been designed by NYU to control the

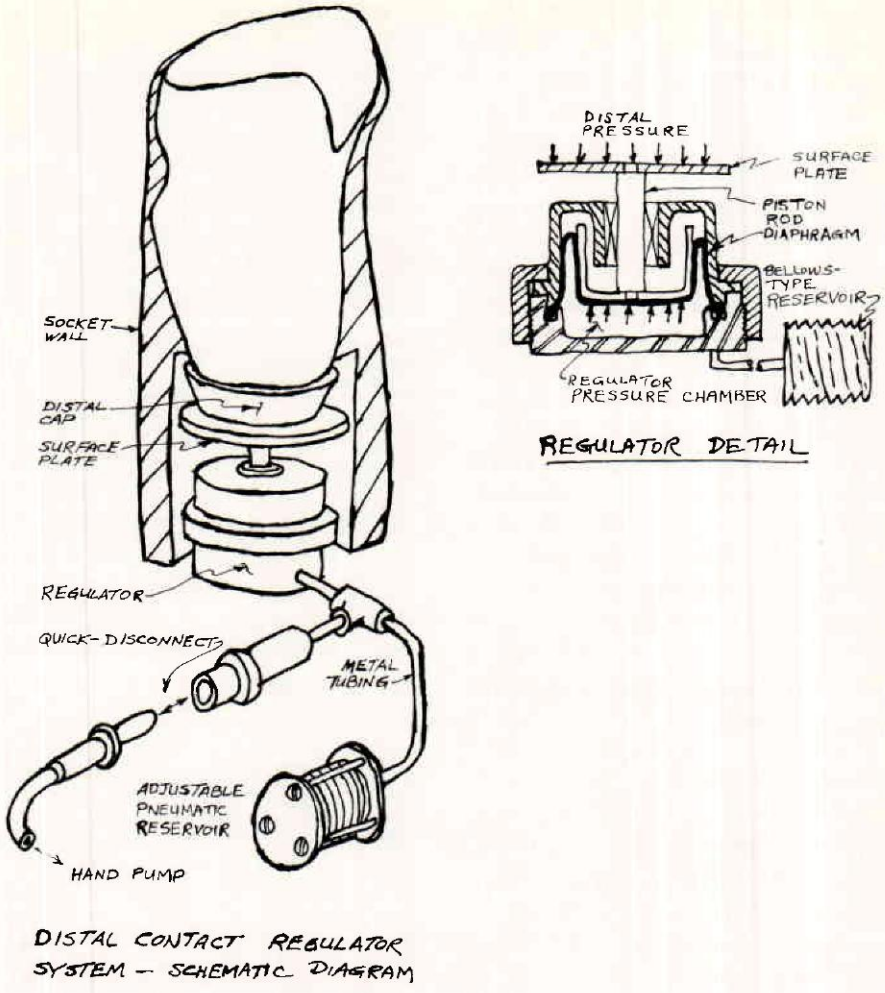


FIGURE 7—Distal-contact regulator developed at NYU.

amount of pressure taken over the end of the stump. The principle, if successful, should apply to both above-knee and below-knee stumps, but current models have been fitted to BK cases.

Two patients had been fitted with the device with generally positive results though it was too early to come to any conclusions. NYU was encouraged to continue the project.

B. Veterans Administration Prosthetics Center

Dr. Edward Peizer reviewed the joint project between the Prosthetics Research Study, Seattle, and VAPC in trying to determine the pressures involved in immediate postsurgical fitting procedures (*2, 3, 5*). This project will include a study involving the effects alignment changes have on pressure distribution. Pressure

data will be correlated with electromyographic data.

C. University of Michigan

Mr. Edward Corell reported on progress being made by him at the University of Michigan in developing a method of displaying the pressure distribution patterns using computer techniques (5). Presently he is using five pressure transducers; one at each corner of a square and one in the center. Data are accumulated in the form shown in Figure 8.

D. Mr. David Harden described the development of a double-wall socket with a very flexible inner wall so that adjustment can be made by injecting fluid with a hypodermic-type needle.

VI. Summary and Recommendations

Recommendations

1. There exists a body of knowledge in BK prosthetics that has been developed in recent years that should be made available to practicing prosthetists and other clinicians for use in everyday practice. (See Chart 1, p. 13, and Bibliography, Appendix E.)

2. All education programs are urged to include this material in their curricula.

3. Postgraduate-type courses in these latest techniques should be made available to practicing clinic teams.

4. It is recognized that manuals and instructional materials are needed. This points out the need for a central group that would be responsible for the preparation and dissemination of technical

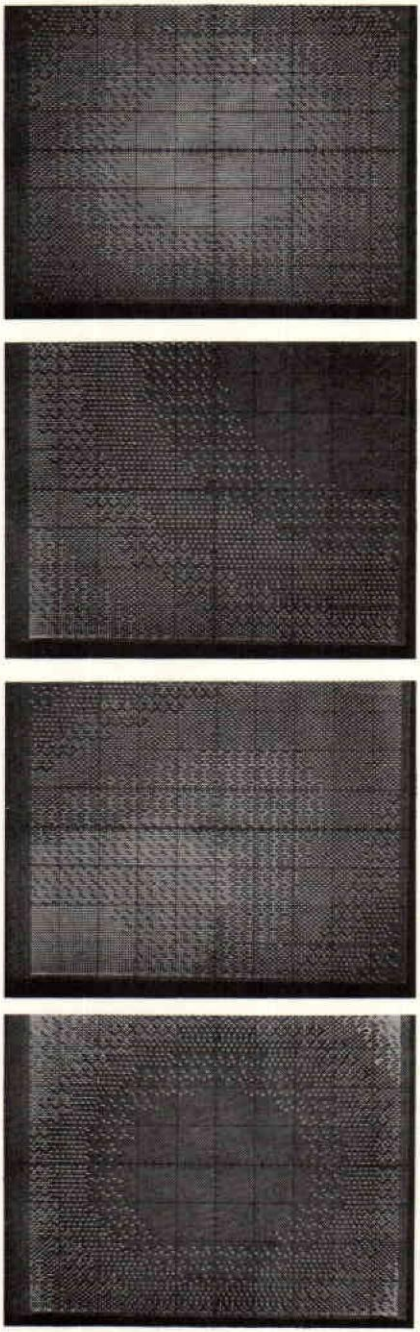


FIGURE 8—Typical readouts for pressure distribution obtained at the University of Michigan.

information. Material is now developed many times without adequate consideration for its ultimate usefulness. In many cases it has been necessary to use technical reports for classroom instruction.

5. Current research efforts in BK prosthetics should be continued with emphasis on the development of a truly refined theory of fitting.

It is clear that the sockets discussed during the Symposium are satisfactory and represent improvement over previous practices. Most of the work in the last few years in improving the original design, especially in suspension, has been accomplished by practical prosthetists working in the field, and it seems unwise for research centers to devote their time developing techniques for further improvement. There is, however, a lack of knowledge of the basic principles underlying an optimum prosthetic fit. Research centers, therefore, should be encouraged to obtain basic factual information concerning the response of tissue to pressure and shear forces and to more clearly indicate biomechanical requirements through the various phases of walking. Following this, development should include methods by which these principles could be realized in practice, including the use of hydrostatic sockets and other methods of automatic adjustment.

February 14, 1969

SCHEDULE

SYMPOSIUM ON BELOW-KNEE PROSTHETICS

Panel on Lower-Extremity Prosthetics Fitting

Subcommittee on Design and Development

Committee on Prosthetics Research and Development

National Academy of Sciences

Veterans Administration Prosthetics Center
252 Seventh Avenue New York City
December 16–18, 1968

I. ORIENTATION	*Chairman*, James Foort
II. REVIEW OF PRACTICES PRESENTLY TAUGHT IN UNIVERSITY PROGRAMS	
A. University of California at Los Angeles	Charles Scott
B. New York University	Ivan Dillee
C. Northwestern University	H. Blair Hanger
III. NEW PRACTICES	
A. Socket Modifications and Suspension Systems	
1. Air Cushion Socket	Charles W. Radcliffe, Roy Snelson, *et al.*
2. PTS-type	Robert Nitschke, Samuel E. Hamontree, *et al.*
3. Supra Condylar-type	Carlton Fillauer, Alvin L. Muilenburg, *et al.*
B. Socket Materials and Fabrication	
1. Polysar Socket and Pneumatic Casting	Henry Gardner
2. Transparent Sockets	Ronald Lipskin, Roy Snelson, Alvin L. Muilenburg
3. Porous Laminates	Clyde M. E. Dolan

APPENDIX B
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APPENDIX C

Clinical Study of the Application of the PTB Air-Cushion Socket

Eric Lyquist, Director
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Orthopaedic Hospital, Copenhagen

During the period January 1966–September 1968 a clinical study of the application of the PTB air-cushion socket was conducted at the Orhopaedic Hospital, Copenhagen, Denmark.

Manufacturing as well as fitting took place in the Prosthetic/Orthotic Research Department. The casting procedure followed that described by Wilson and Lyquist[2], and the manufacturing procedures followed, with no significant modifications, the procedures described by Lyquist, Wilson, and Radcliffe[1].

The preliminary results based on examinations of 24 amputees were presented to the Danish Association of Orthopaedic Surgeons by J. Kjølbye, M.D., in October 1967.

In September 1968 the Prosthetic/Orthothic Research Department published a technical report about the manufacturing and fitting procedures as well as results based on 45 amputees fitted with air-cushion sockets.

The total number of amputees include the 24 amputees mentioned above. The remaining 21 amputees were all checked and evaluated by an orthopaedic surgeon at the time of delivery of the prosthesis and several of them again at later visits. The final extensive medical examination has, however, not yet been completed for this group, but since these amputees have been under close observation by the Research Department it is very unlikely that the results will have changes at the time of the final medical examination.

In the following the figures in ( ) refer to the preliminary results.

Of the 45 (24) amputees in the test series, 4 (2) have been dropped, three of them because they could no longer fulfil the obligation to meet for reexamination at request, and one amputee suffering from a progressive vascular disease became confined to a wheelchair.

Of the thus remaining 41 (22) amputees, 11 (6) are female and 30 (15) male. The average age was 44 (43) years (ages ranging from 7 to 74 years).

Seventeen (9) amputees had been contented wearers of the PTB prosthesis for a minimum of 12 months. When fitted with air-cushion sockets

13 (7) amputees obtained better comfort and function,

3 (1) amputees found no changs in comfort and function,

1 (1) amputee complained of stump pains at night, and after 6 months he returned to wearing an ordinary PTB prosthesis.

Seven (6) amputees had previously been fitted with the standard type of PTB prosthesis, but a successful fitting had never been achieved. With the air-cushion socket

4 (4) amputees obtained satisfactory comfort and function,

1 (1) amputee's condition must be characterized as unchanged, but he is wearing a modified air-cushion socket with soft insert, and

2 (1) amputees had to abandon the air-cushion socket. After 8 months one

amputee was fitted with a conventional B/K (with thigh corset) as his weight fluctuated due greatly to an ulcus ventriculi. Both amputees had short stumps 2½ inches) with distal hypersensitivity.

Seven (4) amputees had previously worn prosthesis and had complications such as secondary edema distally and ulcerations. When fitted with air-cushion socket

6 (3) amputees obtained satisfactory comfort and function.

1 (1) amputee was after 4 weeks fitted with a standard PTB prosthesis. Her stump was 2 inches long, and skin transplantations covered the entire stump and the distal part of the thigh.

Four amputees had for 40, 30, 13 and 6 years, respectively, successfully worn a conventional B/K, but when fitted with an air-cushion socket they all preferred that to the conventional prosthesis.

As far as the 35 amputees who had previously worn a prosthesis are concerned, fitting with the air-cushion socket gave the following results:

in 27 cases, increased comfort and function.

in 4 cases, unchanged condition

in 3 cases, return to standard PTB prosthesis

in 1 case the amputee had to be fitted with a conventional prosthesis.

Of the remaining 6 amputees, 5 had not before worn a prosthesis and

in 2 cases the amputee had edema distally and ulceration which healed when air-cushion socket was applied.

in 1 case the amputee manages well with air-cushion socket. He has had stump problems which cannot, however, be attributed to the prosthesis.

in 1 case the amputee, who had no stump problems, is wearing an air-cushion socket with success.

in 1 case the amputee had to be fitted with a different type of prosthesis because his stump volume was constantly changing and his stump was hypersensitive distally.

in 1 case the amputee has previously been fitted with an air-cushion socket by a private prosthetist, and she is doing very well.

Of the 41 amputees in the test series, 36 are now wearing the air-cushion socket, whereas 5 amputees had to abandon it.

As earlier mentioned, 22 of the 41 amputees have been through an extensive medical reexamination. The remaining 19 amputees are also to be reexamined, and then a more detailed report on the results and the basic pathology will be published.

LITERATURE

1. Lyquist, E., L. A. Wilson, and C. W. Radcliffe, *Air-cushion socket for patellar-tendon-bearing below-knee prosthesis, principles and fabrication procedures*. Biomechanics Laboratory, University of California, San Francisco and Berkeley, 1965. (Technical Memorandum).
2. Wilson, L. A., and E. Lyquist, *Plaster bandage wrap cast*, Prosthetics International, Vol. 3, no. 4-5, 1968.

APPENDIX D
EXPERIENCE WITH THE AIR-CUSHION BELOW-KNEE SOCKET IN YUGOSLAVIA

BOSKO ZOTOVIĆ, M.D.*

The production of air-cushion sockets for below-knee prostheses was introduced into Yugoslavia by the Center for Prosthetics in Belgrade, in January 1966, very shortly after the return of Engineer L. Gavrilović from the States, where he had been taught the technique by Prof. Radcliffe and his group. During his visit to the University of California, Eng. Gavrilović made a number of prostheses. With the help of Prof. Radcliffe's Manual, he began to fit air-cushion sockets in the Center.

Betweeen January 1966 and November 1968, 28 patients have been provided with air-cushion sockets. In addition, patients in other parts of the country, where we have trained the staff, have been fitted with the new type socket.

The technique of work, as well as the applied material with some minor modifications, follows the manual closely. SILASTIC #388, a product of the Dow Corning Co., Midland, Mich., is imported for use in

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the socket. For the prosthesis itself, a local polyester resin has been used, in standard proportions of rigid and flexible components. The VAPC casting stand, which we have been using for the past several years in all below-knee fitting, is used. Alignment of these protheses has been carried out in the standard way using the VAPC coupling.

However, in fabrication of the air-cushion socket, certain changes from the initial technique described by Prof. Radcliffe have been undertaken.

1. For stumps with marked sensitivity at the distal end, reduction of the pressure at the bottom of the socket has been achieved by using the plaster-of-Paris mold as it is made, i.e., without modifications.

2. Corrections of the distal part of the plaster-of-Paris mold have been carried out only for those cases which tolerate distal pressures. In this case, we have followed instructions given in the Manual.

3. When bony prominences as well as the marked oversensitive areas are present, the distal reduction of cast, for about 9 mm., is performed all over, except for areas where the sensitivity and pressures have been noted. In certain cases, at these areas, even the local buildups of the cast, for about 3-4 mm. had to be performed.

These were the only changes made, and these are minor, yet they are significant in providing prostheses that can be used by patients with overly sensitive stumps.

For several years now it has been our policy to trim the anterior, medial and lateral walls at the level of the proximal border of the patella, or even higher, with a slight rounding anteriorly around and above the patella. This practice yields better retention of the stump within the socket and therefore less need for suspension, and shorter stumps can be fitted. At the same time more stability about the knee is obtained, a feature that is necessary for some cases with certain knee disabilities. This higher socket border had been applied to air-cushion sockets.

Stumps as short as 2¼ in., measured from the tibial plateau, have been fitted satisfactorily. Not a single patient required a thigh corset with mechanical joints as a suspension means. For the cases with extremely short stumps, suspension was achieved by using a special 3 mm. thick Ortholen cuff attached to the socket by vertical uprights. Such a cuff provides not only suspension but stability about the knee as well.

During fitting and alignment the pressure within the air-chamber is controlled by a manometer attached to the socket, during both the swing and stance phases of ambulation. During the swing phase, the pressure was negative and amounted to 0.2 atmospheres while in the stance phase its value was increased by 0.07 atm. After the trials, the manometer is detached, the connective tube is sealed with a plastic resin, the coupling device is removed, and the prosthesis is finished in the normal manner.

The patients fitted with these prostheses were of different age groups, their amputations resulted from various causes, and they have undergone regular one-month and three-months follow-up studies. The results were very satisfactory for all of them. There was not any objection on the part of the wearers, and they all were very contented with these prostheses. Not a single patient fitted with the air-cushion socket discarded it or switched to some other type. There have been, however, several cases who have ordered the second prosthesis with an air-cushion socket, and three have ordered a third.

The statements and subjective estimations of the patients correspond, to a great extent, to our findings, as follows:

1. Better and more intimate fit between the stump and the prosthesis.

2. Better positioning of prosthesis during ambulation; better coordination of gait, i.e., better coordination of movements and more improved and easier gait.

3. Better control over the prosthesis has been reported by all wearers.

4. The patients stress the subjective sense of relative elongation of the stump length.

5. The blood circulation within the stump was improved, even where some circulatory changes have been previously diagnosed. The skin quality has been improved to a certain extent, and the skin recovered its normal color. After some time, hair began to grow on stump surfaces where it had vanished due to shear.

6. Muscle function was more obvious while using the air-cushion socket, and muscle strength was improved to a certain extent. This assessment was established on the basis of comparative muscle tests which were performed for all patients.

In several cases, when stump atrophy was present, there were attempts to correct the sockets by making a new Silastic chamber over the cast and mold to make a double air cushion. Unfortunately, this trial, as well as some other attempts at corrections, has failed. The only reasonable method presently known for correcting for stump atrophy is to make a new socket.

After the experimental work was finished and we became familiar with the technique, we organized a Seminar for teaching the other orthopedic enterprises in Yugoslavia, and now the air-cushion socket is being produced in several other places. These institutions report findings parallel to our own.

Last year we demonstrated the use of the air-cushion socket in Hungary and Bulgaria. We are informed that the patients that have been fitted with this type of prosthesis in Hungary and Bulgaria are very satisfied with them. The appraisal of experts in these countries is also very praiseworthy, and it corresponds to our opinion as submitted in this report.

Before closing we would like to point out that we have applied this technique with some modification to below-elbow stumps as well. We have experimented with cases where oversensitivity at the stump end was obvious, or the stump was bulbous, or where bony prominences were present. The patients responded very well to this type of air-cushion socket. They had a feeling of relative elongation of the stump, the positioning of the prosthesis was better, the sense at work was better, and, in their words, they were more manipulative. This was particularly demonstrated in the case of a bilateral below-elbow amputee, where one side was fitted with the air-cushion below-elbow prosthesis, while the other side was fitted with a standard-type of preflected Hepp-Kuhn prosthesis. With this work, Mr. Hector Kay has been acquainted, during his recent stay with us.

In conclusion, we would like to stress that our results with air-cushion sockets have been very good. No contraindications for use have been found. We would like to point out that this technique requires a solid knowledge and training, and that accuracy and studiousness are necessary for success. Because the accuracy required is greater than that for other types of BK sockets, it is not surprising that some enterprises make a socket which is not adequate. For this reason the clinic team must check out each case most carefully to prevent the unjustified failure of this really good and useful type of below-knee socket.

BIBLIOGRAPHY INCLUDING LITERATURE CITED

1. Bakalim, Georg, *Experiences with the PTB prosthesis*, Artif. Limbs, *9*:1:14–22, Spring 1965.
2. Burgess, Ernest M., *Amputations below the knee*, Artif. Limbs, Spring 1969, in press.
3. Burgess, Ernest M., *The below-knee amputation*, Inter-Clinic Inform. Bull., *8*:4:1–22, January 1969.
4. Caldwell, Jack L., *Inverted V-strap suspension for PTB prostheses*, Artif. Limbs, *9*:1:23–26, Spring 1965.
5. Committee on Prosthetics Research and Development, *Pressure and force measurement*, National Academy of Sciences, Washington, D. C., 1968.
6. Dolan, Clyde M. E., *The Army Medical Biomechanical Research Laboratory porous laminate patellar-tendon-bearing prosthesis*. Artif. Limbs, *12*:1:25–34, Spring 1968.
7. Dunfield, Vaughn, *An electronic aid for the alignment of the below-knee pylon prosthesis*, Thesis for M.S. degree, University of New Brunswick, September 1967.
8. Fillauer, Carlton, *Supracondylar wedge suspension of the P.T.B. prosthesis*, Orth. & Pros., *22*:2:39–44, June 1968.
9. Foort, James, *The patellar-tendon-bearing below-knee prosthesis for below-knee amputees, a review of technique and criteria*, Artif. Limbs, *9*:1:4–13, Spring 1965.
10. Foort, J., and D. A. Hobson, *A pylon prosthesis system for shank (BK) amputees*, Prosthetics and Orthotics Research and Development Unit, Manitoba Rehabilitation Hospital, Winnipeg, Report No. 6, November 1965.
11. Goldner, J. Leonard, Frank W. Clippinger, and Bert R. Titus, *Use of temporary plaster or plastic pylons preparatory to fitting a permanent above-knee or below-knee prosthesis*, Final Report of Project No. 1363 to Vocational Rehabilitation Administration, DHEW, from Duke University, no date given; circa 1967.
12. Hamontree, Sam E., Howard J. Tyo, and Snowdon Smith, *Twenty months experience with the "PTS,"* Ortho. & Pros., *22*:1:33–39, March 1968.
13. Hampton, Fred, *Silicone rubber for distal pads in above-knee and below-knee prostheses*, Prosthetics Research Center, Northwestern University, Chicago, 1962.
14. Hampton, Fred, *Suspension casting for below-knee, above-knee, and Syme's amputations*, Artif. Limbs, *10*:2:5–26, Autumn 1966.
15. Hill, James T., Henry Mouhot, and Robert E. Plumb, *Manual for prepa-*

ration of a porous PTB socket with soft distal end, Army Medical Biomechanical Research Laboratory, Walter Reed Army Medical Center, Washington, D. C., Tech. Rep. 6804, May 1968.
16. Kuhn, G. G., S. Burger, R. Schettler, and G. Fajal, *Kondylen bettung Münster am unterschenkel stumpf, "KBM prothese,"* Atlas d'Appareillage Prothétique et Orthopédique, No. 14, 1966, 18F.
17. Lambert, Claude N., *Applicability of the patellar-tendon-bearing prosthesis to skeletally immature amputees*, Inter-Clinic Inform. Bull., *3*:7:7, May 1964.
18. Lipskin, Ronald, and Thomas Grille, *The development of the NYU transparent socket fabrication technique*, Prosthetics and Orthotics, New York University Post-Graduate Medical School, November 1968.
19. Litt, Bertram D., and LeRoy Wm. Nattress, Jr., *Prosthetic services USA--1961*, American Orthotics and Prosthetics Association, Washington, D. C., October 1961.
20. Lower-Extremity Amputee Research Project, *Minutes of symposium on BK prosthetics*, University of California, Berkely, April 17-20, 1957.
21. Margetis, Peter M., Walter L. Shepard, Robert E. Plumb, and Fred Leonard, *A fluid resin technique for the fabrication of check sockets*, Ortho. & Pros., *22*:4:8-27, December 1968.
22. Marschall, Kurt, and Robert Nitschke, *Principles of the patellar-tendon-supra-condylar prosthesis*, Orthop. and Pros. Appl. J., *21*:1:33-38, March 1967.
23. Marschall, Kurt, and Robert Nitschke, *The P.T.S. prosthesis (complete enclosure of patella and femoral condyles in below-knee fittings)*, Orthop. and Pros. Appl. J., *20*:2:123-126, June 1966.
24. Murphy, Eugene F., and A. Bennett Wilson, Jr., *Anatomical and physiological considerations in below-knee prosthetics*, Artif. Limbs, *6*:2:4-15, June 1962.
25. Pierquin, L., J. M. Paquin, and G. Fajal, *Discussion sur les prothèses tibiales*, Atlas d'Appareillage Prothétique et Orthopédique, No. 9, 3 mo. Trimestre, 1965.
26. Pierquin, L., G. Fajal, and J. M. Paquin, *Prothèse tibiale a emboîtage Supra-condylien*, Atlas d'Appareillage Prothétique et Orthopédique, No. 1, January 1964.
27. Pierquin, L., J. M. Paquin, and G. Fajal, *La prothèse tibiale Americaine, patellar-tendon-bearing*, Atlas d'Appareillage Prothétique et Orthopédique, No. 8, 2 mo. Trimestre, 1965.
28. Plumb, Robert E., and Fred Leonard, *Patella-tendon-bearing below-knee porous socket with soft Silastic distal end*, Army Medical Biomechanical Research Laboratory, Walter Reed Army Medical Center, Washington, D. C., Tech. Rep. 6311, June 1963.
29. Radcliffe, C. W., and J. Foort, *The patellar-tendon-bearing below-knee prosthesis*, Biomechanics Laboratory, University of California, Berkeley and San Francisco, 1961.
30. Veterans Administration Prosthetics Center, *Direct forming of below-knee patellar-tendon-bearing sockets with a thermoplastic material*, Ortho. & Pros., in press.
31. Wilson, L. A., E. Lyquist, and C. W. Radcliffe, *Air-cushion socket for patellar-tendon-bearing below-knee prosthesis*, Department of Medicine and Surgery, Veterans Administration, Tech. Rep. 55, May 1968.
32. Witteck, Frank A., *Evaluation of thirteen below-knee amputees fitted with patellar-tendon-bearing, cuff suspension prostheses*, Veterans Administration Prosthetics Center, New York, October 1959.
33. Witteck, Frank A., *Some experience with patellar-tendon-bearing below-knee prostheses*, Artif. Limbs, *6*:2:74-85, June 1962.

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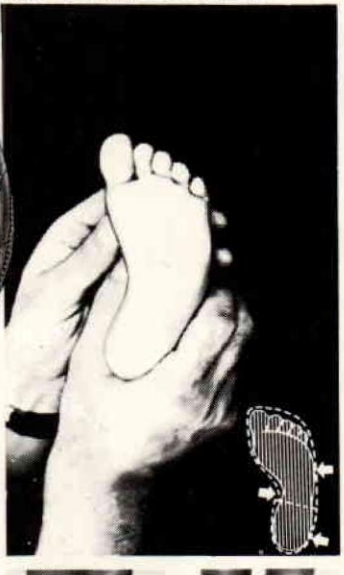

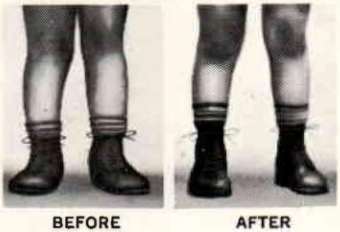

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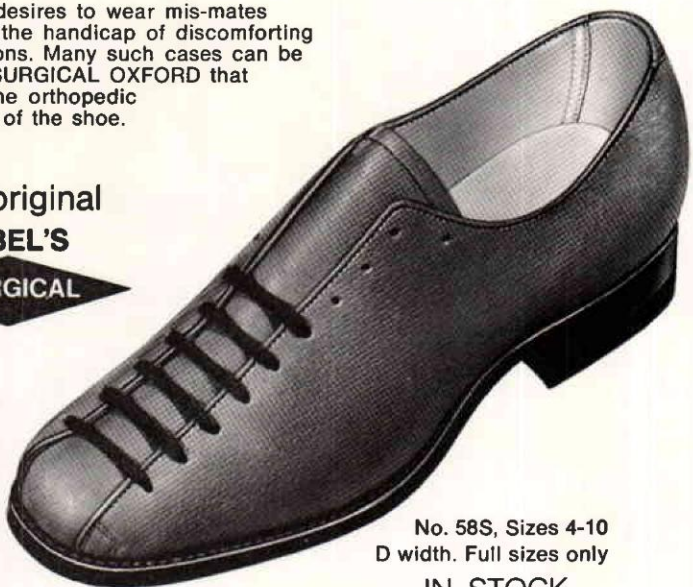

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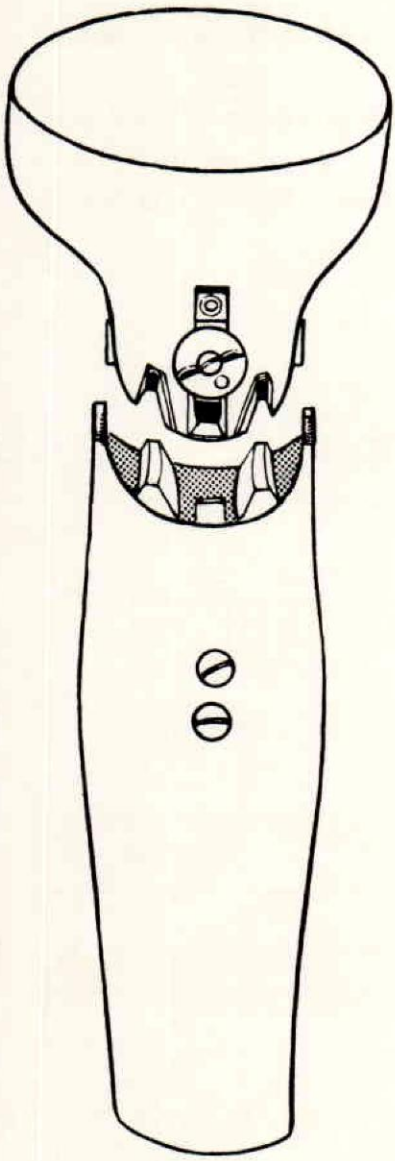

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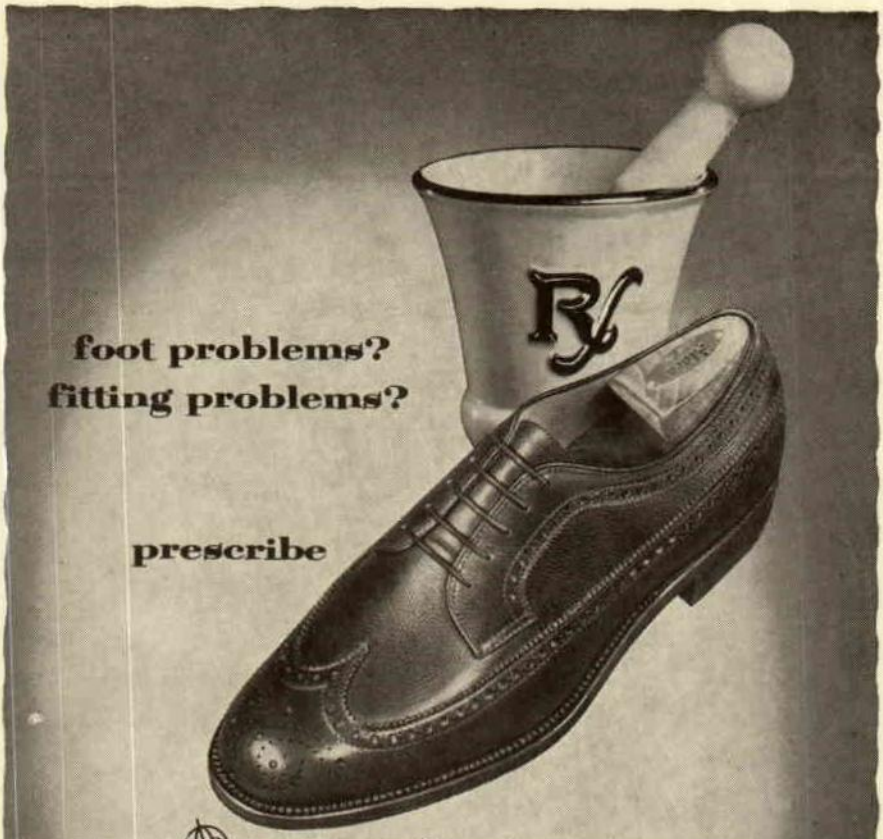

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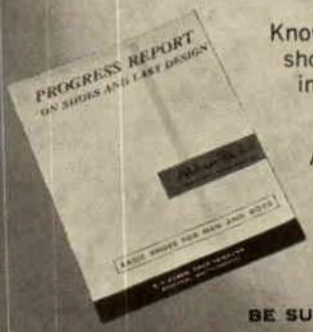

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