

DECEMBER 1974

Orthotics and Prosthetics



Orthotics and Prosthetics

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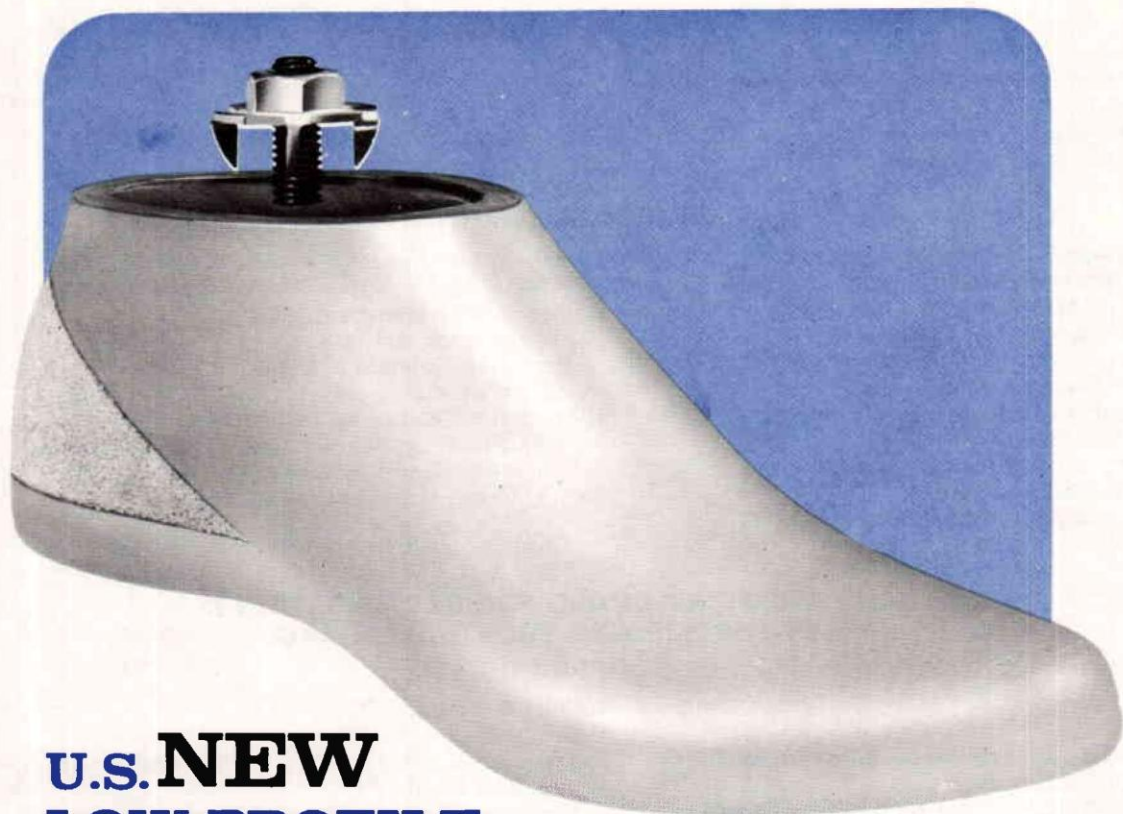
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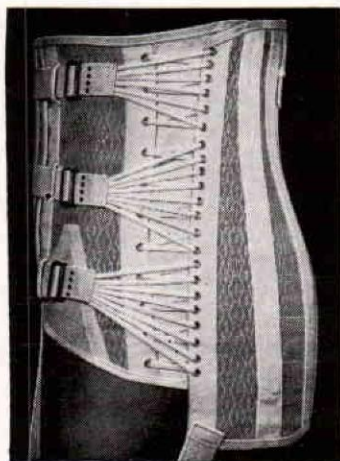
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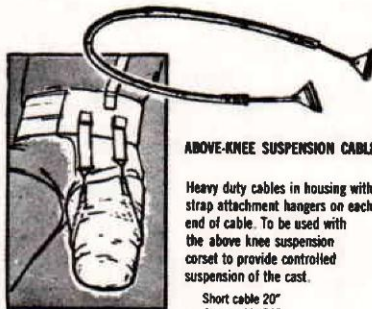


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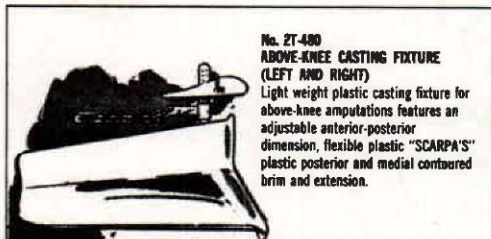
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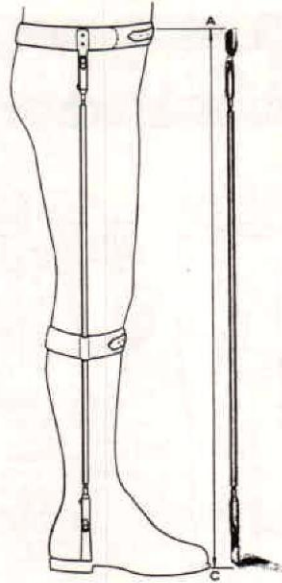
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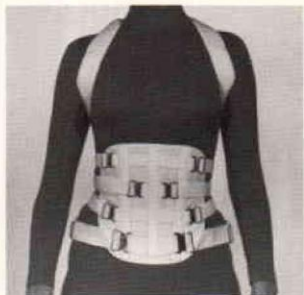
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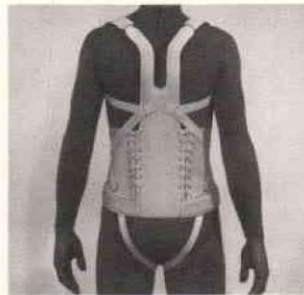
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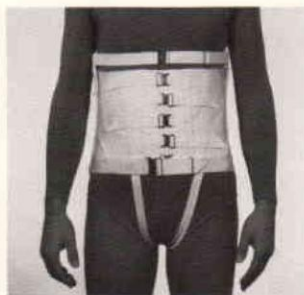


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SPREADING THE WORD

Several years ago, someone asked, "Where may I find literature on Prosthetics and Orthotics?" If this person had been from the medical or allied health fields, he could have been referred to the medical library but the findings would have been meager. If they were not related to the medical field, to tell them to go to the public library would have been virtually useless because they would probably find only some fairy tales of pirates with either a hook or a pegleg.

In 1972 one of the few publications in the fields of prosthetics and orthotics stated, "Until relatively recently, there was essentially no professional literature to be found pertaining to the field of prosthetics and orthotics." Why has this been so? Is it because we have nothing new to tell? I cannot believe that this is so. Every patient presents a new challenge to the prosthetist or orthotist and other members of the clinic team, and thus there should be a good deal of material that should be presented.

Is it because we don't have time? We seem to find time to do most of the things that we really want to do.

Is it because we are afraid that we may be criticized by some of our colleagues? This may be true in some sizable proportion.

Is it because we don't know how to write or don't know how to organize the material to write an educational, informative and interesting article? Perhaps, but most of us are managing a very successful organization that requires many letters and other forms of communication.

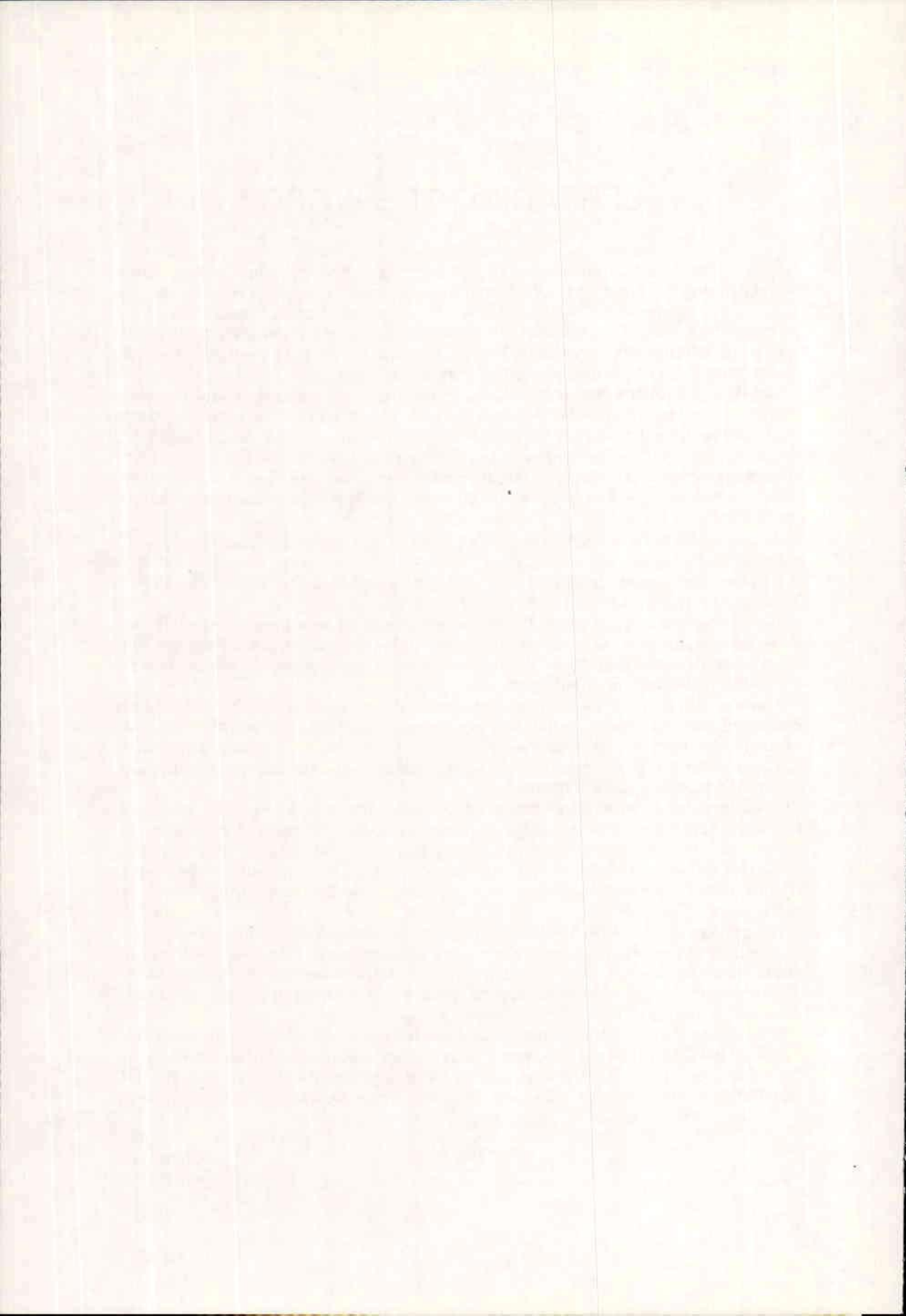
Many of us use one or more of these reasons for not writing articles that should be published and thus made available to our colleagues around the world. Very few useful books, journals, and other publications are available to clinicians in prosthetics and orthotics, partly because of the rapid rate of change that has been made during the past couple of decades.

Orthotics and Prosthetics and its predecessors have been a source of reference for many years, and is now available in many medical libraries. Its quality has varied, but since 1972 it has developed into a truly professional source of information. The Editorial Board has had little to do with this, and the bulk of the credit should go to A. Bennett Wilson, Jr., who has served as the editor during these past three years.

If members of AOPA, AAOP, and other readers want *Orthotics and Prosthetics* to continue as a professional publication, we must prepare and submit articles for publication. Style is not important. The editorial staff can remedy any lack of style. The important factor is the presentation of ideas and methods of providing service that will be useful to fellow practitioners.

It has been a very enlightening experience for me to serve as Chairman of the Editorial Board for the past two years. The complete cooperation of all members of the committee, the staff in the Washington office, and the officers of AOPA, AAOP and ABC have made this job very easy. I wish the new Chairman the same pleasure.

Bert R. Titus, C.P.O.
Chairman
Editorial Committee



SOME OBSERVATIONS ON UPPER-LIMB PROSTHETICS AND ORTHOTICS¹

David G. Murray, M.D.²

On behalf of the State University of New York Upstate Medical Center, the Department of Orthopedic Surgery, and the Division of Orthotics Research and Education, I would like to take this opportunity to welcome you to Syracuse.

It has been my observation that when persons organizing a seminar or conference in the winter-time want to insure a good attendance, they schedule the meeting for some place like Aspen or a cruise ship in the Caribbean. When you are caught with Syracuse, New York, during one of the rainiest May's in history, you are left with only one alternative to attract a group of people; that is, to assemble the best program and faculty possible. Judging from the number I see here today, I would say that the program Chairmen have been extremely successful; and it is certainly a tribute to their organization ability and the quality of the papers you are going to hear.

I have another observation I would like to pass on to you after having looked over the sophisticated list of topics in this program. Fifteen years ago as I was training in Orthopedic Surgery, I developed an interest in prosthetics and spent some time at that point working on early fitting of below-knee amputees with plaster sockets and pylons. In the course of this work, I attended the standard courses in prosthetics and orthotics—learned about plastic laminated sockets, triceps pads, control cables, Dorrance terminal devices, shoulder harnesses, and so forth.

Over the years, the number of other responsibilities has encroached nearly 100 percent on the amount of time I have had to devote to a continuing interest in prosthetics. Suddenly,

after a long hiatus, I was called upon to attend a prosthetics clinic at the Upstate Medical Center last month as a substitute. Mind you, in the interval, we have seen the development of portable color television, the landing of men on the moon, the production of pocket-sized electronic computers, and cameras which spit out instantaneously a snapshot that is developed before your eyes. Therefore, it was with a certain amount of uncertainty and a feeling of inadequacy that I approached my assignment to the prosthetics clinic. The first patient was a youngster with a congenital below-elbow amputation. Would you believe I suddenly found myself back in the old world, talking about plastic laminated sockets, triceps pad placement, shoulder harness adjustment, ring position, and cable tension? Even the plastisol was peeling off the terminal device (a hook) in the same way that it used to peel off when I was attending clinic 15 years ago. In a way, it was comforting to realize that in this dynamic decade, something at least hadn't changed. On second thought, it was a bit surprising and not a little disappointing.

My own particular efforts over the past few years have been devoted for the most part to studying and utilizing internal prostheses such as hip joints and knee joints. Over the years, there have been two ways in approaching the problem of a destroyed joint. One group has attacked the problem by attempting to replace the joint with a biologic substitute—either a joint from another human being or a mechanism for internal repair of the damaged joint. The other group has approached the problem from the standpoint of creating an artificial substitute of inert material which could be implanted in the body. There is no question as to which group has been the most successful. We are currently implanting artificial joints in great numbers and the current success of these artificial substitutes have eclipsed attempts to improve on methods of biologic substitution.

Much the same thing seems to be going on in

¹Welcoming remarks given at the Advanced Seminar on External Energy in Upper-Limb Prosthetics and Orthotics sponsored by the American Academy of Orthotists and Prosthetists, Syracuse, New York, May 31, 1974.

²Professor, Orthopedic Surgery, Upstate Medical Center, Syracuse, New York.

the area of substitution for destroyed or missing limbs. At the Veterans Administration Hospital several blocks away, Dr. Robert Becker is working on methods for regrowing normal limbs through electrical stimulation of tissue at the end of the amputation stump. It is his contention that lost limbs will eventually be replaced biologically. However, as evidenced by this program, other groups are actively at work developing sophisticated prosthetic replacements. If I had to bet on which approach would turn out to be the most feasible, there is no question but that logically I would place my money on the prosthetic replacements. Judging from my recent experience, however, on the practical improvements made in this field over the past 15 years, I am afraid I might have to hedge my bet.

There are generally three types of stimuli for accomplishment in any particular sphere. First of all, there may be a crying need for a solution. The development of the polio vaccine is an example of a response to this stimulus. Secondly, a problem may simply present a challenge. The climbing of Mt. Everest fits in this category as being a drama-

tic feat, but of no particular practical benefit. Thirdly, technological advances may suddenly make something possible that had been merely a pipe dream up to that point. We could place space exploration in this category.

Now as we look at the field of upper-limb prosthetics and orthotics, I think that all three of these factors apply. There is unquestionably a crying need for improvement—the challenge of a difficult problem is inescapable and I have to believe that the technologic capabilities are now at hand.

It seems like the time has arrived for educators and innovators in this field to get off the mark, to stop talking about the amazing features of the Dorrance 5XA hook and to apply their talents to the obvious, unsolved problems. From the topics listed for discussion at this meeting, I sense that a start is being made. I am sure that it will be a valuable day and a half, and I hope that seminars such as this, combining the talents of the leaders in this field, are heralding an era of innovative advancement in the orthotics and prosthetics fields.

EXPERIENCE WITH PLASTIC PATELLAR-TENDON-BEARING ORTHOSES

James T. Demopoulos, M.D.,¹ and
John E. Eschen, C.P.O.²

The management of patients with lower-limb deficiencies that produce gait abnormalities has undergone considerable evolution during the last decade. Current concepts in lower-limb orthotics include the development and use of plastics, creation of a new functional nomenclature, introduction of the multidisciplinary approach proven so valid in prosthetics, and the use of instrumentation and data systems to monitor results.

The application of the above concepts to the field of "lower-limb bracing" is a rather recent development, demonstrating new trends as reviewed by Lehman and his colleagues (8, 9). Other investigators, including Corcoran (1), Jebesen (5), Simons (15), Lehneis (10, 11), and Sarno (14), have utilized plastic materials and technol-

ogy in prescribing lower-limb orthoses. Additionally, the authors have prescribed and fabricated over 200 lower-limb plastic orthoses for a wide range of musculoskeletal defects found in adults and children (2, 3, 4).

The principle of using the patellar-tendon and condylar areas of the tibia for weight-bearing in the below-knee amputee was successfully transferred to the discipline of orthotics by McIlmurray and Greenbaum (6, 7, 12, 13, 16), resulting in the development of the VACP patellar-tendon-bearing "brace." The early design combined a pretibial plastic shell and conventional metal uprights to "unload" the tibia and the foot-ankle complex. In an effort to achieve reduction of weight, to improve cosmesis and comfort, and to provide more physiological motion, the authors have developed an all-plastic patellar-tendon-bearing orthosis.

This paper relates our experience with the plastic patellar-tendon-bearing orthosis and describes the details of fabrication.

¹Director, Rehabilitation Medicine, Hospital for Joint Diseases and Medical Center, 1919 Madison Ave., New York, N.Y. 10035.

²Eschen Prosthetic and Orthotic Laboratories Inc., 156-158 East 116th St., New York, N.Y. 10029.

TABLE 1. DIAGNOSIS AND AGE OF REVIEWED POPULATION

Patient	Age (Yrs)	Diagnosis
F.G.	9	Congenital intra-articular denervation of knees and ankles
A.S.	58	Charcot's arthropathy of ankles
H.S.	61	Spontaneous subluxation, ankle
M.R.	48	Severe burns of hindfoot
A.M.	39	Primary tumor of tibia
G.R.	27	Failed arthrodesis of ankle
L.H.	54	Delayed union of distal tibia fracture
M.M.	7	Osteogenesis imperfecta, tibia
L.P.	68	Neurofibromatosis, fracture of tibia
G.D.	59	Severe osteoarthritis of ankle

CLINICAL MATERIAL

The patient-study population consisted of ten patients who were evaluated and provided with plastic patellar-tendon-bearing orthoses.

Our initial experience dates to July 1972 and our follow-up extends over an 18-month period.

Chronologically, our youngest patient was 7 years old; the oldest, 72. The study group included three females and seven males. The diagnoses of the population are listed in Table 1.

METHOD

Eight of the ten patients who received a plastic patellar-tendon-bearing orthosis were referred to us by the staff of the Department of Orthopaedics, and therefore had the benefit of complete orthopaedic evaluations, including radiographic determinations, prior to prescription.

The members of the Orthotic Clinic Team of the Department of Rehabilitation Medicine, including the physicians and allied health professionals, measured and recorded data relating to muscle strength, joint motion, presence of contractures, gait, elevation ability, spasticity, sensation, joint stability, and the degree of edema if present. The unit's orthotist provided the technical expertise needed to formulate the final prescription. As required, pre-orthotic and post-orthotic physical therapy was prescribed. In addition, the patients' psychosocial and vocational characteristics were measured.

The completed orthosis was delivered and both patient and device were subjected to a final analysis, with attention focused on relief of pain, comfort, fit, appearance, alignment, degree of deformity correction, and total overall functional improvement. Both static and loading conditions were used in our determinations. Finally, serial reexaminations were conducted over a period of months, our longest follow-up being 18 months.

RESULTS

Our experience with the plastic patellar-tendon-bearing orthosis in ten patients indicates that many musculoskeletal defects of the lower limb can be managed with this device, offering many advantages over conventional designs. The advantages are:

- Superior cosmesis
- Lighter weight
- Improved comfort
- Superior alignment
- Improved biomechanics
- Favorable strength-weight ratio
- Ease and constancy of application
- Minimal maintenance

However, not all advantageous features were present in each case. Disadvantages included the considerably higher cost of the plastic orthosis. Problems were encountered with growing children who required frequent replacement. It was most important to observe carefully those patients with vascular and sensory problems since

the plastic orthosis is applied snugly. Edema of the foot-ankle area had to be carefully controlled also.

The various disabilities that are amenable to orthotics management utilizing the plastic patellar-tendon-bearing orthosis are listed below:

- Congenital denervation of ankle joint
- Acquired denervation of ankle joint
- Delayed or nonunion of fractured tibia
- Imminent fracture of tibia, secondary to tumor, bone atrophy and development defects
- Degenerative disease of ankle joint
- Inflammatory disease of ankle joint
- Trauma of foot-ankle joint
- Failed foot-ankle surgery
- Infectious disease of foot
- Disease of trauma of sole of foot



Fig. 1. Conventional ischial weight-bearing orthosis is heavy and bulky.

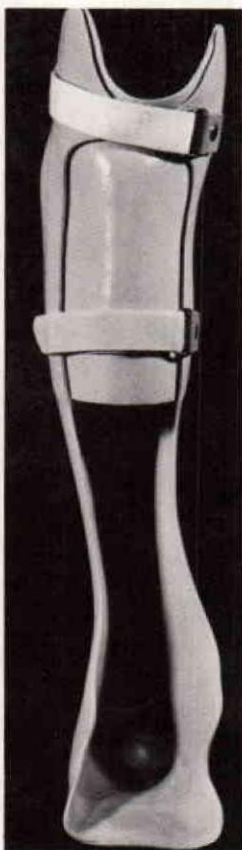


Fig. 2. Front view of the plastic patellar-tendon-bearing orthosis.

The alternative orthosis required for most of the disabilities listed would be a heavy, bulky, ischial weight-bearing orthosis (Fig. 1).

The lighter, more cosmetic, plastic patellar-tendon-bearing orthosis is shown in Figures 2 and 3. The orthosis is donned properly with ease; the separate patellar-tendon-bearing panel is inserted when the knee is flexed at 90 deg. The orthotic foot-ankle section is molded so that it is highly congruous with the patient's foot and ankle; and the position of the patient's ankle can be fixed in the desired attitude. A special shoe heel is used (comparable to a prosthetic SACH heel), together with a rocker assembly when "unloading" of the posterior aspect of the foot is desirable. In other instances, an ordinary shoe suffices.

A number of case discussions will illustrate the criteria used in prescribing the patellar-tendon-bearing orthosis; fabrication details appear at the end of the paper.

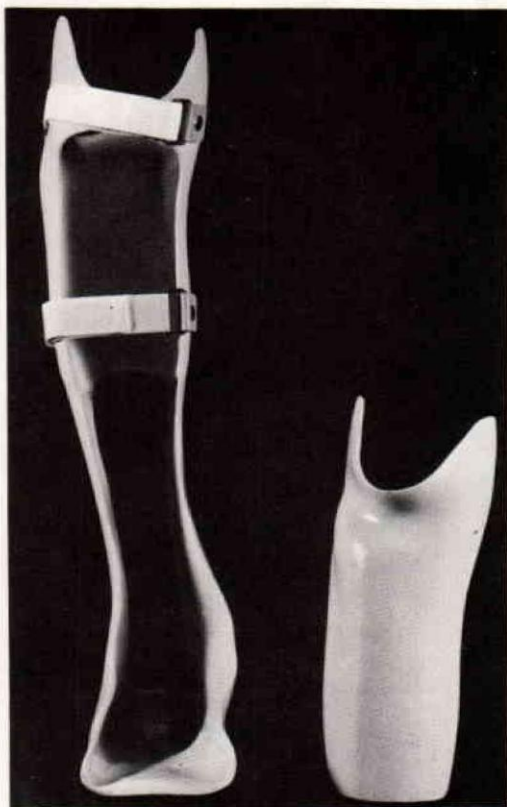


Fig. 3 The removable PTB section is easily donned.

CASE PRESENTATIONS

Case No. 1. F.G. is a 9-year-old boy with congenital absence of intra-articular innervation of his knees and ankles (Fig. 4). Functionally, the left knee and right ankle created considerable difficulties in ambulation and elevation activities. In our initial experience with patellar-tendon-bearing orthoses, we adhered to the original concept of using plastic materials for patellar and

tibial condylar weight support and conventional metal uprights attached to a molded leather-covered footplate; the uprights were extensible and the ankle-joint position was adjustable (Fig. 5). A plastic quadrilateral socket, attached to conventional uprights, was used to reduce weight-bearing forces at the left knee and ankle (Fig. 6). Clearly, the right patellar-tendon-

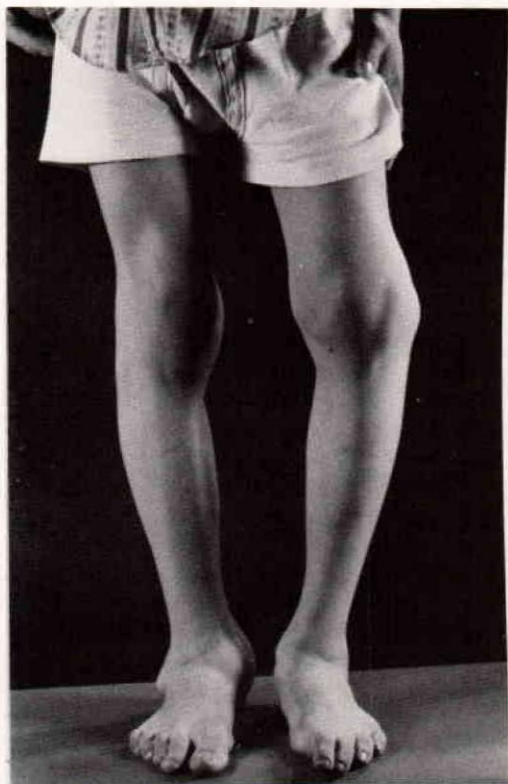


Fig. 4. Congenital absence of intra-articular innervation produced severe deformities of left knee and right ankle. Case No. 1.

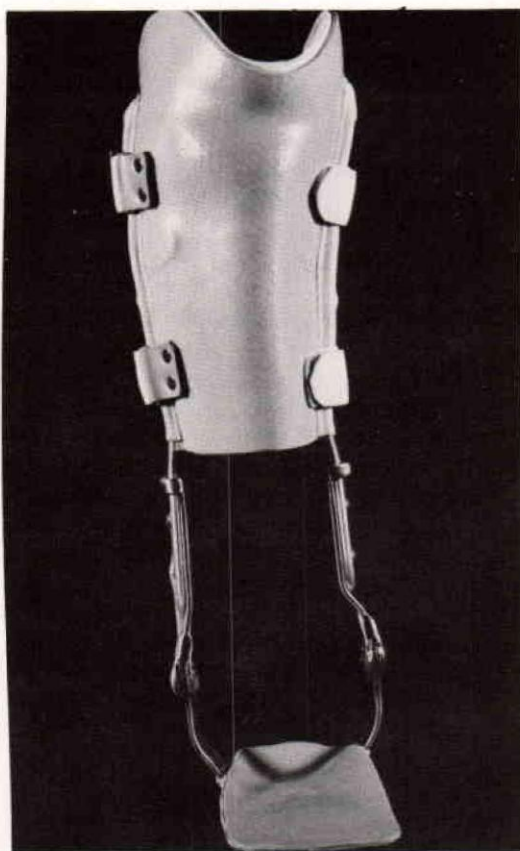


Fig. 5. The early design combined plastic and metal components.

bearing orthosis was more acceptable to the patient. As we evolved the all-plastic PTB orthosis, we substituted this device for the original orthosis. A 65 percent weight reduction was accomplished, with more efficient alignment of the foot and ankle, with resultant reduction of the abnormally high intra-articular forces at the ankle.

Case No. 2. L.H. is a 54-year-old woman with severe deformity of the tibia following malunion of pathological fractures. Figure 7 illustrates the original PTB orthosis; the newer plastic PTB orthosis prevented recurrence of fractures for an 11-month period, until the patient succumbed to metastatic disease.

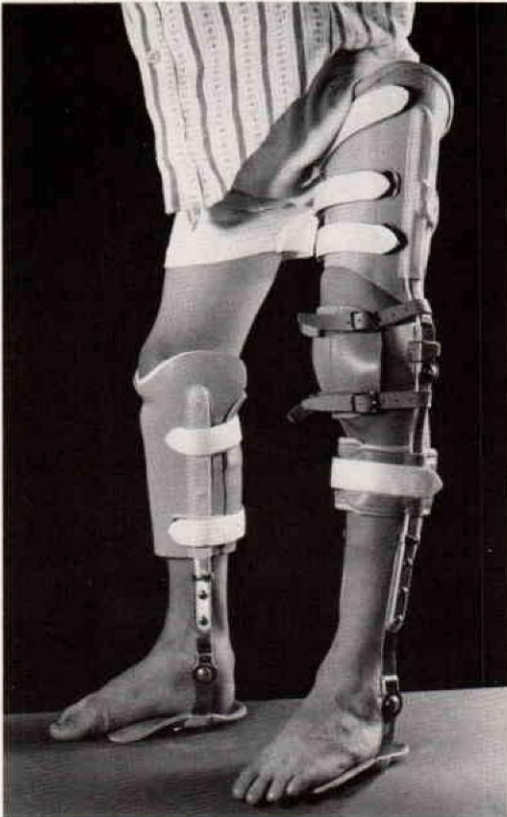


Fig. 6. An "early" PTB orthosis is used to reduce trauma to the right ankle. Case No. 1.



Fig. 7. Use of a PTB orthosis prevented recurrence of pathological fractures of the tibia. Case No. 2.

Case No. 3. A.S., a 58-year-old mechanical engineer, was admitted to our hospital with a history over several years of progressive Charcot's arthropathy of both ankles. The right foot required a below-knee amputation secondary to intractable osteomyelitis. In an effort to prevent a similar process in the aneural left ankle,

we prescribed a plastic patellar-tendon-bearing orthosis. The patient was able to return to work as an engineer, with a below-knee prosthesis and a PTB orthosis (Fig 8). Figures 9 and 10 are, respectively, front and lateral views of the patient wearing the PTB orthosis. Note the removable panel in Figure 10.



Fig. 8. The patient's functional level was significantly improved with provision of a PTB orthosis. Case No. 3.



Fig. 9. The PTB orthosis reduced ankle intra-articular forces and provided mediolateral knee stability. Case No. 3.

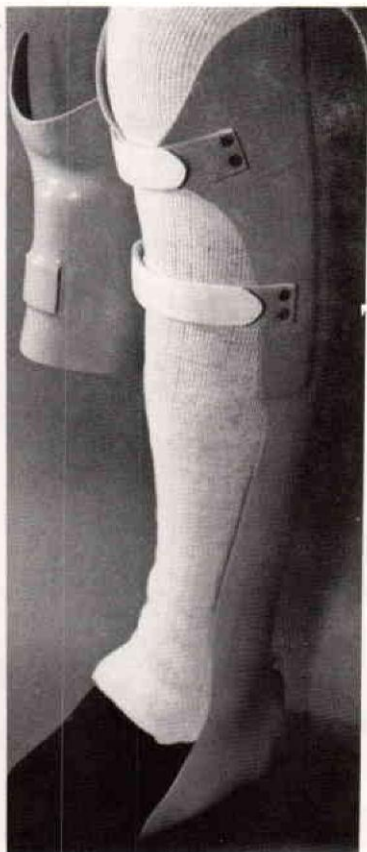


Fig. 10. The PTB panel is inserted with the knee flexed to 90 deg. Case No. 3.

Case No. 4. H.S., a 61-year-old individual employed as a truck driver, sustained a chronic subluxation of his subtalar joint with increasing pain and inability to walk more than a few steps. The abnormalities are shown on the radiograph in Figure 11. A plastic patellar-tendon-bearing orthosis prevented further malalignment, reduced the pain considerably, and permitted resumption of relatively unlimited ambulation.



Fig. 11. Subtalar subluxation produced considerable pain and limited ambulation. Case No. 4.

Case No. 5. M.R., a 48-year-old woman, sustained severe burns of the plantar surface of her foot, with multiple grafting that repeatedly failed because of inadequate orthotic management. Figure 12 depicts the pathology, while Figure 13 demonstrates use of the plastic PTB orthosis.

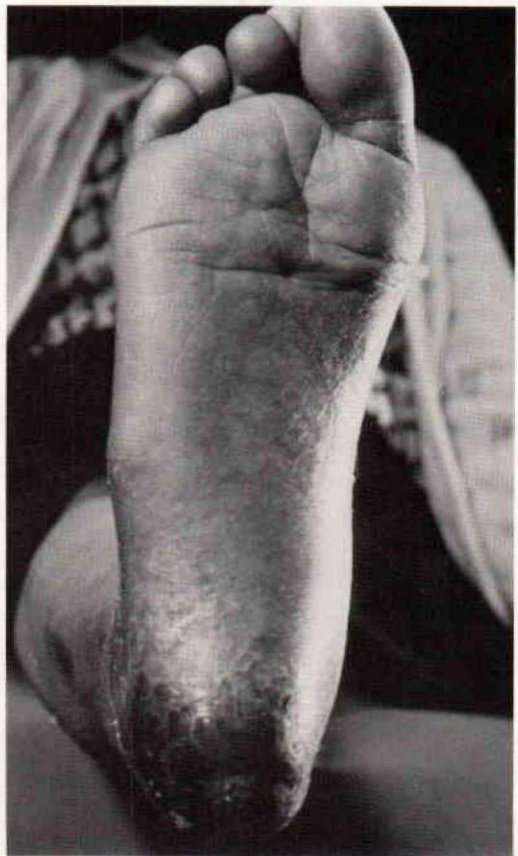


Fig. 12. Multiple grafting of the plantar surface was required prior to prescription of a PTB orthosis. Case No. 5.



Fig. 13. The plastic PTB orthosis effectively eliminated contact between the orthosis-shoe unit and the ground. Case No. 5.

FABRICATION DETAILS

MATERIALS AND EQUIPMENT NEEDED FOR CASTING

- Two rolls of elastic plaster bandages
- Cotton stockinette 3 in. wide, to place over knee down to and including the foot
- Indelible pencil
- Water in basin 6 in. deep
- Surgical tubing or webbing strip
- Cast cutter
- Bandage shears
- Yardstick
- Tape measure
- Ritz stick
- Measurement chart
- Casting lasts for matching heel height of shoe to orthosis

CASTING

The cast is taken in two sections. The first section includes the foot-ankle to the mid-calf areas. The second section includes the mid-calf area to a point above the femoral condyles.

First Section (Fig. 14)

1. Patient is seated on a plinth or chair with the foot held in 5 deg. of dorsiflexion on the properly selected last.
2. Stockinette, sewn at the toes, is placed on the leg and brought above the knee.
3. The leg is brought into 5 deg. of dorsiflexion relative to the floor.
4. With the indelible pencil the patella is located and its borders marked; tibial tubercle, crest of tibia, head of fibula, lateral flare of tibia, medial condyle flare, both medial and lateral malleoli, first and fifth metatarsal heads, and any

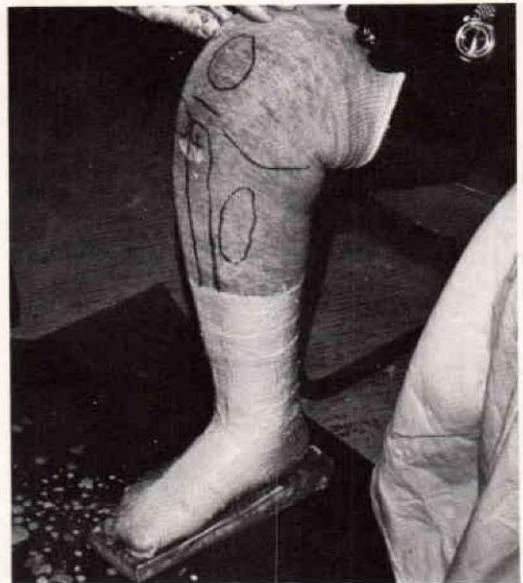


Fig. 14. The major bony landmarks are outlined on the cotton stockinette; elastic plaster-of-Paris bandage is used to wrap the foot while it is positioned on a last.

other pertinent bony prominences. The midpoint of the patellar tendon is also marked (Fig. 14).

5. A strip of surgical tubing is placed along the medial side of the knee and down the anterior midline of the leg, extending to the toes, to permit removal of the cast later (Fig. 15).

6. Elevate the foot and wrap with elastic plaster bandage going to the mid-calf level.

7. Replace the foot on the last and hold in the correct position until plaster has hardened (Fig. 14).

Second Section

1. After the foot-ankle cast has hardened sufficiently, extend the knee to 30 deg. of flexion.

2. Wrap from the mid-calf area to a point above the femoral condyles with the second plaster-of-Paris bandage.

3. Locate the patellar tendon and popliteal fossa, and compress as is done regularly for any PTB casting procedure.

4. After the plaster has hardened, several horizontal orientation lines are placed along the outline of the surgical tubing. Removal of the cast is now accomplished by cutting down the outline of the surgical tubing with a cast cutter (Fig. 15). The hash lines are used to reestablish the cast, which is then filled with plaster of Paris (Fig. 15). The plaster bandage is stripped off in the conventional manner.

MEASUREMENTS

The measurements required are:

- Calf circumference
- Ankle circumference
- Femoral condyles width
- Malleoli width
- Height from floor to mid-patellar-tendon level
- Anteroposterior width of knee at mid-patellar-tendon level



Fig. 15. The negative wrap has been removed. Note the patellar-tendon indentions and cast reference lines.

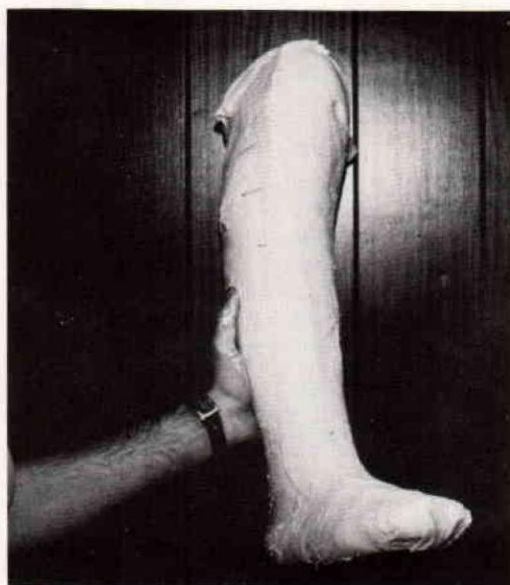


Fig. 16. The completed negative wrap is ready for filling with plaster of Paris.

CAST MODIFICATION

1. The proximal section of the cast is modified in the same manner recommended for the conventional PTB down to the mid-leg level (Figs. 17, 18, and 19).

2. Extra relief is given to the medial and lateral malleoli and any other prominences as appropriate.

3. A metatarsal arch is cut into the sole of the

foot—located $\frac{1}{2}$ in. behind the apices of the metatarsals, the high point being under the second metatarsal and extending into a triangular shape under the shaft of the metatarsals (Fig. 20).

4. The longitudinal arch is defined further (Fig. 21).

5. The cast is then smoothed and prepared for lamination in the conventional manner (Fig. 22).

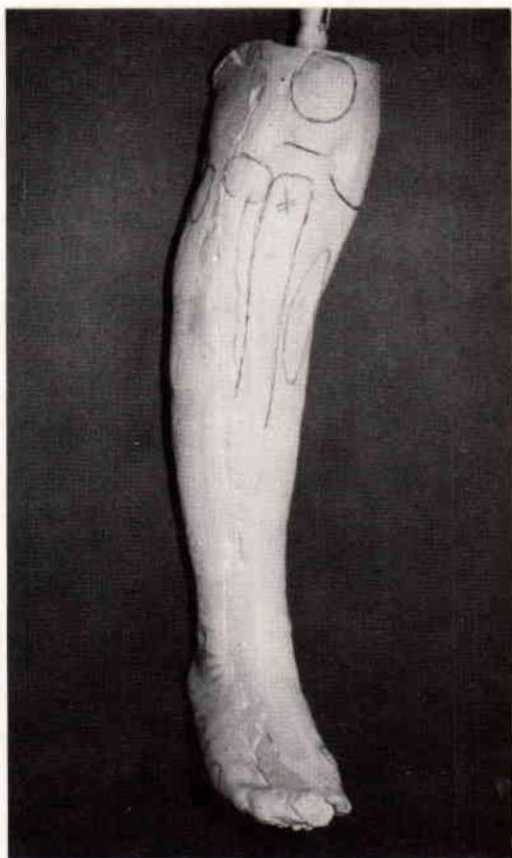


Fig. 17. The negative wrap has been stripped away, and reference lines outlining bony prominences have been reinforced on the crude positive model.

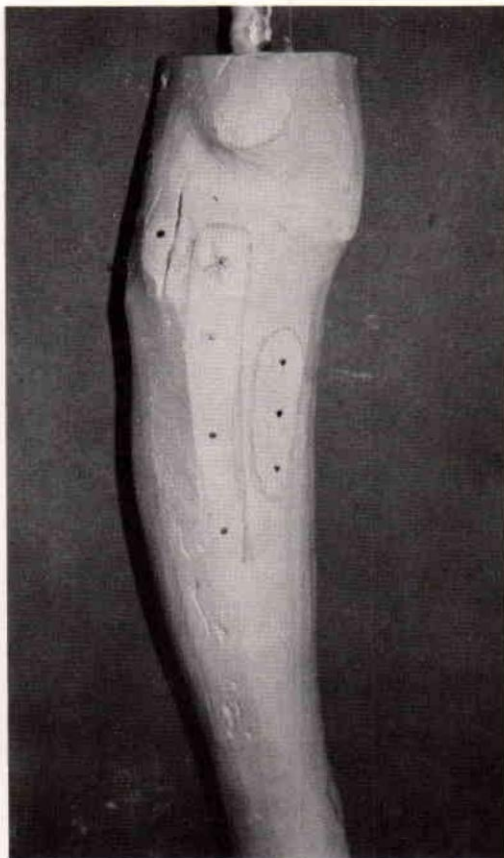


Fig. 18. Plaster has been removed in the area of the patellar tendon, under the medial condyle, and along the proximal part of the tibia and fibula.

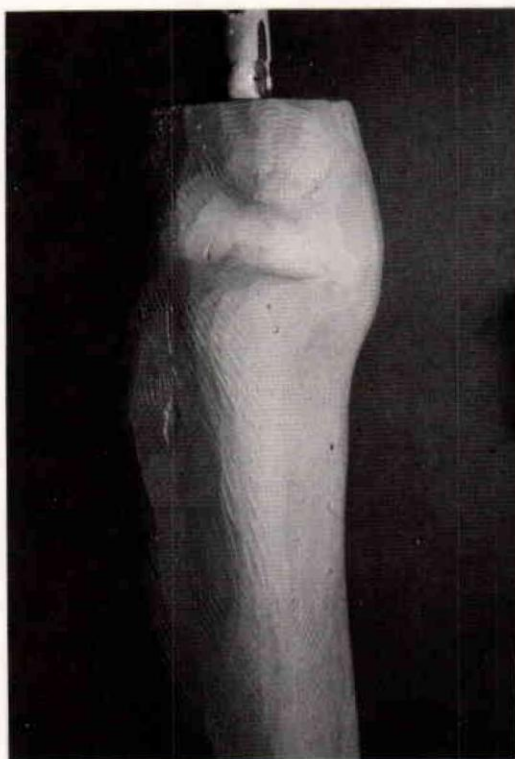


Fig. 19. Plaster of Paris has been added over the head of the fibula, lateral tibial condyle, proximal tibial shaft, and the tibial tubercle. Posteriorly, the popliteal area is built up and flared for the hamstring tendons.

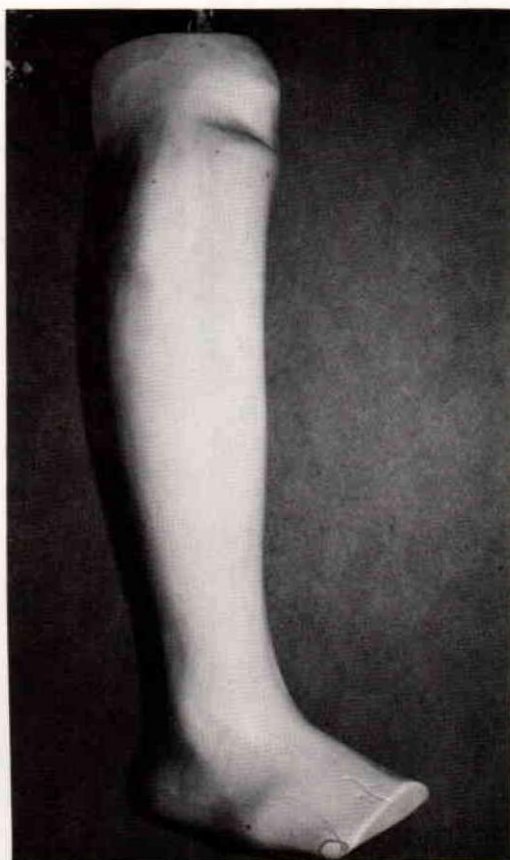


Fig. 20. Finished plantar surface of positive mold; note formation of metatarsal and longitudinal arches and relief for base of fifth metatarsal.

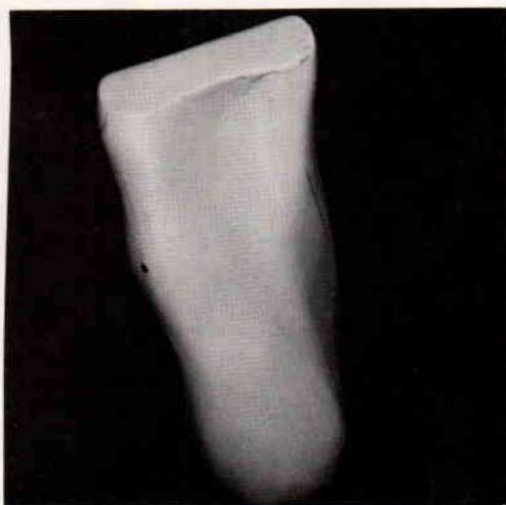


Fig. 21. The finished positive mold is ready for the first lamination process; note relief for malleoli.

PLASTIC LAMINATION

The lamination process is carried out in two steps.

Anterior-Proximal Section (Figs. 22, 23, and 24).

1. A layer of PVA foil is placed over the modified cast.

2. Four layers of Perlon stockinette are applied to the distal section.

3. Four layers of fiberglass stockinette are applied.

4. One layer of reinforced fiberglass matting is added.

5. Four additional layers of Perlon stockinette are applied.

6. The second PVA bag is then applied.

7. A mixture of 80% Laminar Harz³ and 20% Degaplast³ with 4% color and 3% catalyst is laminated under suction (Fig. 25). A batch of 300g is usually a sufficient quantity.

8. The lamination is removed taking care not to damage the anterior section of the cast.

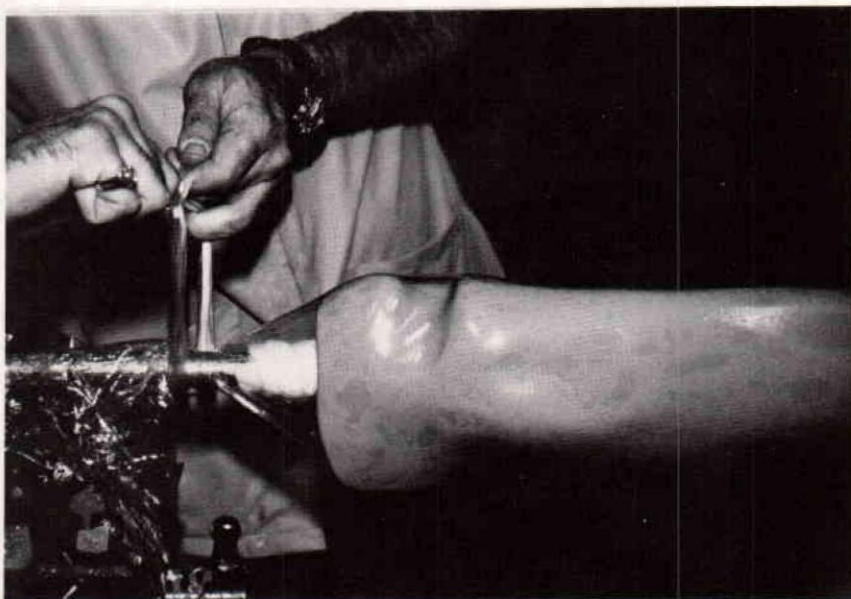


Fig. 22. The completed positive mold has been lacquered and sprayed with silicone; the first PVA foil has been applied and the pipe cast drilled for the suction attachment.

³Otto Bock Industries, Duderstadt, West Germany

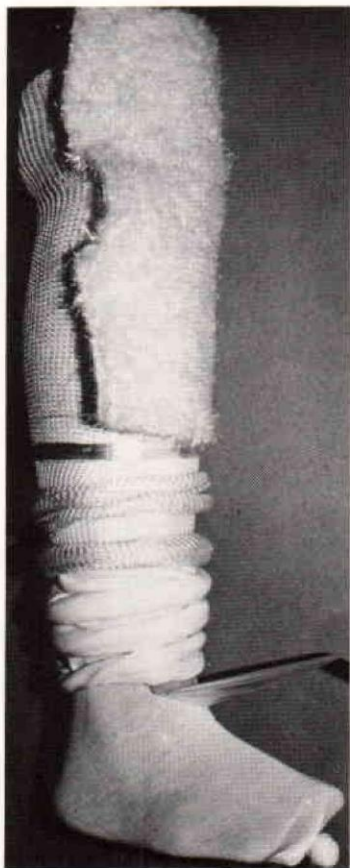


Fig. 23. The positive mold has been wrapped with 4 layers of Perlon and 3 layers of fiberglass stockinette; a single layer of fiberglass stockinette has been applied to the anterior mold surface.



Fig. 24. The prepared positive mold, covered by a second PVA foil, is ready for lamination.

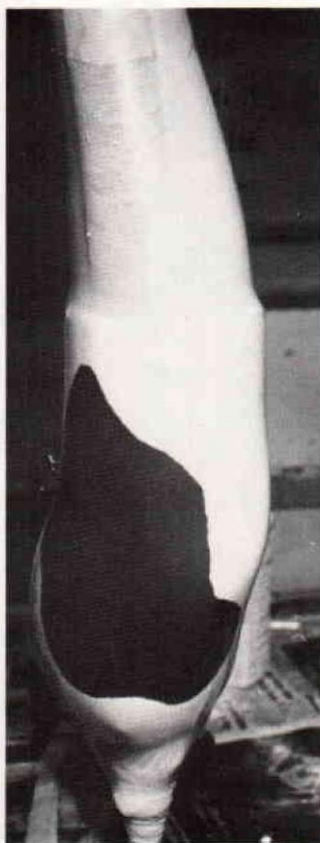
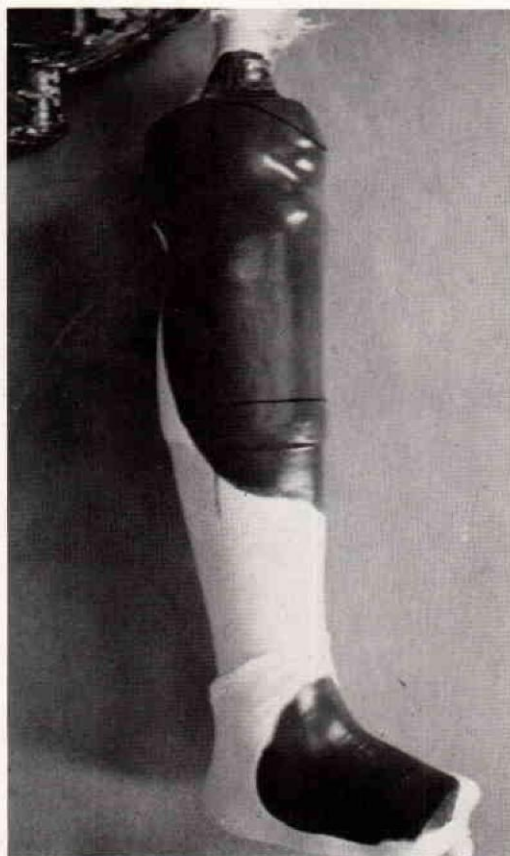


Fig. 25. Laminar Harz (dark area) is flowing through a PVC tube, impregnating the stockinette and fiberglass areas of the proximal knee section.



9. The anterior section is marked and trimmed (Fig. 26) according to the following criteria:

- a. mid patella anteriorly;
- b. going proximally at least 2-2½ in. above the mid-patellar tendon medially and laterally;
- c. at mid A-P of the leg, two vertical lines are dropped and the lamination trimmed to this line;
- d. the distal edge is a horizontal line anywhere between the proximal third to proximal half of the leg.

10. The anterior section is reapplied to the cast after all edges have been smoothed.

Shank Section

1. A strip of Dacron webbing is placed down the center of the anterior section (Fig. 27).

2. The hindfoot section is built up to a thickness between $\frac{3}{8}$ and $\frac{1}{2}$ in. with a material such as SACH foot rubber to allow relief during weight-bearing (Fig. 28).

Fig. 26. The first lamination has been completed; the anterior insert (shell) has been marked prior to its removal from the cast.

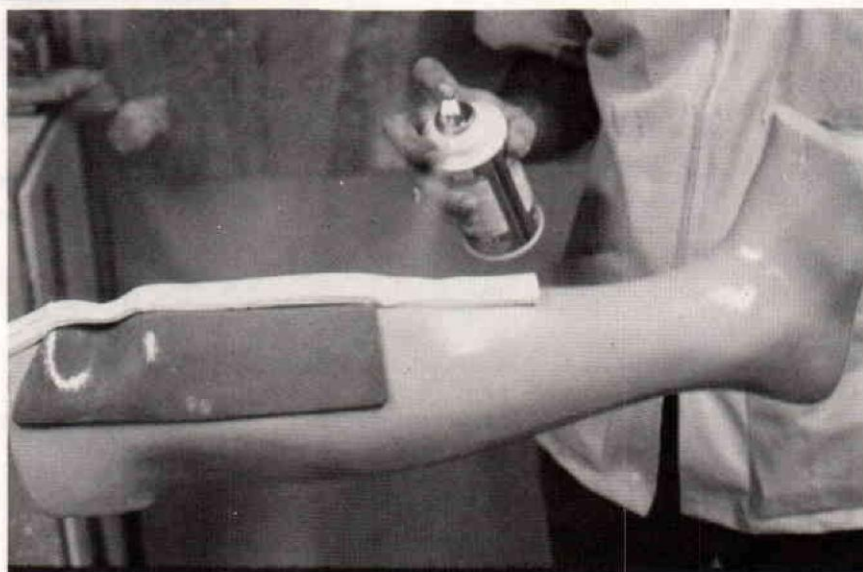


Fig 27. The anterior PTB shell is placed on the cast. A strip of 1 in. Pelite is placed on the shell prior to the second lamination process.

3. A PVA bag is placed over the cast and the anterior section.

4. When patient weighs less than 175 lb, four layers of Perlon stockinette are applied to cast. For heavier patients, two layers of fiberglass are used.

5. One piece of fiberglass mat about 2 in. wide is placed under the medial flare of the tibia running distally along the medial side under the sole of the foot, going proximal along the lateral side of foot and ending under head of the fibula.

6. A T-shaped fiberglass mat is placed under the sole of the foot cupping the heel and going proximally halfway up the medial and lateral sides.

7. Two layers of fiberglass stockinette are applied.

8. Four additional layers of Perlon stockinette are applied.

9. The second PVA bag is applied.

10. Lamination is then accomplished with 700g of resin - 80% Laminar Harz - 20% Degaplast (Fig. 29). When the patient weighs more than 175 lb., an additional fiberglass mat is placed under the medial flare and under the sole of the foot to neck of the fibula.

11. Lamination is carried out under a vacuum of 20 kg/sq cm.

12. Lamination is removed by cutting through the anterior part of the shank section, taking care not to cut through the first section.

13. The trimlines of the shank section are then drawn (Fig. 30).

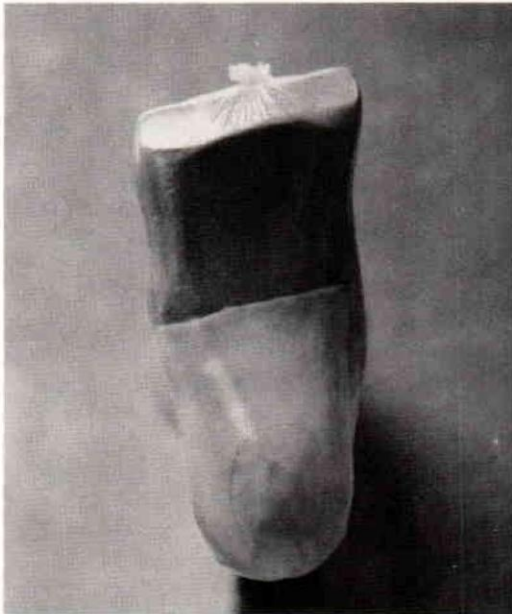


Fig. 28. The hindfoot section of the cast has been built up with hard SACH-foot rubber to allow relief of the hindfoot during weight-bearing.

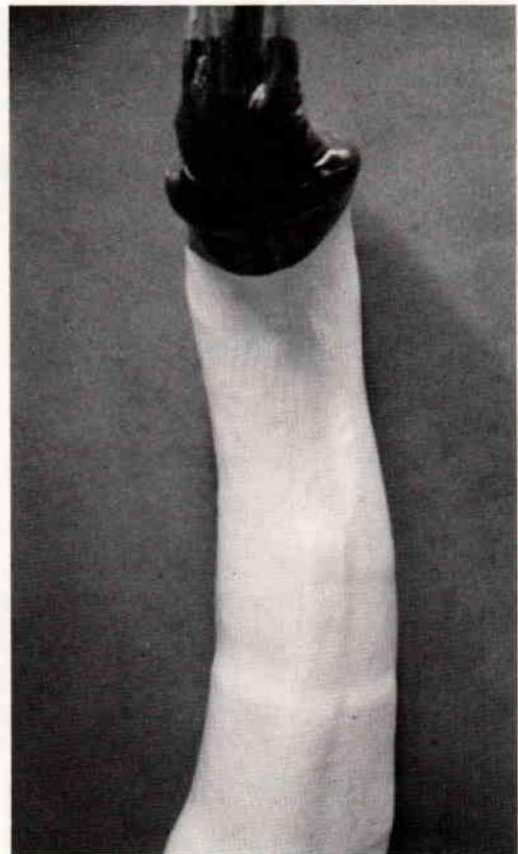


Fig. 29. The second lamination process is begun following the addition of layers of Perlon, fiberglass stockinette, fiberglass matting, and a PVA foil.

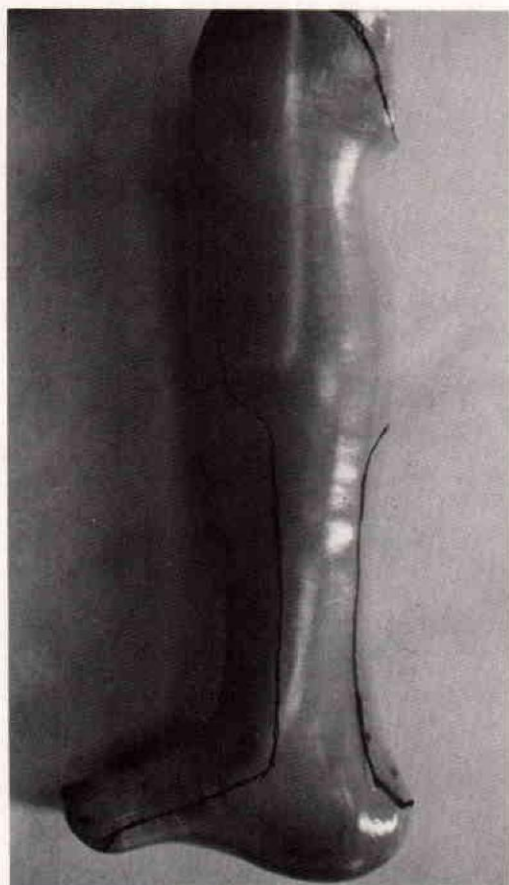


Fig. 30. Following completion of the second lamination, the orthosis is marked for cutting away from the cast.

FITTING

1. A length of stockinette is applied to the patient's leg.
2. The shank section is donned by spreading apart the patellar-tendon groove and sliding the foot through (Fig. 31).
3. The section is applied by sliding in from the anterior section until the section keys into the shank section.
4. Velcro is placed around the patellar-tendon area and the mid-point of the anterior section.
5. The patient's shoe is placed on the orthosis and the patient is asked to stand.
6. Normal checkout for the PTB is performed making sure weight-bearing is on the patellar ten-



Fig. 31. During donning of the orthosis, the patient inserts the anterior PTB shell; final fitting and "check-out" complete the process.

don and medial flare of tibia. If the orthosis is fitted correctly, the patient should experience a contact of the sole on the footplate of the orthosis but no weight-bearing.

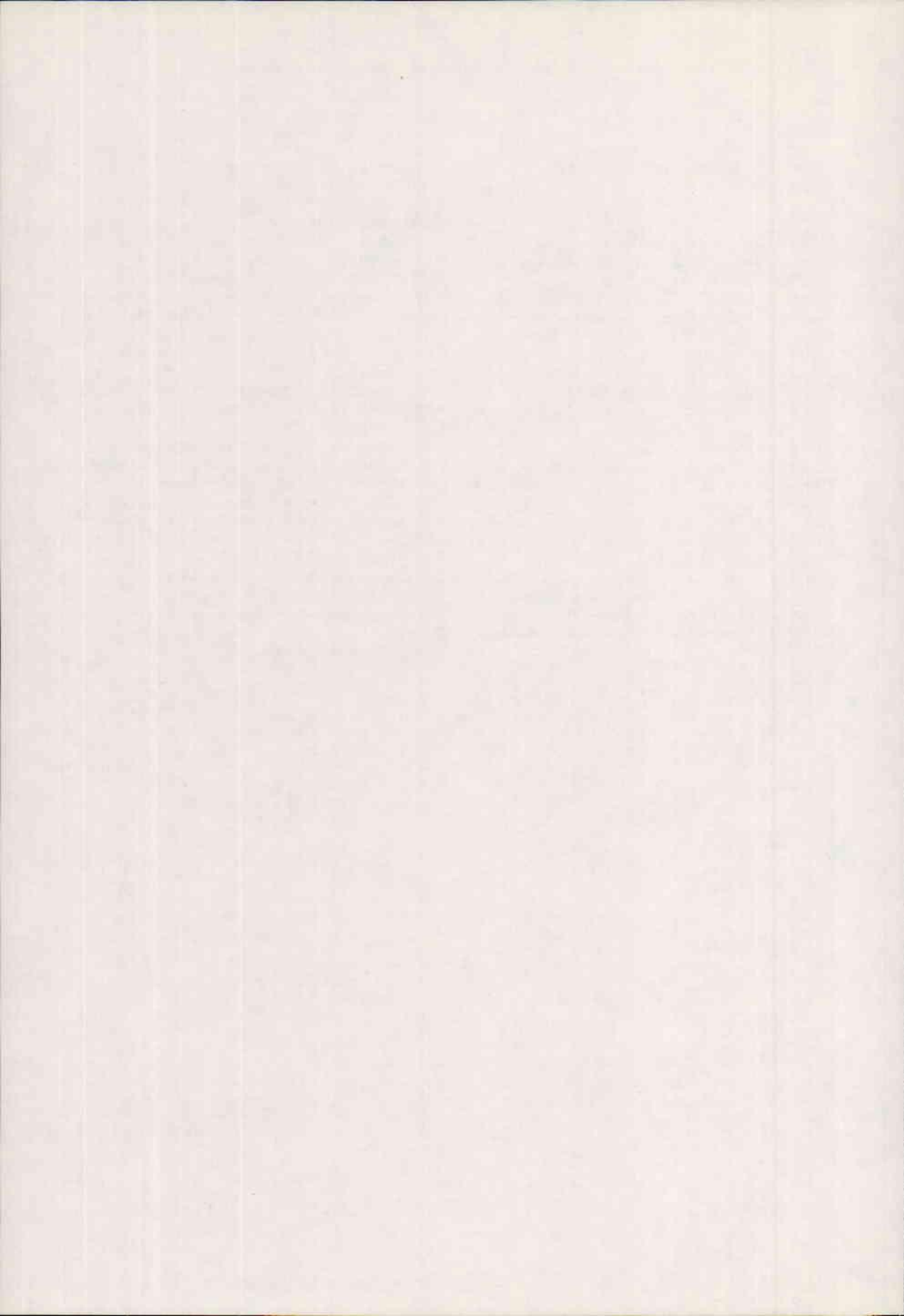
SUMMARY

Our experience with plastic patellar-tendon-bearing orthoses in ten individuals with varying musculoskeletal defects of their lower limbs has been presented. We concluded that several disabilities of the lower limb can be successfully managed with this device, affording superior cosmesis, reduced orthotic weight, more comfort, and improved physiological and anatomical alignment. Disadvantages included increased cost, frequent replacement in children, and potential skin problems in those individuals with impaired vascular and sensory areas.

Our preliminary 18-month experience led us to the conclusion that the plastic patellar-tendon orthosis is a valuable tool in the care of disabled adults and children; we are continuing our clinical trials and will publish a subsequent paper outlining our experiences with neuromuscular disabilities.

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A THERMOPLASTIC STRUCTURAL AND ALIGNMENT SYSTEM FOR BELOW-KNEE PROSTHESES

Hans Richard Lehneis, C.P.O.¹

Because changes in alignment are often indicated as the amputee patient progresses through the various stages of gait training, ideally prostheses should be provided with relatively simple means of changing alignment, days, weeks, or even months after the prosthesis is first applied. Until the amputee is able to walk unaided, i.e., without crutches or canes, often changes are required in the alignment of the prosthesis owing to the increased shift of weight towards the injured side and other changes in his gait pattern.

Although the system described in this paper will not lend itself completely to extended post-fitting changes, it represents a step in that direc-

tion. The system consists of a thermoplastic polyvinyl chloride (PVC) tubing that is available commercially from plumbing supply houses. During the early fitting stage of amputee management, this tubing represents both the structural connection between the socket and foot as well as a means of aligning the prosthesis.

STATIC ALIGNMENT

For the purpose of statically aligning the prosthesis, a vertical alignment jig² is used with a minor modification which consists of the exchange of the mandrel bushing with a metal

¹Director, Orthotics and Prosthetics, New York University Medical Center, 400 East 34th St., New York, N.Y. 10016.

²VFJ-100; A. J. Hosmer Corporation, P.O. Box 37, Campbell, Calif. 95008.

sphere which is held in the mandrel clamp (Fig. 1). The sphere is drilled to receive a standard $\frac{7}{8}$ -in. pipe inserted in the plaster cast so as to permit universal movement of the cast-socket up on the alignment jig for proper orientation of the socket in space.

A polyvinyl chloride (PVC) footplug and a wood base of plywood 1.5 to 2 cm thick is fas-

tened to the foot base of the vertical alignment jig with screws (Fig. 2). The relationship between the socket and the foot is established, using standard procedures which need not be elaborated upon here.

Once this relationship has been established, the socket is moved proximally on the vertical bar of the alignment jig, and a PVC tube with two

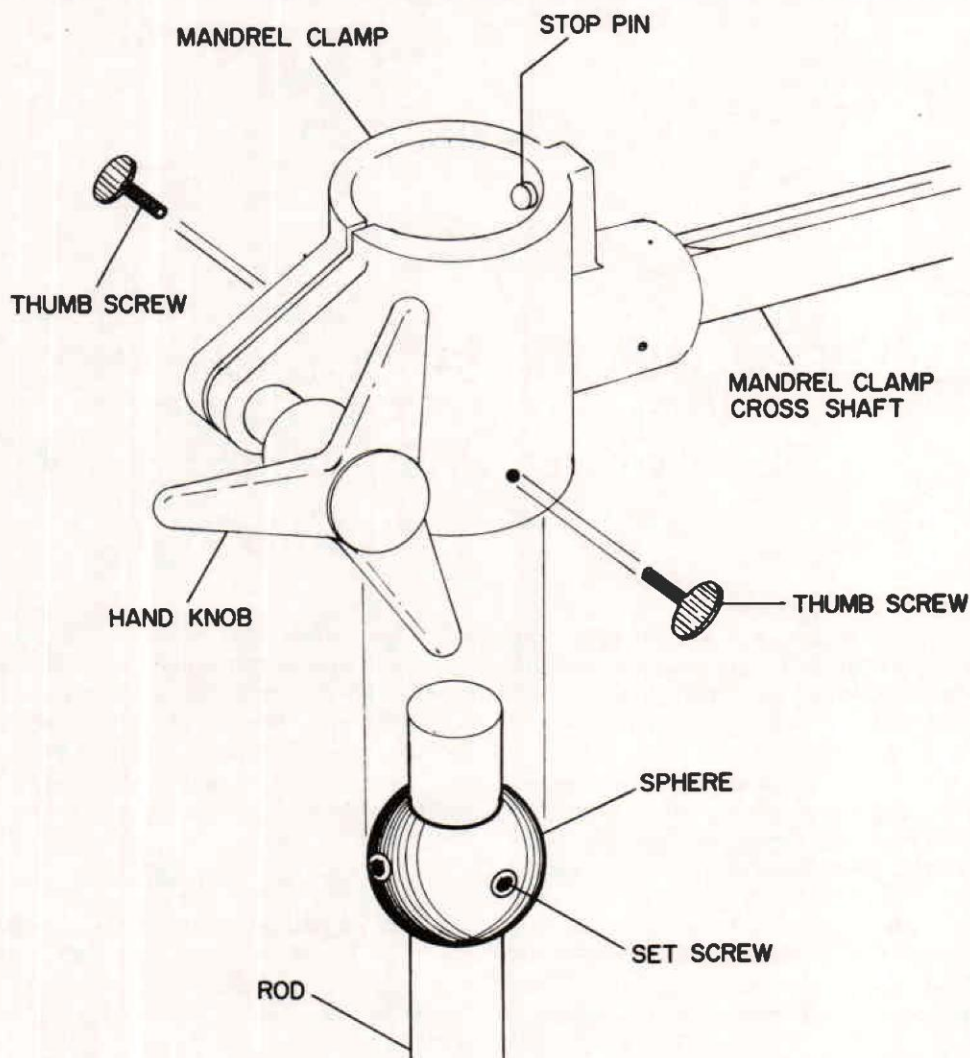


Fig. 1. Spherical insert for use with VFJ-100 fabricating jig.

longitudinal cuts of 15 cm depth at right angles to each other on the proximal end of the tubing is installed on the foot block with a hose clamp (Fig.

3). Before the tubing is cut longitudinally, two holes should be drilled through the tubing at the distal end of each of the planned cuts to prevent

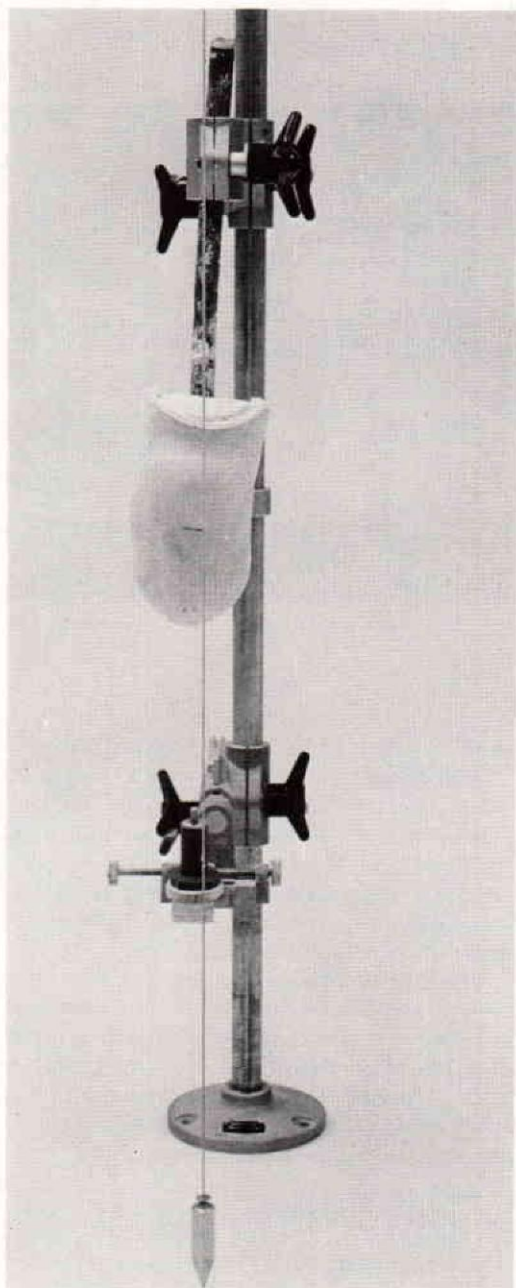


Fig. 2. A PVC footplug on a plywood base is placed in the alignment jig.

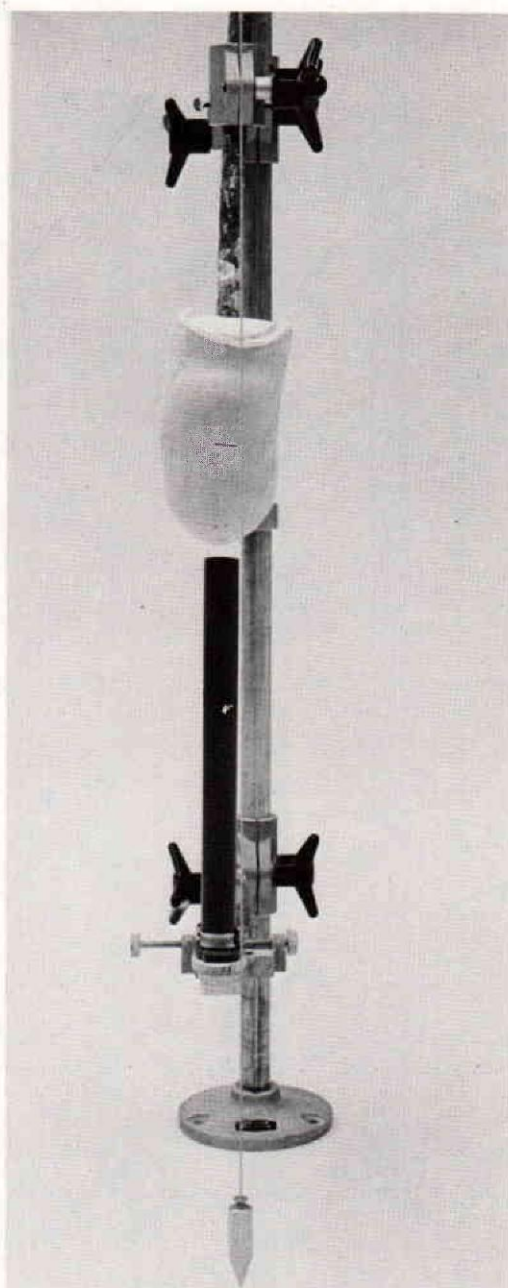


Fig. 3. Installation of the PVC tube.

stress concentrations at the end of the saw cuts.

The proximal end of the tube is heated to allow spreading of the tubing at the saw cuts made previously, and thus to produce four straps for attachment of the tube to the socket.

The socket with its outer surface roughed up is

lowered to the appropriate level into the spreaded section of the tubing at the proximal end (Fig. 4). The plastic straps are heated, are made to conform to the shape of the socket, and are held in place temporarily by masking tape (Fig. 5). One layer of fiberglass stockinette is then pulled over

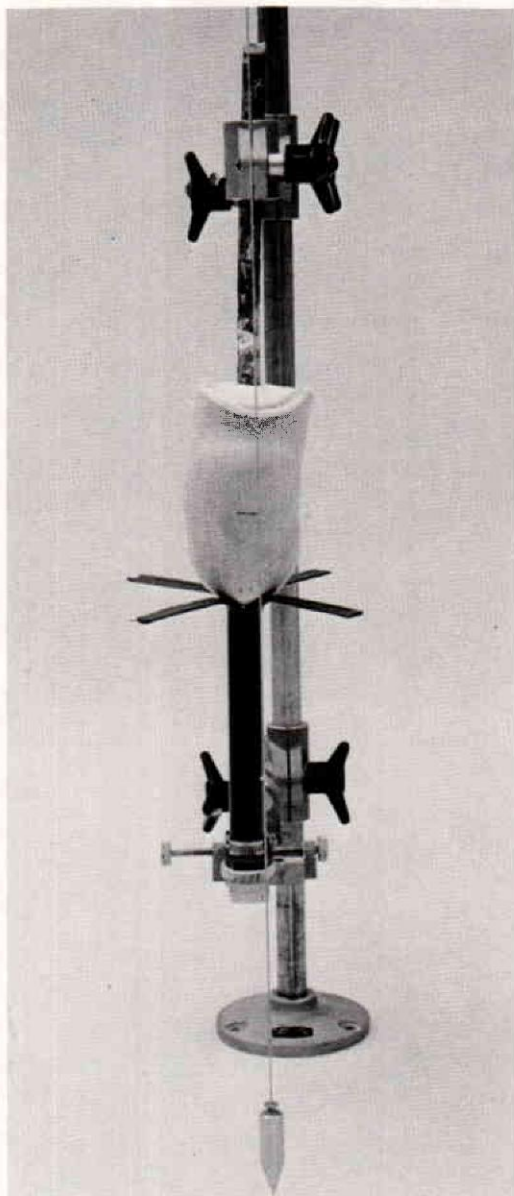


Fig. 4. View of setup showing the attachment straps before being formed in place.

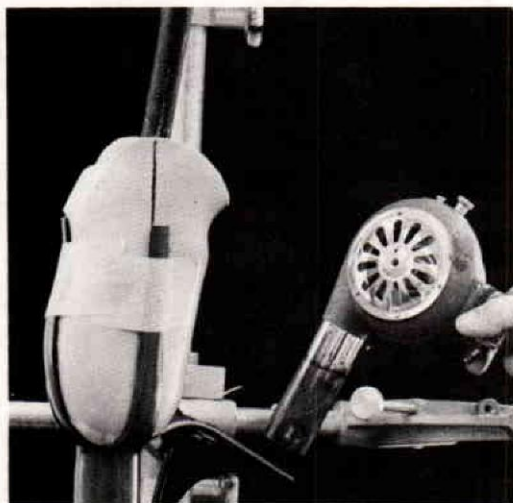


Fig. 5. First step in attaching the tube to the socket.

the PVC tubing from the foot block to the intersection of the plastic straps and the socket, at which point the fiberglass is tied to the PVC tubing (Fig. 6). A mixture of rigid polyester resin and silica powder is then spread over the socket and the plastic-strap area, and the tubular stockinette is pulled up to cover the portion of the socket over which the plastic straps extend.

When the stockinette has been pulled over the socket, additional amounts of the resin-silica mixture are spread onto the stockinette (Fig. 7). This may be done easily when plastic gloves are worn. After the resin has hardened, the foot is attached to the foot block and wooden base, and the prosthesis is ready for fitting (Fig. 8).

DYNAMIC ALIGNMENT

Any alignment changes can be accomplished readily by heating the PVC tubing for either angular or translatory alignment adjustments. For example, to increase socket flexion, the proximal

tubing area should be heated near the attachment to the socket. If, however, a translatory movement is desired, e.g., anterior movement of the socket over the foot, the proximal area of the tubing immediately below the socket as well as at its attachment to the PVC plug must be heated in

order to move the socket anteriorly over the foot (Fig. 9). These adjustments can be made by means of a heat gun directly on the tube while the patient is standing between parallel bars or, alternately, the adjustments indicated may be made by placing the prosthesis in the vertical

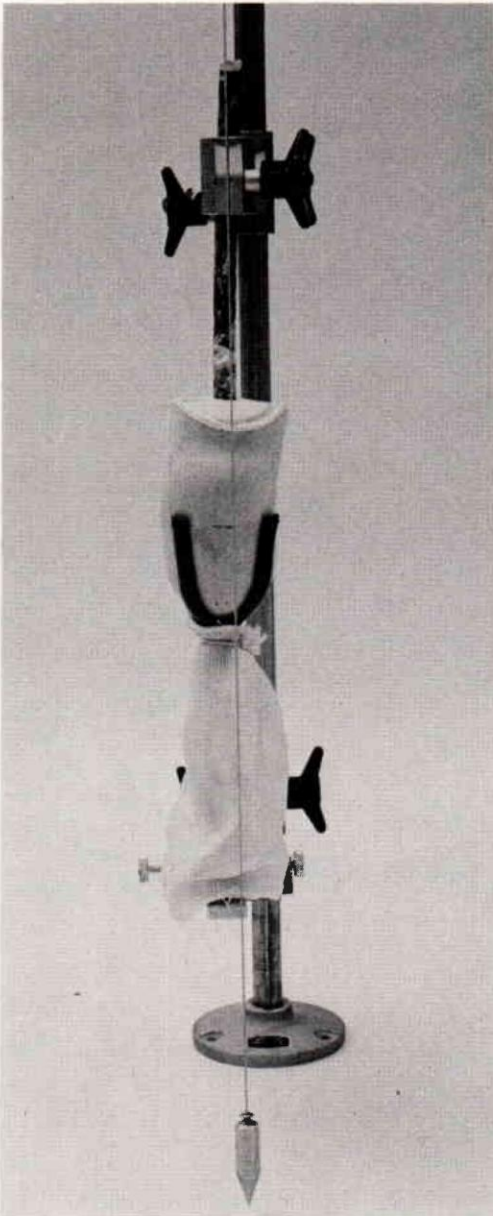


Fig. 6. Application of fiberglass stockinette used in attaching tube to socket.



Fig. 7. Impregnating the stockinette with polyester resin and silica powder.

alignment jig and by appropriately indexing the various adjustment scales on the jig where the alignment changes need to be made. The tubing can then be heated and a more accurate adjustment can be carried out.

FINISHING

If a hard exterior finish is desired, a rigid foam buildup is made, shaped, and laminated in the conventional manner, i.e., extending from the wood ankle base over the socket.

When a soft exterior finish is desired, the PVC tubing is reinforced by laminating two layers of nylon stockinette over the tube and extending over the wood base and the socket. A soft foam cover is then applied, shaped, and finished appropriately.

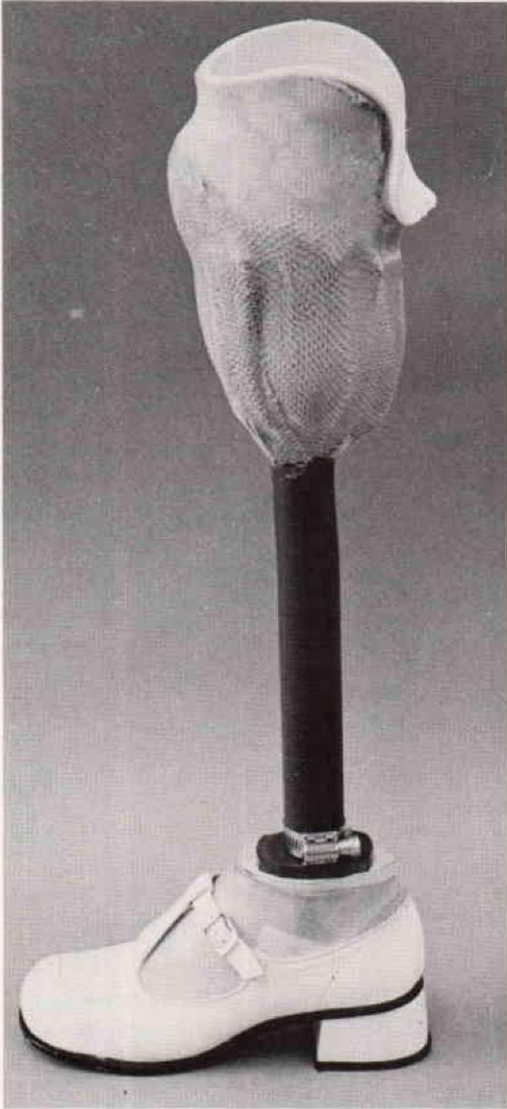


Fig. 8. Prosthesis ready for fitting.

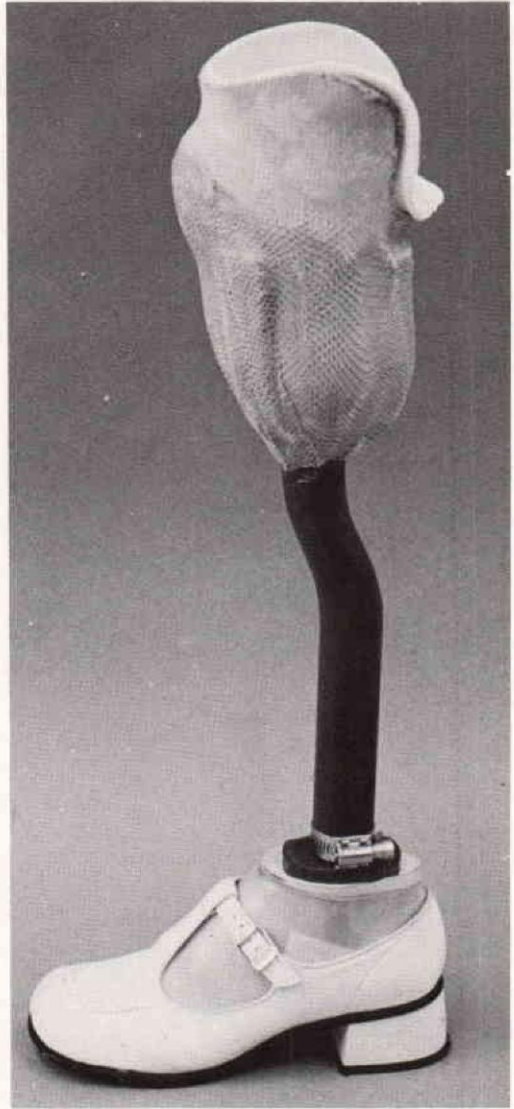


Fig. 9. Aligned prosthesis.

IMMEDIATE POSTOPERATIVE PROSTHETICS FITTING

The tube system has also been applied in a number of cases of below-knee immediate postoperative fittings, resulting in a considerable weight reduction, a condition especially important to geriatric amputees. There are no provisions for quick disconnection, but the light

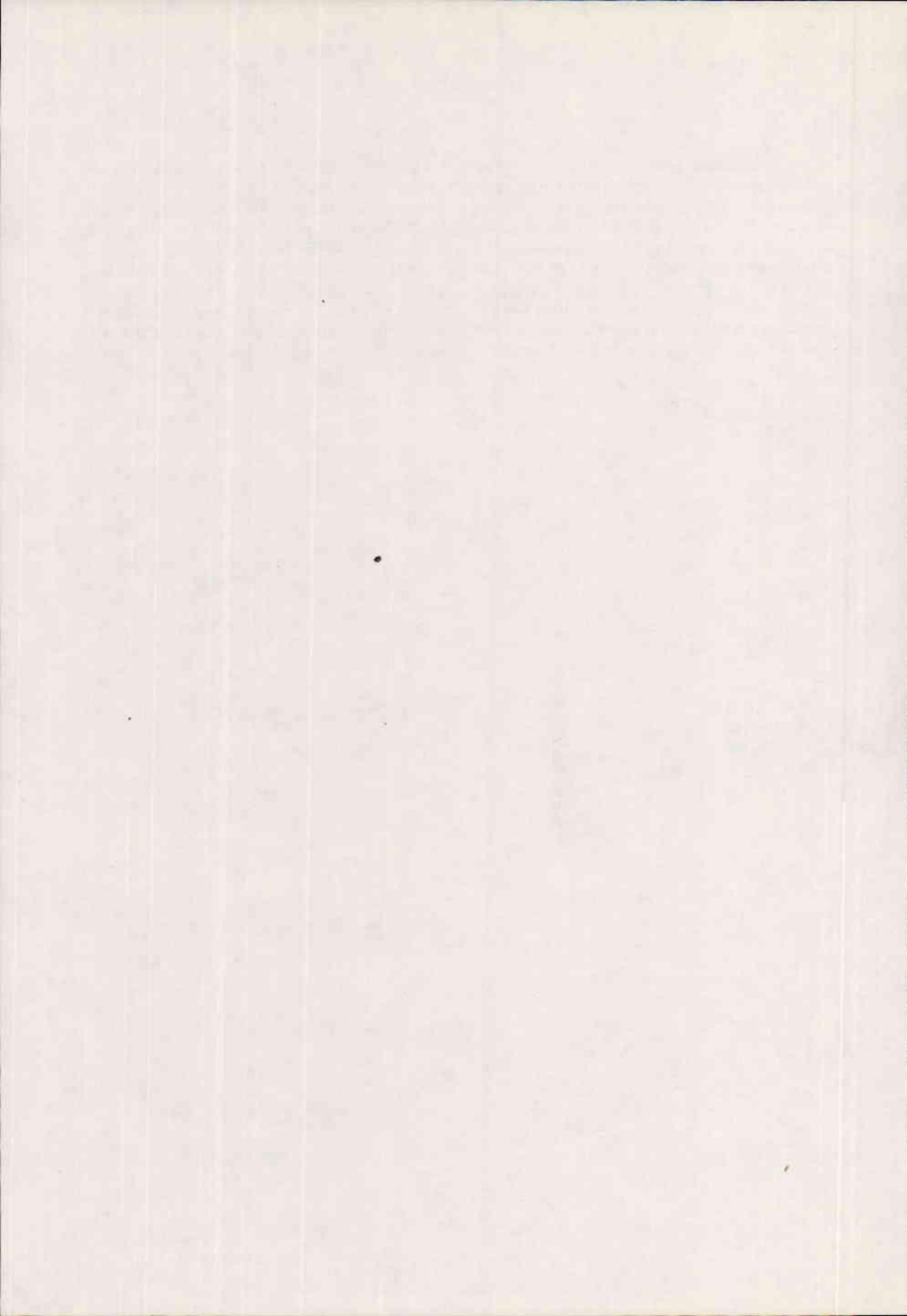
weight of the prosthesis seems to alleviate the need for removal of the prosthetic components from the socket.

SUMMARY

A below-knee prosthetics structural support and alignment system consisting of a PVC tube has been described. It results in extraordinary

weight reduction, especially when a soft exterior finish is intended and, at least in the early stages of prosthetics fitting, provides the possibility of infinite alignment changes to accommodate the patient's changing gait pattern. When a rigid exterior finish is indicated, this type of prosthesis is at least of the same or superior strength as the conventional BK prosthesis, and with a soft exterior finish of adequate strength when reinforced with fiberglass laminate as described above. It

has also been found to possess definite advantages in postoperative prosthetics fittings in geriatric amputees to reduce the weight substantially. The utility of this system, i.e., whether a rigid or soft exterior finish is desired, or for the purpose of immediate postoperative fittings, has proven to be successful in its exclusive application for below-knee amputees over the past three years at the Institute of Rehabilitation Medicine, New York University Medical Center.



DEVELOPMENT OF A THERMOPLASTIC BELOW-KNEE PROSTHESIS WITH QUICK-DISCONNECT FEATURE

Charles H. Pritham, C. P.

In recent years, considerable interest has been focused on the development of endoskeletal, modular systems for the various levels of amputation. Logically, such systems should be fully competitive with conventional fabrication techniques in regard to cost, ease and speed of fabrication, function, and weight. In addition, they should offer improved cosmesis and interchangeability of components. The most successful application has been in the hip-disarticulation case, and perhaps the least satisfactory has been in the below-knee case, particularly in reference to weight and expense. In an attempt to redress this situation, Richard Lehneis in conjunction with various co-workers has developed a below-knee prosthesis utilizing a pylon of commercially available polyvinylchloride pipe, a thermoplastic. (See preceding article. Ed.)

In their technique, one end of a piece of approximately 1¼ in. I.D. pipe is attached to a socket, cut to length, and a foot is applied by using an ankle plug of metal or PVC. Any alignment changes indicated by walking trials are made by heating and bending the pipe. The prosthesis can then be equipped with a cosmetic cover. This pylon has been used for immediate postoperative prostheses even though no quick-disconnect feature is provided.

Inspired by this, and at the instigation of Virgil Faulkner, C.P.O., the author late in the winter of 1973 began investigating the possibilities of developing a similar system from locally available materials. It soon became apparent that the smallest size pipe suitable and available locally is of about 1½ in. I.D. with a 3/16 in. wall thickness. PVC pipe of this size is used extensively in the

plumbing trade, and therefore a wide variety of fittings is available for use with this size. Consequently, the decision was made to provide a quick-disconnect feature by utilizing some of these fittings. One method used consists of cementing a threaded male connector to the pipe and adding socket-attachment straps to the matching female connector. (Figs. 1 and 2).

For their original purpose, the mating pieces were designed to be softened by heat and/or a solvent cement before being screwed together. For our purposes, it has been necessary to reform the threads using heat and a tap and die im-



Fig. 1. Various components of the plastic pylon. The primer and solvent cement are shown also.

¹Staff Prosthetist, Department of Orthopedics, Division of Prosthetics and Orthotics, University of Virginia Medical Center, 1224 West Main Street, Charlottesville, Va. 22903.



Fig. 2. An assembled pylon with galvanized straps.

vised from corresponding metal fittings (Fig. 3). Socket-attachment straps of conventional (and expensive) stainless steel have been used as well as less expensive straps of galvanized material that is generally used to hang water pipes (Fig. 1). These straps are attached to the female receptacle with machine screws, but pop rivets may be

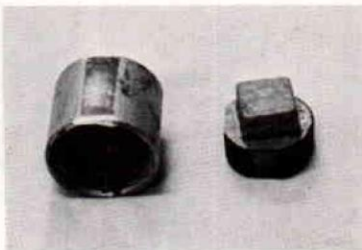


Fig. 3. Improvised tap and die showing flats and grooves needed for cutting threads.

satisfactory. The resulting assembly can be laminated into a plaster-of-Paris rigid dressing, a Lite-Cast II temporary socket, or a polyester laminated socket (Figs. 4, 5, and 6). The last mentioned procedure results in a temporary prosthesis of particularly pleasing appearance (Fig. 7).

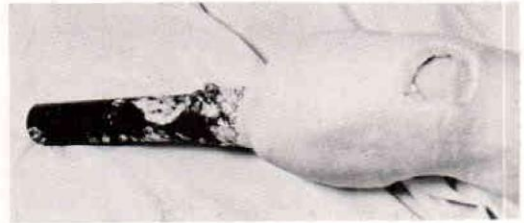


Fig. 4. Pylon laminated into a rigid dressing.

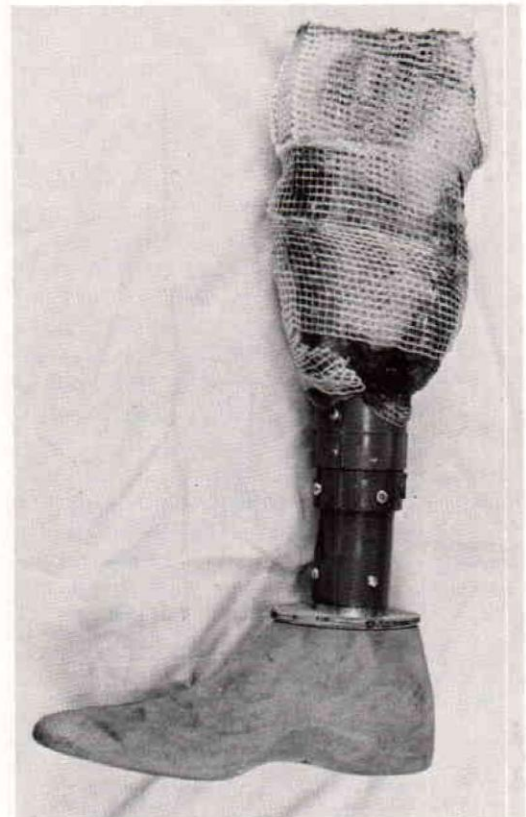


Fig. 5. Pylon laminated into a Lite-Cast II socket with foot attached.

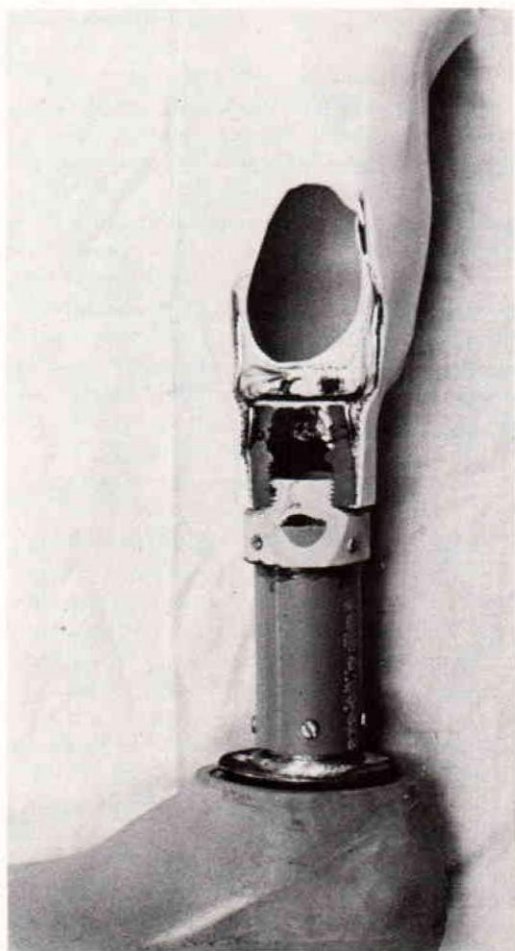


Fig. 6. Cutaway view of pylon laminated into a polyester socket.

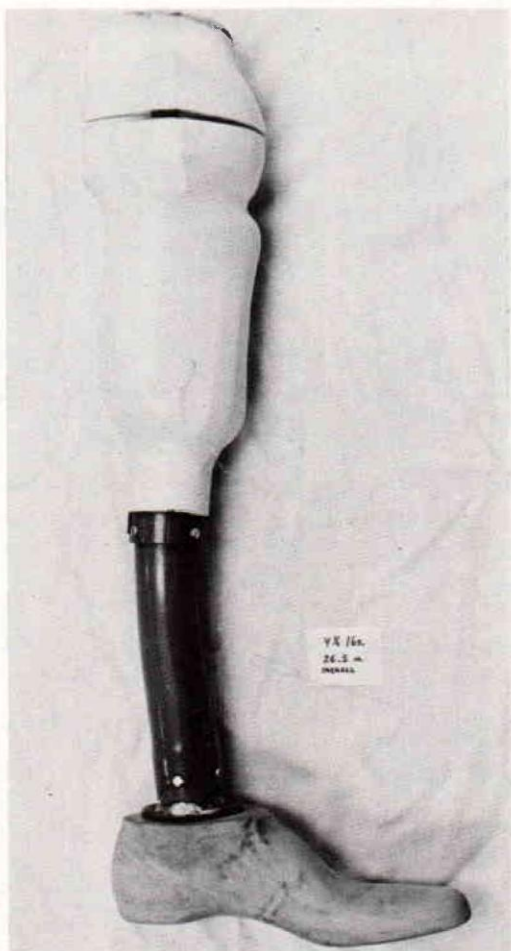


Fig. 7. Assembled temporary prosthesis.

Various ankle plugs have been used including some of modified PVC fittings, wood with adaptor nuts, and cut-down aluminum pylon tubes (Fig. 8). The latter have proven to be the most practical to date. Currently, work is under way to develop ankle plugs of either aluminum or PVC stock.

When using the pylon for an immediate post-operative prosthesis, a locking pin is provided to assure proper alignment of the various segments when the lower assembly is removed and replaced by the nurses and therapists (Figs. 1, 4, and 9). In surgery, the socket-attachment straps are incorporated in the cast and aligned while the pipe is still attached. The patient is "squared-up"

and the pipe is marked at a point corresponding to the sole of the opposite foot; the pipe is then removed. The foot is then attached to the pipe making suitable allowance for the height of the foot.

When the female receptacle is laminated into a polyester socket, considerable care must be taken in aligning it to avoid the necessity of making excessive bends. While not detracting materially from the strength of the prosthesis, these bends can present quite a peculiar appearance. In this instance, no pin is used and the two sections are forcefully "screwed home" so as to insure that no slippage occurs during use. For maximum strength, the threaded end of each fitting should

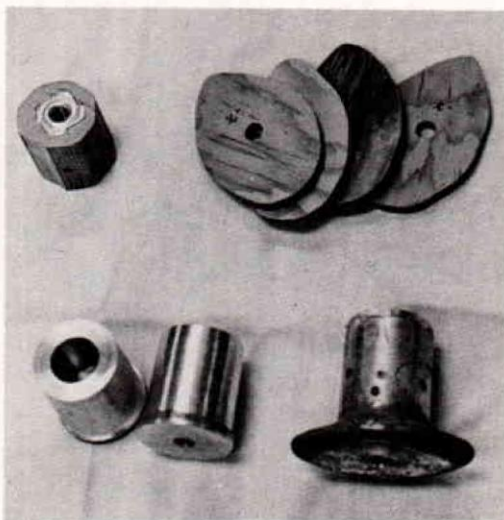


Fig. 8. Various ankle plugs and $\frac{1}{4}$ in. spacers.



Fig. 9. Disassembled immediate postoperative prosthesis with locking pin.

be resting solidly on the shoulder of the opposite piece. This has proven satisfactory to date, although additional security can be obtained by heating the male connector slightly beforehand. If desired, the two sections could also be cemented together, of course.

To make height changes readily possible, the prosthesis is assembled $\frac{1}{2}$ in. short and the difference is made up with $\frac{1}{4}$ in. spacers, a number of which are on hand at the time of fitting (Figs. 5 and 8). Any bends in the pipe should be made in the proximal portion so as to leave the distal portion unaffected for better observation of results. While such changes are made readily, considerable heat is needed. The necessity for extensive alignment changes can be avoided with ex-

perience and if due care is taken in the laminating procedure.

This system has not yet been used in a definitive prosthesis as it is still in the process of being proven and refined. However, no significant difficulties can be seen as the work of others bears out. This system has been in general use for sometime now, and no significant failures have occurred. Some 15 temporary and 5 immediate postoperative prostheses have been fitted over a period of 6 to 9 months using these components. In the author's opinion, this constitutes a sufficient sampling over a sufficiently long period to warrant serious consideration of further development.

CONCLUSIONS

The foregoing portion of this article describes our early experience in the use of PVC pylons. Since January of 1974, our experience with this early system and our dissatisfaction with it have resulted in adoption of the system we are presently using. This system consists of a female connection made from a commercially available PVC slip-fitting coupling with three short galvanized straps fastened to the proximal portion with pop rivets. The connection to the pipe distally is made by either a simple pin or two machine screws and nuts. This modification eliminates the tedious re-cutting of threads that was necessary in the previous design as well as breakage. At the distal portion of the pipe, a PVC ankle plug fastened to the pipe by sheet metal screws is used to connect the foot. Due to the furor over the possibility of PVC causing cancer, the use of PVC solvent glue has been avoided lately.

These changes have simplified production and reduced the time required as well as eliminating the breakage that occurred formerly at the base of the threads of the male connector. Alignment changes of temporary prostheses have not proven to be a problem as attention to detail during socket lamination results in an alignment that commonly needs only minor changes. Because of the large external diameter of loosely available components (which results in increased bulk and weight), the system is not commonly used for definitive prostheses. Early attempts at fabricating soft cosmetic covers for a water-based foam recently available on an experimental basis from Alimed have been inconclusive. Here,

too, the external diameter of the pylon poses a problem.

The author wishes to make full acknowledgment of the work of Messrs. Lehneis and Wunder, as well as others in the New York area, and to point out that his own contribution has been in the matter of a quick-disconnect feature which seems to offer significant advantages. Further-

more, the development of a comparable commercial system at reasonable cost involving the use of such a disconnect feature and a smaller size pipe appears to be feasible. Such a commercial system should logically include an ankle plug of PVC and a locking pin on a lanyard for optional use.

A PROPOSED NOMENCLATURE FOR LIMB PROSTHETICS

Hector W. Kay

This report reflects decisions made at two 1974 meetings of the Task Force on Standardization of Prosthetic-Orthotic Terminology, one on February 21 at Rancho Los Amigos Hospital, Inc., in Downey, California, and the other on July 9 at the Rehabilitation Institute of Chicago, Illinois. Jacquelin Perry, M.D., is the General Chairman of the Task Force; Paul R. Meyer, Jr., M.D., and Robert G. Thompson, M.D., were Acting Chairmen, respectively, at the two sessions under discussion, which dealt primarily with prosthetics matters. Present at both meetings were Task Force members; liaison representatives from the prosthetics education institutions; the American Academy of Orthotists and Prosthetists; the American Board for Certification in Orthotics and Prosthetics, Inc.; the American Orthotic and Prosthetic Association; and the Veterans Administration. A list of participants is appended to this report.

The Task Force on Standardization of Prosthetic-Orthotic Terminology, established by the Committee on Prosthetic-Orthotic Education (CPOE), National Academy of Sciences—National Research Council, with Jacquelin Perry as Chairman met on January 21, 1971. At this initial meeting both Herbert W. Warburton, on behalf of the American Orthotic and Prosthetic Association—American Board for Certification (AOPA-ABC), and Anthony Staros for the Veterans Administration presented reasons for the development of a standardized prosthetics

and orthotics nomenclature. Some of the needs advanced were:

- The establishment of bases for prices of devices in connection with Medicare, Medicaid, and similar programs. Proposed computerization of government billing information reinforced the need in this area.

- The elimination of problems resulting from inconsistencies in nomenclature as they affect examinations for certification of prosthetists and orthotists.

- Consistency in the use of orthotics terms in the field, in clinical and educational situations, and in Volume 1 of the *Orthopaedic Appliances Atlas* now being rewritten.

- Development of a glossary of prosthetics and orthotics terms in response to a suggestion made by the International Society for Prosthetics and Orthotics (ISPO). The proposed glossary should lend itself to translation into other languages, make maximum use of Latin and Greek terms, and avoid "Americanisms."

- Completion of a VA project to standardize nomenclature for preparation of contracts, for control of statistical information, and for use in coding, filing, and retrieving numerous documents and other types of literature stored by the Veterans Administration.

The Task Force has met on a continuing basis, usually once or twice a year, and has made major progress in the area of orthotics nomenclature. As a result of the Task Force's efforts a new set of terms—actually acronyms—has been developed, and this language is already being used extensively. The basic principle of the orthotics nomenclature is essentially simple, being that of categorizing orthoses by the joints they encompass. Thus, an "FO" (foot orthosis) is one which pertains to the joints of the foot; an "AFO" (ankle-foot orthosis) encompasses the ankle as

¹Assistant Executive Director, Committees on Prosthetics Research and Development and Prosthetic-Orthotic Education (CPRD-CPOE), National Academy of Sciences, Washington, D.C. 20418.

well as the foot; and a "KAFO" (knee-ankle-foot orthosis) spans the knee as well as the ankle and foot, etc. This new orthotics nomenclature has now been incorporated into technical analysis forms for the upper and lower limbs and the spine; a prescription procedure; and computerized billing procedures. The nomenclature is also being included in the revision of Volume I of the *Orthopaedic Appliances Atlas* now in process, one of its applications being to provide a basis for the description of orthotic components and systems for the upper limb, lower limb, and spine. Cognizance of the new system is also taken

in the revision of descriptors, or key words, for the Winnipeg Information Retrieval System. A comprehensive report covering the applications of the new orthotics nomenclature is in preparation and will be published in the near future.

Despite the marked progress made with the standardization of orthotics nomenclature, very little progress was made with regard to the standardization of prosthetics terms. The reasons for the lack of progress in the prosthetics aspect of the Task Force's assignment probably were:

- Prosthetics nomenclature was much less confusing than was the case in orthotics when the

TABLE I. AMPUTATION LEVELS—UPPER LIMB

<i>New Terms (with Abbreviations)</i>	<i>Current Terms</i>
Shoulder (Sh), complete	Forequarter
Arm (Arm), ¹ complete	Shoulder disarticulation
Arm (Arm), ¹ partial ² (upper 1/3)	Short (upper-third) AE
Arm (Arm), ¹ partial ² (middle 1/3)	Medium (mid-third) AE
Arm (Arm), ¹ partial ² (lower 1/3)	Long (lower-third) AE
Forearm (Fo), ¹ complete	Elbow disarticulation
Forearm (Fo), ¹ partial ² (upper 1/3)	Short (upper-third) BE
Forearm (Fo), ¹ partial ² (middle 1/3)	Medium (mid-third) BE
Forearm (Fo), ¹ partial ² (lower 1/3)	Long (lower-third) BE
Carpal (Ca), complete	Wrist disarticulation
Carpal (Ca), partial	WD, with some carpals still present
Metacarpal (MC), complete	} Partial-hand amputations, usually without precise differentiation.
Metacarpal (MC), partial	
Phalangeal (Ph), complete	
Phalangeal (Ph), partial	

(For amputations involving the metacarpals and the phalanges, detail can be provided as desired by use of the standard numbering system, e.g., an amputation at the MCP joints of the ring and little fingers would be designated as "Ph, 4, 5, complete"; an amputation of the same two fingers at the PIP joints would be "Ph, 4, 5, partial.")

¹To identify the level when the amputation was close to a joint, it was agreed that the epiphyseal growth plate or scar would be the reference line, e.g., an amputation at or above the proximal humeral growth plate would be "arm, complete"; one a little lower than this would be "arm, partial (or upper 1/3)."

²"Partial arm" would be the new general term for above-elbow (AE); "partial forearm" for below-elbow (BE).

Task Force began its meetings. Thus, there has been less incentive or urgency to change the current terminology, which many people find quite acceptable.

- Following the success achieved in the revision of the orthotics nomenclature, an attempt was made to follow the same organizational pattern in prosthetics. It took two or three unproductive trials to convince the group that the approach used in orthotics was not applicable to prosthetics.

Conversely, numerous individuals continued to be disturbed by the fact that such terms as

"knee disarticulation," "knee exarticulation," "through knee," "Gritti-Stokes," and "Stokes-Gritti" were all applied to amputations which were or appeared to be essentially the same from a functional standpoint. Moreover, the needs of the Veterans Administration and other purchasers of prosthetic devices and services for a nomenclature which described components in functional terms rather than brand names continued to exist, and so the search for a standardized prosthetics nomenclature continued.

At the February 1974 meeting of the group a

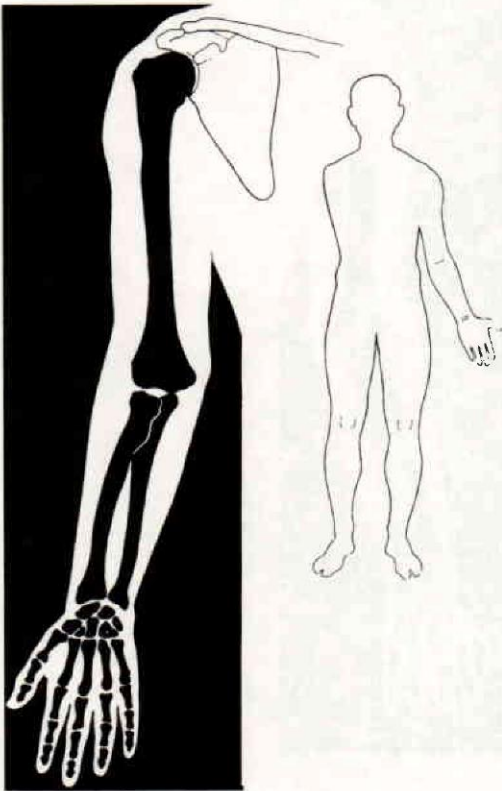


Fig. 1. An Arm, complete amputation (shoulder disarticulation).

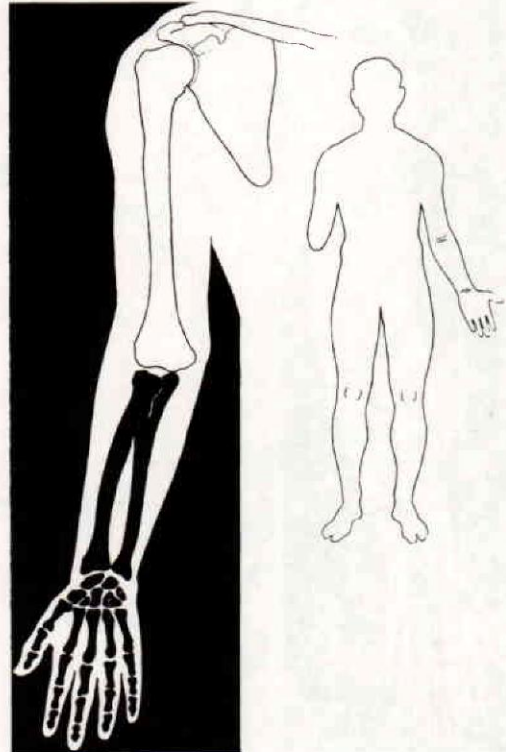


Fig. 2. An Fo, complete amputation (elbow disarticulation).

fresh approach to the problem was made along two lines:

- Amputation Levels and Prosthesis Types

Here the incentive was a report on a new terminology for the classification of congenital limb deficiencies developed at an international workshop held in Dundee, Scotland, in June 1973. It appeared likely that this new terminology would be accepted internationally. In the new system for the classification of limb deficiencies, all defects were classified under one or two major

categories—transverse or longitudinal. The transverse deficiencies present as amputation-like stumps, and prosthetics management is essentially the same as with surgical amputations deriving from trauma or disease. After extensive consideration and discussion, therefore, the Task Force decided to adopt the nomenclature for transverse congenital defects in designating amputation levels for non-congenital amputations. The present report describes this proposed new nomenclature. It has been designated as Part I of the Task Force's recommendations on prosthetics nomenclature.

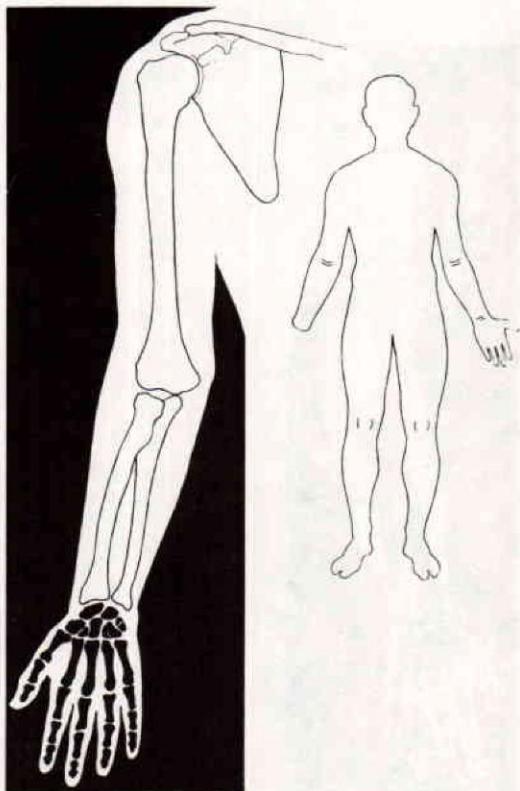


Fig. 3. A Ca, complete amputation (wrist disarticulation).

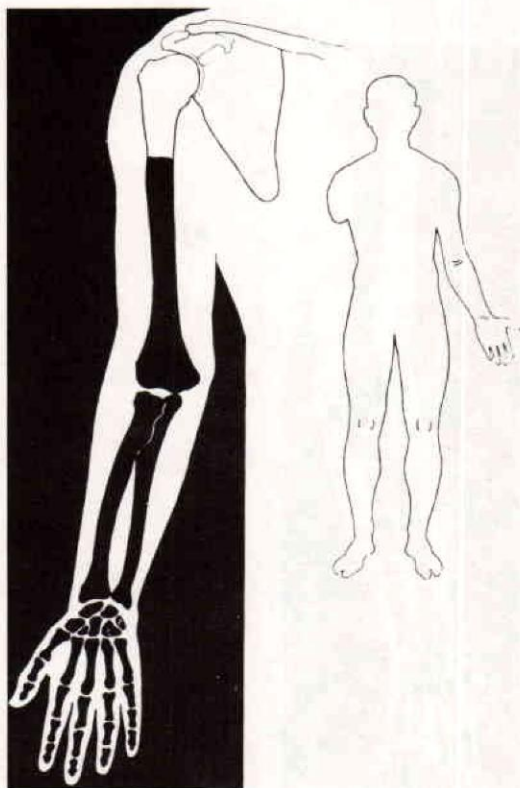


Fig. 4. An Arm, partial or upper 1/3 amputation (short above-elbow).

• Terminology of Prosthetic Components Based on Function

Here the Task Force simply took each component of a prosthesis—socket, knee joint, ankle joint, etc.—and attempted to classify each in functional yet relatively simple terms. The outcome of this work is being written up as Part II of the Task Force's prosthetics report.

The essence of the new system for naming transverse congenital deficiencies or surgical amputations is that the name designates the level at which the limb terminates (or the most proximal

segment that is missing). It is understood that all elements distal to the level named are also absent. For example, a short below-elbow amputation would be identified as a "forearm, upper $\frac{1}{3}$." An elbow disarticulation or through-elbow amputation would be named "forearm, complete," thus indicating the most proximal missing portion (Table I and Figs. 1-5).

The new terminology for lower-limb amputations (with abbreviations) and the equivalent levels in current terms as shown in Table II and illustrated in Figures 6-10 are in conformity with the format previously presented for upper limbs.

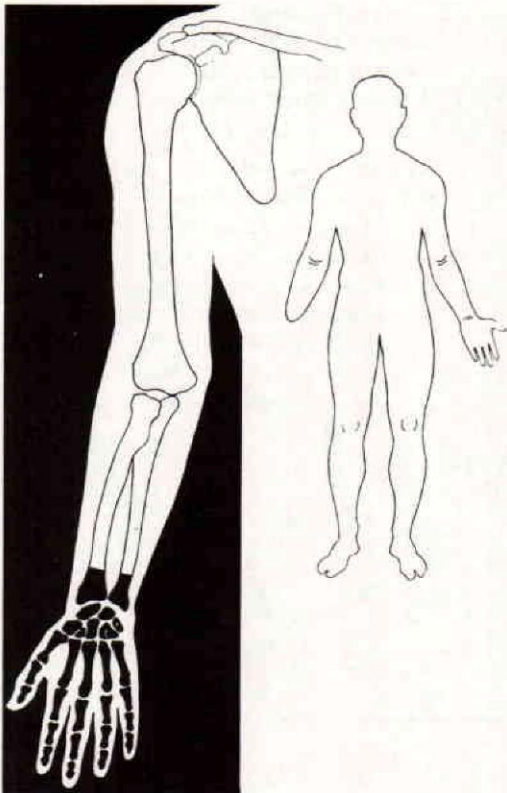


Fig. 5. An Fo, partial or lower $\frac{1}{3}$ amputation (long below-elbow).

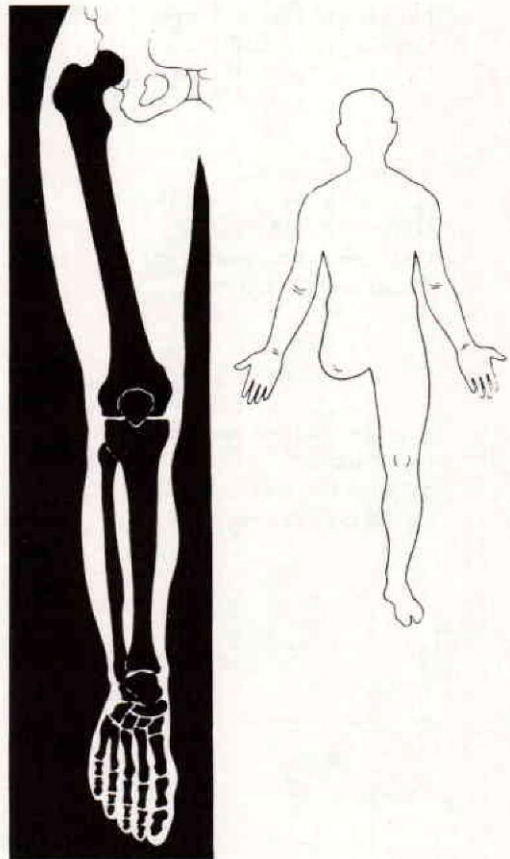


Fig. 6. A Th, complete amputation (hip disarticulation).

TABLE II. AMPUTATION LEVELS—LOWER LIMB

<i>New Terms (with Abbreviations)</i>	<i>Current Terms</i>
Pelvic (Pel), complete	Hemicorporectomy
Hip (Hip), complete	Hemipelvectomy
Thigh (Th), ¹ complete	Hip disarticulation
Thigh (Th), ¹ partial ² (upper 1/3)	Short (upper-third) AK
Thigh (Th), ¹ partial ² (middle 1/3)	Medium (mid-third) AK
Thigh (Th), ¹ partial ² (lower 1/3)	Long (lower-third) AK
Leg (Leg), ¹ complete	Knee disarticulation
Leg (Leg), ¹ partial ² (upper 1/3)	Short (upper-third) BK
Leg (Leg), ¹ partial ² (middle 1/3)	Medium (mid-third) BK
Leg (Leg), ¹ partial ² (lower 1/3)	Long (lower-third) BK
Tarsal (Ta), complete	Ankle disarticulation or Syme's amputation
Tarsal (Ta), partial	Known collectively as partial foot amputations, some specifics being: Chopart's amputation Forbe's amputation Hancock's amputation Hey's amputation Lisfranc's amputation Pirogoff's amputation
Metatarsal (MT), complete	
Metatarsal (MT), partial	
Phalangeal (Ph), complete	
Phalangeal (Ph), partial	

(For amputations involving the metatarsals and the phalanges, additional detail can be provided by using the standard numbering system for the elements of the individual rays.)

¹When the amputation was close to a joint, the epiphyseal growth plate or scar would be the reference line, e.g., an amputation just above the level of the distal femoral growth scar would be "Th, partial (or lower 1/3)"; one at the scar or between the scar and joint would be "leg, complete."

²"Partial thigh" would be the new general term for above-knee (AK); and "partial leg" for below knee (BK).

PROSTHETICS TYPES

During the course of the discussion on nomenclature to describe amputation levels, it became apparent that the same nomenclature should be used to identify the prostheses which would be fitted to these levels. For example, a complete leg prosthesis would be fitted to a "leg, complete" (or knee disarticulation) amputation (Figs. 11-13).

NEXT STEPS

AMPUTATION LEVELS

Following adoption of the new nomenclature to designate amputation levels and types of prostheses, the Task Force made three additional recommendations:

- That an article describing the new nomenclature be developed for possible publication in *Orthotics and Prosthetics* and other journals.³

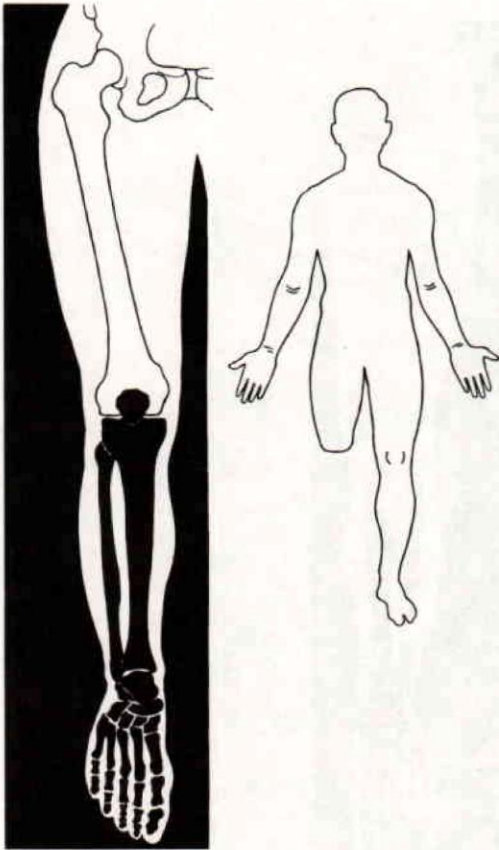


Fig. 7. A Leg, complete amputation (knee disarticulation).

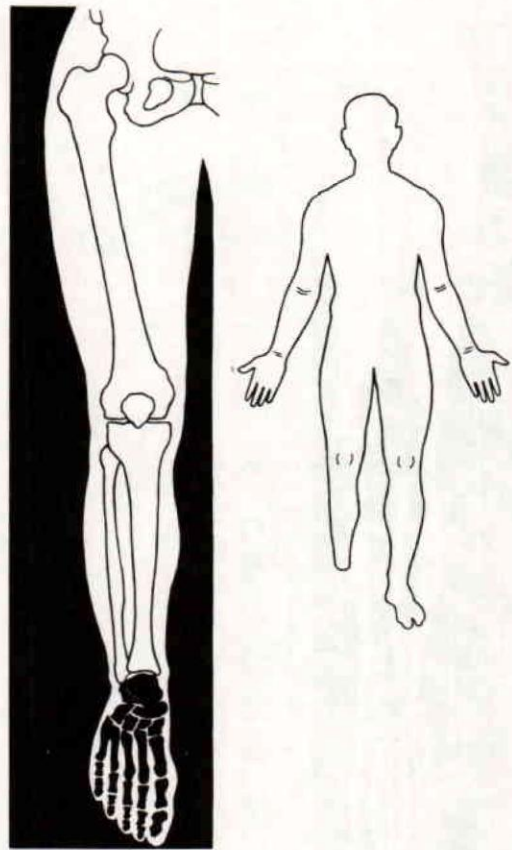


Fig. 8. A Ta, complete amputation (ankle disarticulation).

³This document was prepared in response to this request.

- That from six to ten prosthetics facilities with large case loads be asked to field-test the new prosthetics nomenclature. (This recommendation is now being implemented and the results will be reported at a later date.)

- That the article describing the new nomenclature for amputation levels and prosthesis types (and the results of the field study when available) be transmitted to the International Society for Prosthetics and Orthotics for consideration by that body's Subcommittee on Orthotics and Prosthetics Nomenclature at its meeting in October 1974.

FUNCTIONAL DESCRIPTIONS

Similarly it was recommended that the Task Force's work on the functional description of prosthetic components be written for publication, field-tested, and referred to the ISPO Subcommittee on Orthotics and Prosthetics Nomenclature. Implementation of these recommendations is now under way (see the following article by E. E. Harris).

SUMMARY

In the course of two meetings held in 1974, the Task Force on Standardization of Prosthetic-Orthotic Terminology of CPRD-CPOE endorsed a new prosthetics nomenclature to designate 1)

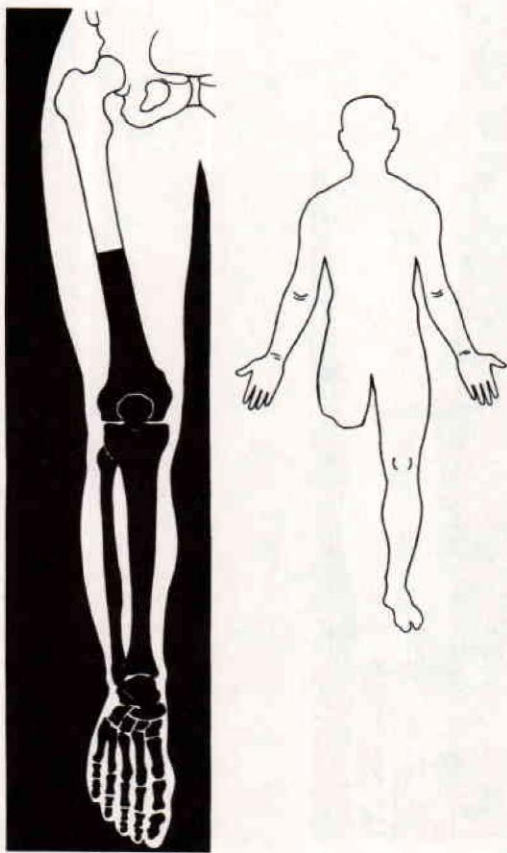


Fig. 9. A Th, partial or middle 1/3 amputation (medium above-knee).

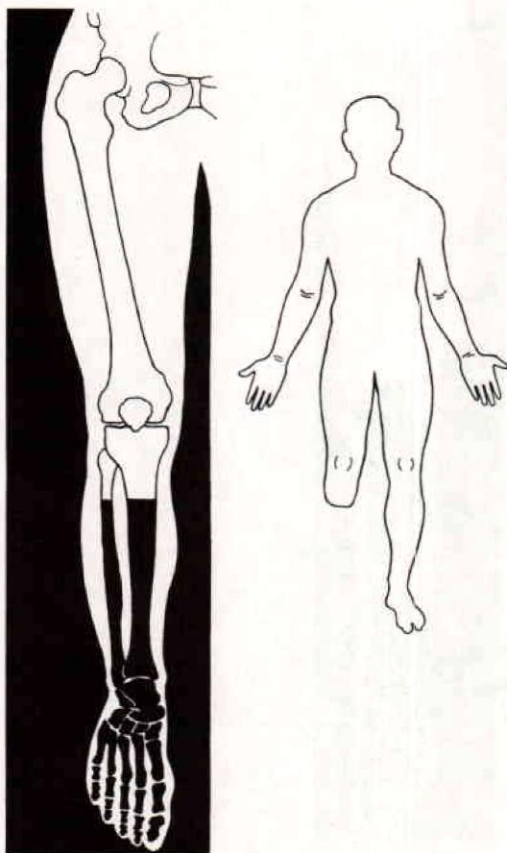


Fig. 10. A Leg, partial or upper 1/3 amputation (short below-knee).

amputation levels, 2) prosthesis types, and 3) the functional description of components.

In the first two categories the new nomenclature (as described in this report) is essentially identical with the terminology developed by the ISPO Subcommittee on Nomenclature and Classification in Congenital Limb Deficiency for the classification of children's transverse congenital deficiencies. The recommended new nomenclature is being field-tested in selected facilities in North America.

A detailed report on the Task Force's recommendations concerning the functional description of prosthetic components has been prepared and is published in this issue of *Orthotics and Prosthetics*.

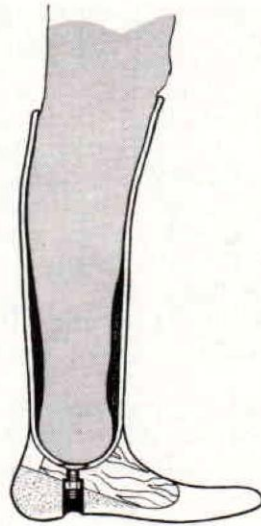


Fig. 12. A Tarsal, complete, prosthesis for a complete tarsal amputation.



Fig. 11. A Leg, complete, prosthesis for a complete leg amputation.



Fig. 13. A Thigh, middle 1/3, prosthesis for a middle 1/3 thigh amputation.

ACKNOWLEDGMENTS

The Task Force was initially established by the Committee on Prosthetic-Orthotic Education (CPOE), and is now jointly sponsored by CPOE and the Committee on Prosthetics Research and Development (CPRD). The joint committees conduct their activities under Contract V101 (134) P-75 between the Veterans Administration and the National Academy of Sciences, and Contract No. SRS 72-6 between the Social and Rehabilitation Service, Department of Health, Education, and Welfare, and the National Academy of Sciences.

Appreciation is expressed to Mrs. June D. Newman, CPRD-CPOE staff, for her valuable assistance in the preparation of this report.

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PARTICIPANTS

(In one or both of the 1974 Meetings of the Task Force on Standardization of Prosthetic-Orthotic Terminology.)

Perry, Jacquelin, M.D. (Chairman), Chief, Research and Development Group, Kinesiology Service, Rancho Los Amigos Hospital, Inc., Downey, California.

Meyer, Paul R., Jr. M.D., (Acting Chairman), Assistant Professor of Orthopaedic Surgery, Northwestern University Medical School, Chicago, Illinois.

Thompson, Robert G., M.D. (Acting Chairman), Associate Professor of Orthopaedic Surgery, Northwestern University Medical School, Chicago, Illinois.

Billock, John N., Research Prosthetist, Prosthetic Research Laboratory, Northwestern University Prosthetic-Orthotic Center, Chicago, Illinois.

Bray, John J., Director, Training Program in Prosthetics-Orthotics Education, University of California at Los Angeles Rehabilitation Center, Los Angeles, California.

Compere, Clinton L., M.D., Program Chairman, Northwestern University Prosthetic-Orthotic Center, and Professor of Orthopaedic Surgery, Northwestern University Medical School, Chicago, Illinois.

Cortright, Everett S., Staff Assistant, Prosthetics Research and Development, Department of Medicine and Surgery, Veterans Administration, Washington, D. C.

Fannin, Robert E., Columbus Orthopaedic Appliance Co., Columbus, Ohio.

Fryer, Charles M., Director, Prosthetic-Orthotic Center, Northwestern University Medical School, Chicago, Illinois.

Harris, E. E., M.R.C.S., Staff Surgeon, Committees on Prosthetics Research and Development and Prosthetic-Orthotic Education (CPRD-CPOE), National Research Council, Washington, D. C.

Hayes, Robert F., President, Starkey Artificial Limb Co., Inc., West Springfield, Massachusetts.

Kay, Hector W., Assistant Executive Director, Committees on Prosthetics Research and Development and Prosthetic-Orthotic Education (CPRD-CPOE), National Research Council, Washington, D. C.

Kolanowski, Stanley J., Technical Information Specialist, Research Center for Prosthetics, Veterans Administration, New York, New York.

Lewis, Earl A., Assistant Director, Research Center for Prosthetics, Veterans Administration, New York, New York.

McCollough, Newton C., III, M.D., Director of Rehabilitation, Department of Orthopaedics and Rehabilitation, University of Miami School of Medicine, Miami, Florida.

Murphy, Eugene F., Ph. D., Director, Research Center for Prosthetics, Veterans Administration, New York, New York.

Nelson, Peter J., Project Engineer, Library, Prosthetic-Orthotic Research and Development Unit, Health Sciences Centre, Winnipeg, Canada.

Peizer, Edward, Ph. D., Assistant Director, Veterans Administration Prosthetics Center, New York, New York.

Pellicore, Raymond, M.D., Clinical Assistant Professor of Orthopaedic Surgery, Abraham Lincoln School of Medicine, University of Illinois, Chicago, Illinois.

Simons, Bernard C., Director, Prosthetics and Orthotics Division, Rehabilitation Medicine, University Hospital, University of Washington, Seattle, Washington.

Snell, Ralph R., Snell's Limbs and Braces, Memphis, Tennessee.

Springer, Warren, Assistant Coordinator, Prosthetics and Orthotics, New York University Post-Graduate Medical School, New York, New York.

Staros, Anthony, Director, Veterans Administration Prosthetics Center, New York, New York.

Storrs, Ralph A., General Manager, Pope Brace Company, Kankakee, Illinois.

Zetttl, Joseph H., Director, Prosthetics Research Study, University of Washington, Seattle, Washington.

A PROPOSED PROSTHETICS TERMINOLOGY

E. E. Harris, M.R.C.S.¹

This report has been prepared for the Task Force on the Standardization of Prosthetic-Orthotic Terminology established by the Committee on Prosthetic-Orthotic Education of the National Academy of Sciences—National Research Council which first met on January 21, 1971, under the chairmanship of Jacquelin Perry, M.D. Many informed members of the various professions concerned with prosthetics from university, government, and private sectors have over the years contributed to the discussions at a number of meetings under the general chairmanship of Dr. Perry. The proposed terminology presented here was mostly formulated at the two meetings at Rancho Los Amigos Hospital, Inc., Downey, California, and the Rehabilitation Institute of Chicago, Illinois, under the acting chairmanship of Robert G. Thompson, M.D., and Paul R. Meyer, Jr., M.D. The participants of these two meetings are listed in the previous article by Hector W. Kay.

The Task Force on Standardization of Prosthetic-Orthotic Terminology (CPRD-CPOE) has agreed that the accepted nomenclature for amputation and prosthetics levels shall be that devised for transverse congenital deficiencies by the Subcommittee on Nomenclature and Classification in Congenital Limb Deficiency, International Society for Prosthetics and Orthotics, as described by Hector Kay in the preceding article. The nomenclature can be used independently of any terminology of systems, components, or materials. It is currently undergoing field trials in selected centers.

TERMINOLOGY

A descriptive terminology of systems, components, and materials was devised by the Task Force at its meeting on July 9, 1974, in Chicago, and is described here. This terminology can be

used with any required degree of detail for prescription, education, fabrication manuals, fee schedules, information retrievals, or component catalogs. It is intended to be used with the nomenclature described in the preceding article, but could also be used independently. It has been proposed that a field trial be started in the fall of 1974, preferably as an international evaluation project through ISPO.

The following is a description of the proposed terminology of *systems, components, and materials*. It is proposed that a prosthesis be described in an orderly manner, proceeding from the general to the more detailed as follows:

A. General Characteristics

1. Prosthetics Level
2. Major Structural Feature
3. Durability
4. Cosmetic Treatment

B. Interface Characteristics

1. Socket
2. Suspension
3. Force Distribution

C. Systems and Mechanics

1. Joints at Each Level from Proximal to Distal
2. Joint Controls
3. Power Source of Controls
4. Alignment Devices
5. Terminal Devices - Upper Limb

D. Materials

GENERAL CHARACTERISTICS

1. Prosthetics level should be described according to the description in the preceding article by Kay (2).
2. Major Structural Feature. By international agreement prostheses are endoskeletal or exoskeletal. In some there may be a hybrid element but one or the other will be the "major" feature. Therefore prostheses are:

Endoskeletal
Exoskeletal

¹Staff Surgeon, Committee on Prosthetics Research and Development, National Academy of Sciences, Washington, D.C. 20418.

3. Durability. Some indication of temporariness or permanence of a prosthesis is needed and whether it is robust. Some agreement was reached at Heathrow (1) about the need for different strengths of prostheses. Durability, therefore, needs two descriptors, one from list "a" and one from list "b."

a	b
Immediate Postsurgical	Geriatric
Training (Diagnostic)	Standard
Definitive	Heavy Duty

4. Cosmetic Treatment. At Chicago it was agreed that "anthropomorphic" and "nonanthropomorphic" were clumsy words, and since "cosmesis" was an acceptable and used term, "acosmetic" was suggested.

It has been suggested further by Anthony Staros that we do not want to say that a prosthesis is "acosmetic"; that is to say it is ugly. What is intended is to distinguish between special cosmetic treatment and standard procedures.

Cosmesis should therefore refer to special cosmetic treatment and would be:

Cosmetic Cover
Plastic on Wood or Metal
Plastic Foam and Skin
None

To say that there is no special cosmetic treatment does not infer that the prosthesis is necessarily ugly.

INTERFACE CHARACTERISTICS

The reaction of the work load across the interface between prosthesis and patient takes place in the socket and sometimes in the suspension. Where that major reaction occurs must be specified but is recorded in the description of the socket and suspension.

1. Sockets. Sockets need three descriptors and may need a fourth for suspension. The first descriptor is the nature of the socket; the second is the nature of the materials constructing the socket; the third is the site of major force distribution. The fourth will be the socket's contribution to suspension. Sockets are therefore:

a
Total Contact
Non-total
Contact

b
Rigid
Semirigid
(e.g., liner)
Compliant
Hybrid

c
Proximal Bearing
Distal Bearing
Total Bearing

Materials (see section on Materials) can also be described, for example, the PTB air cushion socket could be "plastic (or even epoxy resin glass fiber) total-contact semirigid distal compliant proximal bearing socket."

2. Suspension. Ideally, suspension is from the socket where it may be "pressure differential" or "suction" or it may be body contour as in the complete tarsus, complete leg, complete hip, some partial leg, and some partial forearm prostheses, etc.

Many prostheses need additional suspension by a harness, belt, etc. This is called auxiliary harness. The Task Force did not consider that distinction need be made between cuffs, bands, corsets, etc.

The connection between the suspension and the prosthesis is a "joint" and if it is a strap or straps, it is indicated under the joint at the appropriate level as "flexible."

When the auxiliary suspension also accepts a work load additional to the forces required to suspend, the anatomical site of that load should be indicated. Suspension is therefore:

Pressure Differential (socket)
Body Contour (socket)
Auxiliary Thigh Bearing
 Ischial Bearing
 Arm Bearing
 Shoulder Bearing
 etc.

3. Force Distribution. This is a function of the interface but is described in the appropriate place under socket or auxiliary suspension.

The nature of the distribution will itself determine some of the character of the socket and auxiliary suspension, e.g., in a partial leg prosthesis, the presence of uniaxial joints and the need for thigh and ischial bearing require a full length corset or thigh lacer.

SYSTEMS AND MECHANISMS

1. Joints. Joints are described by the number of axes and the number of planes in which they move. There was some discussion about the use of "rigid" where no mechanical joint exists, but it was agreed that where there is no prosthetic mechanical joint at an anatomical joint level, this should be so described. Joints are therefore:

No motion at an anatomical joint level

Rigid

Motion in one plane

about one axis

Uniaxial

about multiple axes

Polycentric

Motion in two planes

about two axes

Dual axis

Motion in three planes

about finite axes

Multiaxial

about infinite axes

Flexible

2. Control Mechanisms. In the lower limb, descriptors from a, b, c, and d, below, will have to be given as required for both stance and swing phases. Since stance is usually a greater requirement than swing, this should be stated first.

- a. Plane and direction of movement (plane need not be stated)

Sagittal

Extension

Flexion

Coronal

Abduction

Adduction

Valgus

Varus

Axial

Internal rotation

External rotation

Pronation

Supination

Eversion

Inversion

Opposition

- b. Type of control mechanisms

Constant or

Intermittent and are:

Mechanical linkage

Hydraulic

Pneumatic

Electric

Other

The term "constant" is necessary to describe certain types of lower-limb swing phase controls and some upper-limb power actuators, etc. "Intermittent" indicates the reverse.

- c. Purpose of control mechanisms at each joint movement

Free

modified as required by

Assist

Variable

Resist

Lock

Stop

Hold

- d. Method of controlling mechanisms

Automatic

Biomechanical, Direct

Biomechanical, Transducer

Bioelectric

3. Power Source

None (e.g., passive terminal devices)

Body

Electric

Hydraulic

Mechanical

Hybrid

4. Alignment

Bench

Mechanical

Single

Integral

Dual

Removed

Bench alignment is always present and need not be specified. When an alignment device is used, it should have two descriptors to denote whether it is at a single site or is at both ends of a "body" segment. It

must also say whether it remains as an integral part or is removed at completion of fabrication.

5. Terminal Devices

Cosmetic

Functional

Hook or Special Tools

They may be:

Voluntary opening

Voluntary closing

Both

Neither

They may be:

Powered as above

Passive

MATERIALS.

The need to specify materials depends upon a number of factors. In prescription, it will depend upon the relative knowledge of the physician and prosthetist which varies greatly in the international field. It may also be necessary in some countries to give fabrication details to satisfy governmental specifications. Instructional and fabrication manuals will need far greater detail than are required in ordinary usage.

Terminology for materials can be in general terms or can be specific; it can be a description in general of a whole system or can be applied to a component, e.g., one can refer to a "wooden leg" or "a wooden foot," a "plastic arm" or a "plastic socket." There are three grades of specification: first, general terms; second, semispecific terms; and third, specific terms. The first and sometimes the second grades are usually sufficient for prescription or normal description. The third will be necessary in professional instruction and fabrication manuals. For this third grade of specification, the national or international description and standards should be used.

1. General

Wood

Leather

Metal

Webbing

Rubber

Plastic

etc.

are often sufficient to distinguish between comparable prostheses or prosthetic components which are made to a known specification once the major grade has been decided.

2. Semispecific

Willow

etc.

Box calf

Chamois

Block leather

etc.

Aluminum

Stainless Steel

etc.

Nylon webbing

Coutil

etc.

Silastic

Polypropylene

Polycarbonate

Glass fiber

etc.

These terms are rather more specific and are sometimes desirable in description and prescription.

3. Specific. When specific materials need to be detailed, there are specific terminologies which are in use either internationally or nationally. Most of these terminologies are also given specific mechanical standards, an exception being leather which has not yet been successfully standardized.

Each nation should use its own national specification first; if none is available, it should be the international standard; and if neither is available, it should choose from another nation's terminology.

Forms that have been proposed for use in the field trials are shown in Appendixes A and B.

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APPENDIX A

PROSTHETICS FORM/Upper Limb**PATIENT DATA**

Name _____ Age _____ Institution _____
 Address _____ Sex M/F _____ Record Number _____
 _____ Amputation Cause _____
 _____ Date of Amputation _____
 _____ Date of 1st Prosthesis _____

OCCUPATION

Work _____ Fee-Paying Agency _____
 Leisure _____ Physician _____
 1 _____ Prosthetist _____
 2 _____ Therapist _____
 3 _____

PROSTHETICS DATA**A. GENERAL**

Level _____ Side Rt/Lt _____
 Durability _____ Structure Endo/Exo Skeletal _____
 Material _____ Cosmetic Treatment _____

B. INTERFACE**SOCKET**

Type _____ Force Distribution _____

 Character _____ Material _____

SUSPENSION

Socket _____ Force Distribution _____
 Auxiliary _____ Material _____

C. SYSTEMS

JOINT TYPE	SHOULDER		ELBOW		WRIST	
	Control Intent	Mechanism	Control Intent	Mechanism	Control Intent	Mechanism
MOTION						
Flexion						
Extension						
Abduction						
Adduction						
Rotation In						
Rotation Out						
POWER						
Source						
Control						

D. TERMINAL DEVICES**HANDS**

	1	2	3	4	5
Cosmetic Passive					
Functional Power Source					
HOOKS, TOOLS, ETC.					
Passive					
Power and Source					

APPENDIX B

PROSTHETICS FORM/Lower Limb**PATIENT DATA**

Name _____ Age _____ Institution _____
 Address _____ Sex M/F _____ Record Number _____
 _____ Cause of Amputation _____
 _____ Date of Amputation _____
 _____ Date of 1st Prosthesis _____

PROSTHETICS DATA**A. General**

Level _____ Side Rt/Lt _____
 Durability _____ Structure Endo/Exo Skeletal _____
 Material _____ Cosmetic Treatment _____

B. INTERFACE**SOCKET**

Type _____ Force Distribution _____

 Character _____ Material _____

SUSPENSION

Socket _____ Force Distribution _____
 Auxiliary _____ Material _____

C. SYSTEMS**HIP****JOINT TYPE****STANCE****SWING**

MOTION	Control Intent	Mechanism	Control Intent	Mechanism
Flex				
Extend				
Abduct				
Adduct				
Rotate In				
Rotate Out				
POWER Source				
Control				

KNEE**JOINT TYPE****STANCE****SWING**

MOTION	Control Intent	Mechanism	Control Intent	Mechanism
Flex				
Extend				
Abduct				
Adduct				
Rotate In				
Rotate Out				
POWER Source				
Control				

ANKLE/FOOT**JOINT TYPE****STANCE****SWING**

MOTION	Control Intent	Mechanism	Control Intent	Mechanism
Flex				
Extend				
Abduct				
Adduct				
Rotate In				
Rotate Out				
POWER Source				
Control				

X-RAYS: A "FITTING TOOL" FOR THE PROSTHETIST¹

James L. Byers²

The purpose of this article is to demonstrate the usefulness of x-rays as a "fitting tool" for the prosthetist, i.e., as a means of checking fit of the prosthesis before completion of fabrication. The use of x-rays eliminates some questionable points that may arise at time about prosthesis fit, weight-bearing areas, trimlines, reliefs, etc., where conventional methods may fail or are not wholly satisfactory.

CONVENTIONAL METHODS OF CHECKING CONTACT BETWEEN PROSTHESIS AND PATIENT

To check for *total contact*, the prosthetist generally uses either a ball of clay or powder in the distal end of the socket. This method does show that the patient has *contact* on the distal end of his stump, but does not show that the patient has *total contact* around the periphery of the distal end of the stump.

After static alignment of the prosthesis has been established to the prosthetist's satisfaction, the prosthesis is removed, and visual inspection and palpation of the stump are employed to check for fit of the socket.

Marks made by either the cast or stump sock are reflected on the patient's stump. This method can sometimes be misleading because sock marks over the entire surface of his stump *do not* necessarily mean that *total contact* is present. With the sock stretched tightly over the stump and then placed into the prosthesis, the sock may, sometimes, reflect marks due to the tension in a snug fitting sock.

Weight-bearing areas will also reflect sock marks, but should show increased pressure by

some discoloration (i.e., redness) in these areas. However, in cases of obese patients or patients with redundant stump tissue, these areas have a tendency to move distally once the prosthesis has been removed. A prosthetist must rely on his judgment and experience to know when these areas are in the proper location when the check-out is made by visual inspection.

The mediolateral trimlines of the prosthesis are checked while the patient bears weight on the prosthesis and while sitting with the knee flexed to 90 deg. The mediolateral and anterior trimlines are checked by palpation of the stump around the proximal border of the socket to determine the degree of fit with respect to the femoral condyles, the patellar, and the popliteal areas. With obese patients, it is sometimes difficult to palpate these areas, a condition that limits the reliability of the technique.

The relationship of the patellar-tendon protuberance to the posterior trim is checked after the prosthesis has been removed. Again, this depends on the prosthetist's experience and judgment.

PROCEDURE

The x-rays are taken using the standard knee technique and taken for soft tissue. The same procedure is also used for other levels of amputations. X-rays are taken at the initial fitting after static and dynamic alignment have been completed and the patient is comfortable. At this point, the information provided by the x-rays is most useful to the prosthetist. After examination of the x-rays, adjustments are made to the prosthesis. When problems arise, they are reviewed and discussed with the clinic chief and appropriate remedial measures are taken. Generally, two weight-bearing views of the stump-socket relationship are taken: anteroposterior and lateral (Figs. 1 and 2). If necessary, a third view is taken while the patient is sitting.

¹This work was performed with fiscal support under Veterans Administration Contract V663P-656.

²Chief of Prosthetics and Orthotics, Prosthetics Research Study, 1102 Columbia Street, Room 409, Seattle, Wash. 98104.

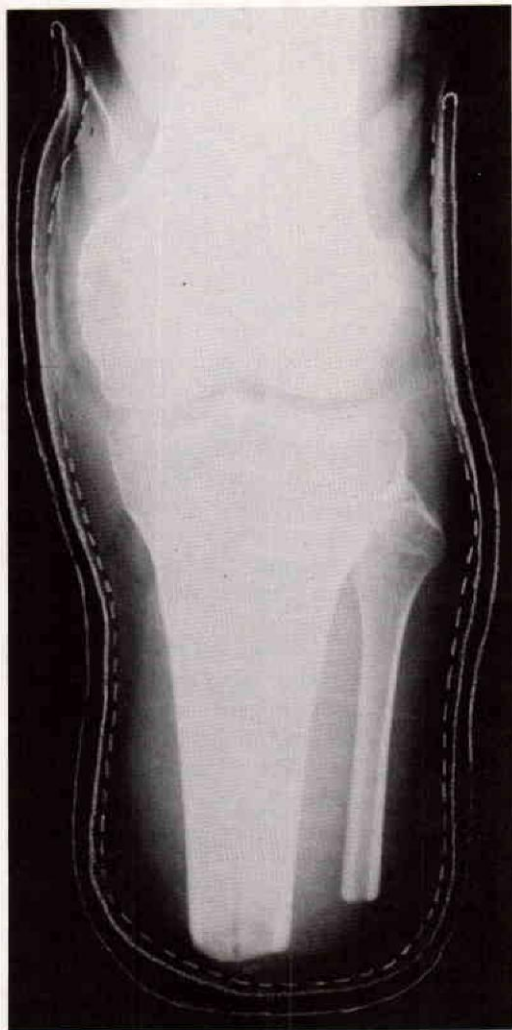


Fig. 1. Anteroposterior view reflects mediolateral relationship of stump to socket, X-ray is outlined for clarity of interfacing and socket shell.

ANTEROPosterior VIEW (Fig. 1)

The proximal mediolateral trimlines are checked for adequate height and fit around the femoral condyles.

The mediotibial flare is checked for adequacy and location of the mediotibial shelf.

The adequacy of relief for the head of the fibula, the distal end of the fibula, and the shaft of the fibula are checked.

The distal end of the stump is checked for *total contact*. (The distal *total contact* is also checked from the lateral view.)

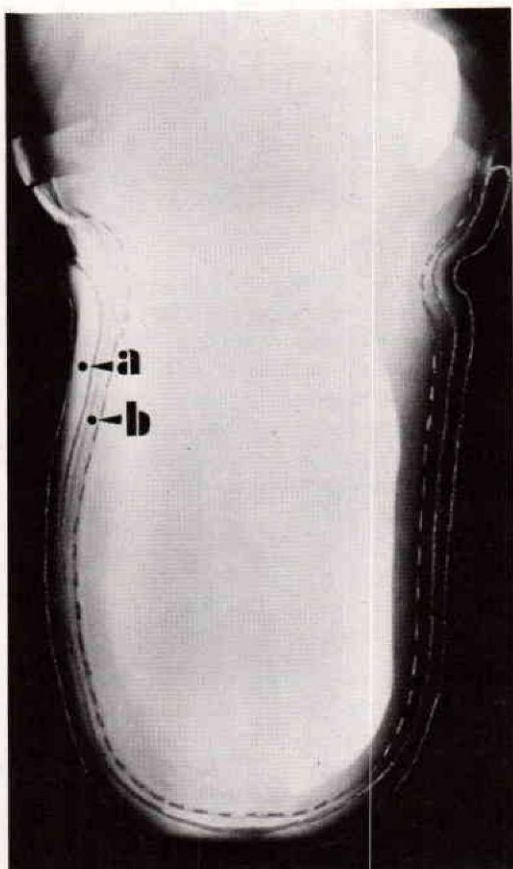


Fig. 2. Lateral view has also been outlined for clarity. (a) Area between the two solid lines represents socket shell. (b) Area between dotted line and solid line represents "Cordo" interfacing.

LATERAL VIEW (Figs. 2, 3, and 4)

The location and adequacy of fit in the area of the patellar-tendon protuberance is determined. At the same time, the posterior brim is checked for height and amount of flare in relationship to the patellar-tendon protuberance.

Relief of tibial tubercle is checked.

The flexion angle of the socket is checked.

The overall fit of the prosthesis for peripheral contact is assessed.

The distal end of the stump is viewed again for *total contact*.

Figure 3 is a lateral view of a condition where the patellar-tendon bar is located too far distally and a lack of total contact in the region of the anterodistal tibia.

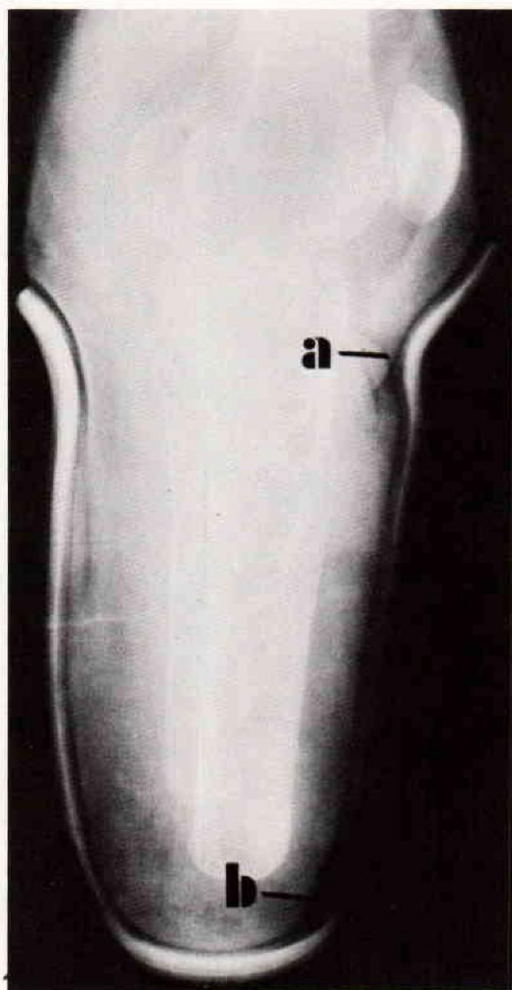


Fig. 3. Lateral view.

- (a) Improper location of patellar-tendon protuberance. It should be located inferior to the patella at the level of the tibial plateau.
- (b) Total contact not maintained at the anteroposterior tibia.

Figure 4 is a lateral view of a Syme's prosthesis and stump where total contact has not been achieved.

LATERAL VIEW IN SITTING POSITION (Optional)

Proximal displacement of the stump in the prosthesis is related to the configuration of the posterior brim of the socket; when the brim is not of the proper height, the displacement will be either inadequate or excessive. The fare of the posterior brim should be rounded so as not to cut

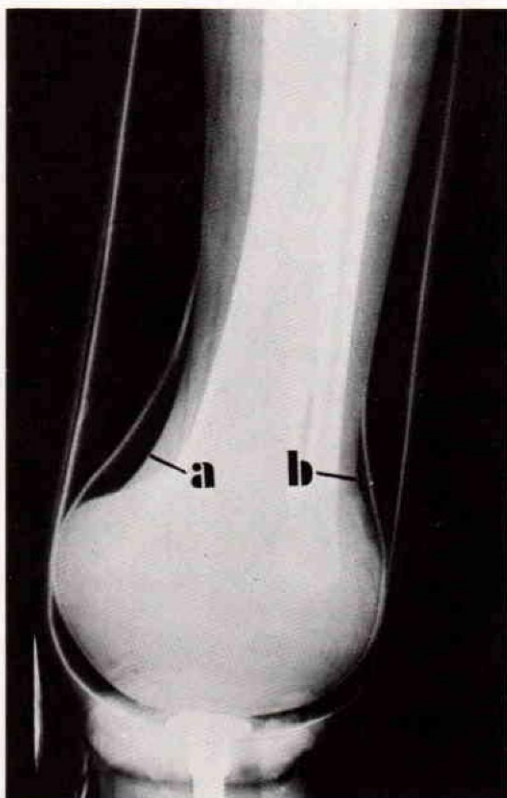


Fig. 4. Closed Syme's prosthesis; a and b illustrate medial and lateral areas that have not maintained total contact under weight-bearing conditions.

into the hamstrings or cause excessive displacement of the stump in the socket.

The location of the patellar-tendon protuberance in relationship to the tibial tubercle is examined to make certain there is adequate relief. This view is used only if doubts about the fitting have been raised by the other x-rays.

The more conventional modes of prosthetics checkout should not be disregarded; but, under proper supervision, x-rays can be a valuable "fitting tool" for the prosthetist assuring him that the patient is given the most effective fit available in prosthetics service.

ACKNOWLEDGMENT

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THE PRESENT USE OF THE UCBL FOOT ORTHOSIS

Michael J. Quigley, C.P.O.¹

In August 1971, the Committee on Prosthetics Research and Development (CPRD) of the National Research Council completed an evaluation of four lower-limb orthoses. They were the VAPC Single-Bar Knee-Ankle-Foot Orthosis (KAFO), the UCBL Dual Axis Ankle-Foot Orthosis (AFO), the New York University Insert Ankle-Foot Orthosis, and the UCBL Shoe Insert Foot Orthosis (FO) (Figs. 1 and 2). The latter two orthoses were considered to be valuable additions to patient services, and it was recommended that they be included in orthotics education programs (2).

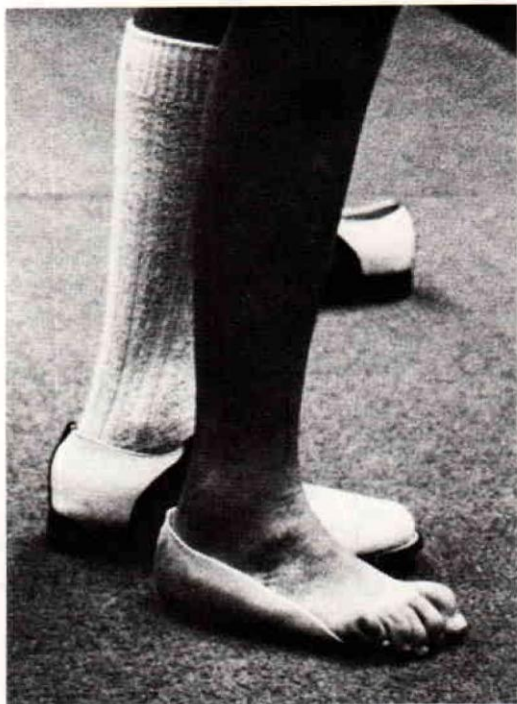


Fig. 1. The UCBL foot orthosis.

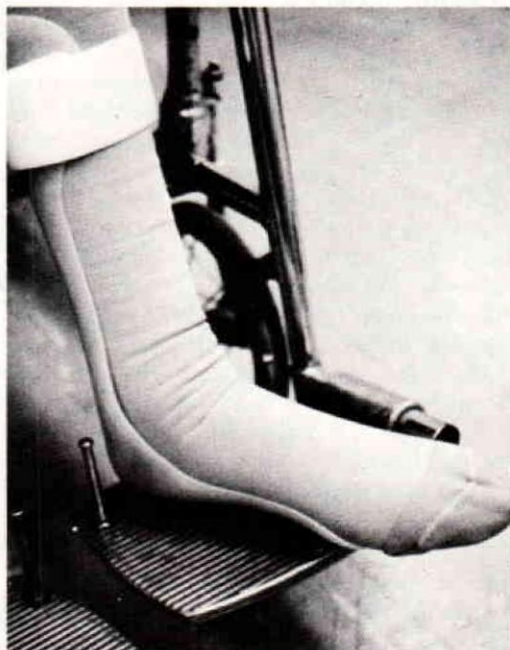


Fig. 2. Principles of the UCBL foot orthosis applied to the foot section of a polypropylene ankle-foot orthosis.

To determine the acceptance of the UCBL shoe insert foot orthosis, how the technique was learned, and something about the experiences in the field, a limited survey was conducted. Thirty-five certified orthotics and prosthetics-orthotics facilities were selected randomly from the 1974 *Registry of Accredited Facilities* (1). This represented an equal distribution of practitioners from twenty cities. The questionnaires (Appendix A) consisted of a section to be completed by the physician and a section to be completed by the orthotist. The orthotist was requested to forward the questionnaire to the physician after his section was completed. The questionnaires were sent out in January 1974. By March 1974, twenty-nine of the forms were re-

¹Staff Prosthetist/Orthotist, Committee on Prosthetics Research and Development, National Academy of Sciences, Washington, D. C. 20418.

turned. The following information was taken from these forms.

The UCBL foot orthosis was used by 75 percent [21] of the surveyed practitioners. However, only seven of the twenty-one practitioners who use this orthosis do so regularly. Of the remaining fourteen respondents, five use the orthosis only when it is requested by a certain physician, five rarely use it, two use it for special conditions only, and one stated he uses the orthosis only as a last resort.

An attempt was made to determine how the practitioners were made aware of the UCBL foot orthosis. The literature rated as the most common source of information. Articles on the UCBL foot orthosis appeared in the *Bulletin of Prosthetics Research* (3) in September 1969 and in *Orthotics and Prosthetics* (4) in March 1972. In addition, New York University published an evaluation report (5) on the orthosis in 1969. The prosthetics-orthotics education courses were the second most common source of information on the subject. Word of mouth rated as the third main channel of communications, since some respondents stated that orthotists, podiatrists, etc., had informed them of the technique.

PRESCRIPTION CONSIDERATION

Eight areas considered to influence the prescription and use of the UCBL foot orthosis were covered in the questionnaire. The most common prescription was bilateral orthoses for a patient 25-40 years old with pes planus.

The pathologies most commonly treated with the UCBL foot orthosis are pes planus and arthritis. Following these, in order of frequency, are plantar fasciitis, metatarsalgia, polio, cerebral palsy and peroneal palsy.

Respondents indicated that the orthosis is used equally on males and females and is fitted bilaterally the vast majority of the time. The age groups that use the UCBL foot orthosis most often are between 1-12 years of age and between 25-40 years of age.

The major disadvantage of using this orthosis is the expense, a fact that was underscored by half of the respondents. The other disadvantages checked off by the practitioners are that a wider shoe is sometimes needed, that the orthosis slips up and down in the shoe, and that breakage occurs. Two practitioners felt the orthosis is difficult to fit.

The major advantages of using this orthosis is that it provides proper foot support, allows the patient to change shoes, eliminates shoe modifications and the need for orthopedic shoes. The practitioners also felt that the UCBL foot orthosis provides improved cosmesis and gives consistent relief from pain.

Most of the respondents indicated that the orthosis usually lasts longer than a year before replacement is necessary, although a few practitioners stated that it only lasts up to one year. The major reason that the UCBL foot orthosis needs replacement is a loss of fit with time. Breakage is the second most common reason replacement was needed. One practitioner stated that he replaces the orthoses in cases when he wants to increase progressively the amount of foot correction.

CASTING, FABRICATION AND FITTING

This part of the survey was structured to determine if the original technique is still practiced, what materials and methods are presently used for fabrication, fitting problems encountered and solutions to these problems.

Nearly every practitioner stated that he uses the same method of wrapping to obtain the mold as was described originally in the literature. Manual alignment of the foot and ankle is practiced by all respondents, as is the use of the contoured casting boards for positioning the patient. One-quarter of the orthotists use standard plaster bandage rather than the elastic type originally recommended, and one-third of the orthotists no longer use the balloon method for casting.

Polyester resin is used exclusively by eight of the orthotists, four use both polyester resin and polypropylene, five use polypropylene exclusively, one uses polyethylene and one uses acrylic.

It is interesting that of the seven practitioners that had breakage problems, six use polyester resin for fabrication and one uses polyethylene. None of the orthotists that utilize polypropylene exclusively mentioned breakage problems.

The most common fitting problem is pain at the location of the navicular (scaphoid) bone, which is located medially at the apex of the arch of the foot. Shoes being too tight when the orthosis is worn is the next most common problem, followed by pistoning of the foot in the shoe, and difficul-

ties in establishing the trimline at the metatarsal area. One practitioner stated that he has his patients acquire a pair of shoes that will accommodate the orthosis.

None of the orthotists do any shoe modifications in addition to using the UCBL foot orthosis.

Six orthotists consistently modify the foot orthosis. Wedges and metatarsal relief pads are added by two practitioners. One orthotist uses Spenco² buildups, presumably for better weight distribution and reduction of shear stresses. Another adds a Velcro strap over the dorsum of the foot to prevent the foot from pistoning. To decrease the sliding of the foot orthosis on the insole of the shoe, one orthotist lines the bottom surface of the orthosis with moleskin or thin non-skid rubber.

DISCUSSION

The UCBL foot orthosis was first publicized in September 1969, and introduced in the education programs in late 1971. The fact that 75 percent of the surveyed practitioners had used the orthosis by January 1974 is a testimony to the speed that proven research in this field is applied to the

patient. Probably no other medical or paramedical specialty can realize these patient benefits from research only four and one-half years after the initial introduction of a technique.

The utilization of this orthosis may decrease in the future as thermoplastic, thermoformed lower-limb orthoses gain acceptance. However, the UCBL foot alignment principles still apply to the foot section of thermoplastic ankle-foot orthoses and knee-ankle-foot orthoses, and should be used whenever possible.

REFERENCES

1. American Board for Certification in Orthotics & Prosthetics, Inc., *1974 Registry of Accredited Facilities and Certified Individuals in Orthotics and Prosthetics*, Washington, D.C., 1974.
2. Committee on Prosthetics Research and Development, *A Clinical Evaluation of Four Lower-Limb Orthoses*, National Academy of Sciences, Washington, D.C., 1971.
3. Henderson, W. H., and J. W. Campbell, UC-BL shoe insert: casting and fabrication. *Bull. Pros. Res.* **10-11**:215-235, Spring 1969.
4. LeBlanc, Maurice A., A clinical evaluation of four lower-limb orthoses. *Orth. and Pros.* **26**:1:27-47, March 1972.
5. Mereday, C., C.M.E. Dolan, and R. Lusskin, *Evaluation of the UCBL Shoe Insert in "Flexible" Pes Planus*. New York University, September 1969.

²A foam rubber that is impregnated with nitrogen bubbles.

**COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT
DIVISION OF MEDICAL SCIENCES—NATIONAL RESEARCH COUNCIL**

**FOLLOW-UP SURVEY OF THE
UCBL SHOE INSERT ORTHOSIS EVALUATION**

Name of Clinic _____

Name of Physician _____

Name of Orthotist _____

I. Clinical Application

A. How often is this orthosis used in your clinic?

- _____ 1) Used regularly
- _____ 2) Used only for special conditions as a last resort
- _____ 3) Used only when requested by a certain physician
- _____ 4) Used for one specific problem only
- _____ 5) Rarely used
- _____ 6) Never used

B. Why did your clinic decide to use this orthosis?

- _____ 1) Involved in research or evaluation of the orthosis initially
- _____ 2) Informed through literature
- _____ 3) Informed through courses
- _____ 4) Informed from other source. Source: _____

II. Prescription Considerations

A. Which of the following pathologies are most commonly treated with this orthosis? Check all that apply.

- | | |
|---------------------------|-------------------------|
| _____ arthritis | _____ polio |
| _____ flat feet | _____ peroneal palsy |
| _____ metatarsalgia | _____ plantar fasciitis |
| _____ other, define _____ | |

Comments: _____

B. Is this more commonly used on males or females?

_____ males _____ females _____ equal usage

C. Is this orthosis more often used unilaterally or bilaterally?

_____ Unilaterally _____ Bilaterally _____ Equal Usage

D. What age group uses the orthosis most often?

_____ 1-12 _____ 25-40 _____ over 60
 _____ 12-25 _____ 40-60

Comments: _____

E. What are the main disadvantages to this orthosis?

- | | |
|---------------------------------|---------------------------------|
| _____ difficult to fit properly | _____ expensive |
| _____ not cosmetic | _____ difficult to fabricate |
| _____ perspiration problems | _____ becomes loose with wear |
| _____ wider shoe needed | _____ breakage |
| _____ doesn't relieve pain | _____ slips up and down in shoe |

Comments: _____

F. What are the main advantages to this orthosis?

- | | |
|---|--|
| <input type="checkbox"/> easy to fit | <input type="checkbox"/> consistent pain relief |
| <input type="checkbox"/> cosmetic | <input type="checkbox"/> proper foot support |
| <input type="checkbox"/> ability to change shoes | <input type="checkbox"/> light weight |
| <input type="checkbox"/> orthopedic shoes not necessary | <input type="checkbox"/> eliminates shoe modifications |

Comments: _____

G. How long does this orthosis wear before replacement is necessary?

- | | |
|---|---------------------------------------|
| <input type="checkbox"/> up to 3 months | <input type="checkbox"/> up to 1 year |
| <input type="checkbox"/> up to 6 months | <input type="checkbox"/> over 1 year |

H. What is the most common reason the orthosis needs replacement?

- | | |
|--|---|
| <input type="checkbox"/> breakage | <input type="checkbox"/> pain reoccurs |
| <input type="checkbox"/> loss of fit with time | <input type="checkbox"/> other; explain _____ |

Name of Orthotist _____

III. Casting, Fabrication and Fitting

A. The instruction manual for the orthosis described a specific method of wrapping the cast:

- (1) Do you use this method? Yes _____ No _____

If no, why? _____

- (2) What bandage do you use? Elastic _____ Standard _____

- (3) Do you use the balloon method? Yes _____ No _____

B. Do you manually align the foot/ankle during casting? Yes _____ No _____

C. Do you use the casting boards to stand the patient on after casting?

Yes _____ No _____

If no, why? _____

D. What materials do you use in fabrication:

- | | | |
|--|--|--------------------------------|
| <input type="checkbox"/> polyester resin | <input type="checkbox"/> polypropylene | <input type="checkbox"/> other |
| <input type="checkbox"/> acrylic | <input type="checkbox"/> polyethylene | |

E. Do you use vacuum forming for this or any other fabrication techniques?

Yes _____ No _____

F. What is the most common fitting problem?

- | | |
|--|---|
| <input type="checkbox"/> metatarsal trimline | <input type="checkbox"/> up and down motion in shoe |
| <input type="checkbox"/> navicular (scaphoid) pain | <input type="checkbox"/> shoe too tight |
| <input type="checkbox"/> other; explain _____ | |

G. Do you modify the shoes in addition to using the UCBL insert orthosis?

Yes _____ No _____

If yes, for what reason? _____

H. Do you add wedges or other modifications to the insert? Yes _____ No _____

If yes, for what reason? _____

I. Do you have any other consistent modifications on the insert?

Example: Extending it over the instep to prevent slippage between insert and foot. Yes _____ No _____

If yes, explain _____

What methods do you use to aid similar problems if you do not use the UCBL shoe orthosis?

- | | | |
|--|--|--|
| <input type="checkbox"/> heel wedging | <input type="checkbox"/> metatarsal bars | <input type="checkbox"/> metatarsal pads |
| <input type="checkbox"/> scaphoid pads | <input type="checkbox"/> Thomas heels | <input type="checkbox"/> shoe plates |
| <input type="checkbox"/> others; explain _____ | | |

NEW PUBLICATIONS

PROCEEDINGS, FIRST INTERNATIONAL CONGRESS ON PROSTHETICS TECHNIQUES AND FUNCTIONAL REHABILITATION, sponsored by the World Veterans Federation, with the cooperation of the International Society for Prosthetics and Orthotics, March 19-24, 1973, Vienna, Austria, 4 Volumes, 1157 pp., 300 Austrian Schillings. Available from Weiner Medizinische Akademie, Stadiongasse 6-8, A1010 Vienna, Austria.

This report contains more than 200 papers presented at the First International Congress on Prosthetics Techniques and Functional Rehabilitation. Although the papers are short, averaging about five pages each, and most, therefore, do not go into detail, nearly every aspect of research and practice in limb prosthetics and orthotics is touched upon. Most of the presentations are concerned with prosthetics, and are in English, although a few are in German and French. Although few of the articles are well illustrated, this 4-volume publication is an excellent reference source and should be available to everyone involved in research in prosthetics and orthotics. It will be also of tremendous interest to clinicians who want to keep up to date by introducing into their practice the latest findings from research.

COMPREHENSIVE MANAGEMENT OF MUSCULOSKELETAL DISORDERS IN HEMOPHILIA, (Report of) A Symposium held in Miami Beach, Florida, October 12-14, 1972; edited by Newton C. McCollough, III, Committee on Prosthetics Research and Development, National Academy of Sciences, Washington, D.C., U.S.A., 214 pp, \$6.25.

This book contains the lectures and following discussions which were given during a symposium about the methods of treating musculoskeletal disorders in hemophilia.

The result is a rather complete synopsis of the present level of knowledge in the problems of hemophilia. Besides a lucid and understandable representation of questions concerning

pathogenesis and pathological physiology, the authors have clinical problems primarily in view, and therefore concentrate on the possibilities and necessities for provision of orthoses for the hemophilic patient. Furthermore, the authors describe the possibilities of surgical proceedings in case of deformities and severe arthrosis deformans occurring because of intra-articular bleeding. It also refers to synovectomy when conservative treatment has failed.

In conclusion, one finds directions of management which are valuable in case of planning a hemophilia center. The actual problems are clearly described in this book, and while reading the papers thoroughly, one can find multiple impulses for further research in this field.

F. Koch (Heidelberg)

ADVANCES IN EXTERNAL CONTROL OF HUMAN EXTREMITIES, Proceedings of the Fourth International Symposium on External Control of Human Extremities, Dubrovnik, August 28-September 2, 1972; Edited by Momčilo M. Gavrilović and A. Bennett Wilson, Jr., Yugoslav Committee for Electronics and Automation (ETAN), Belgrade, Yugoslavia, 803 pp. \$20.

As indicated in the title, this massive volume is composed of the papers presented at the Fourth International Symposium on External Control of Human Extremities. This series of symposia continues to attract more and more workers throughout the world who are engaged in research and development concerning externally powered prostheses and orthoses and related work such as the stimulation of denervated muscle for function. This is not a book that most clinicians will want to do more than peruse, but it is a publication that all people involved in rehabilitation engineering research and development should have because it contains information concerning nearly every past and present project in the field of externally powered prostheses and orthoses, plus a great deal more in allied areas.

THE CARE OF THE RHEUMATOID HAND, Third Edition, by Adrian Flatt, The C. V. Mosby Co., St. Louis, 1974, 296 pp., \$24.75.

The third edition of "The Care of the Rheumatoid Hand" is a rather major revision of the second edition of this definitive text on the rheumatoid upper limb which was published in 1968.

REHABILITATION AFTER CENTRAL NERVOUS SYSTEM TRAUMA, edited by Harry Boström, Tage Larsson, and Nils Ljungstedt, Nordiska Bokhandels Förlag, Stockholm, 255 pp., 1974.

This book is a report of an international symposium sponsored in 1973 by the Skandia Group. Fifteen papers, and ensuing discussion, on various aspects of rehabilitation of individuals suffering from central nervous system disorders are included.

1974 CONFERENCE ON ENGINEERING DEVICES IN REHABILITATION, Biomedical Engineering Center, Tufts University, Boston, Massachusetts, Richard A. Foulds and Brenda L. Lund, eds., 150 pp., \$20.

This is a collection of 36 papers given at the 1974 Conference on Engineering Devices in Rehabilitation, held May 2-3, and sponsored by the Biomedical Engineering Center, Tufts-New England Medical Center, Medical Rehabilitation Research and Training Center, Tufts University, the Department of Physical and Rehabilitation Medicine, Tufts University, and the Rehabilitation Institute of the New England Medical Center Hospital. Included are papers on "Sensory Impairment," "Blindness and Low Vision," "Telephone Aids," "Sensory Control and Feedback," "Locomotion and Mobility," "Innovative Programs," and "Deafness." Because the papers were presented voluntarily, this report by no means covers the fields.

Nevertheless, some relatively new concepts are offered in this well-edited and nicely presented publication, and though the price seems excessive, it should be included in every library collection on rehabilitation research.

BULLETIN OF PROSTHETICS RESEARCH, FALL 1973, (BPR 10-20), U.S. Veterans Administration, 390 pp., 190 illus., available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; \$3.15 (payable in advance).

Featured in This Issue:

"The More Things Change, the More They Stay the Same"—T. J. Radley

Displacement Sensors and Their Application to Control of Synthetically Powered Prostheses and Orthoses—C. H. Hoshall

Experimental Evaluation of Wheelchair Cushions: Report of a Pilot Study—G. V. B. Cochran and G. Slater

Swivel Walkers for Paraplegics—Considerations and Problems in Their Design and Application—G. K. Rose and J. T. Henshaw

Functional Electrical Stimulation—A New Hope for Paraplegic Patients?—A. Kralj and S. Grobelnik

Transferring Load to Flesh—Part VI. Socket Brim Radius Effects—L. Bennett

A Method of Recording Pressure Distribution Under the Sole of the Foot—P. Lereim and F. Serck-Hanssen

The Extra-Ambulatory Limb Concept as it Applies to the Below-Knee Amputee Skier—J. M. Graves and E. M. Burgess

Bioengineering Design and Development of Lower-Extremity Orthotic Devices—H. R. Lehnis, W. Frisina, H. W. Marx, and Tamara T. Sowell

Semiflexible Body Jacket with Inflatable Pads—J. M. Morris, K. L. Markolf, and H. Hittenberger

Abstract of a Summary Report on Research and Development in the Field of Artificial Limbs (July 1973)—H. A. Mauch

Abstract of a Summary Report on the Development of a Reading Machine for the Blind (July 1973)—G. C. Smith and H. A. Mauch

Committee on Prosthetics Research and Development, Committee on Prosthetic-Orthotic Education, Division of Medical Sciences—National Research Council, National Academy of Sciences—National Academy of Engineering, Annual Summary Report Activities for Year Ended June 30, 1973

VA Prosthetics Center Research Report—A.
Staros and E. Peizer

Highlights of Other VA Research Programs
Prosthetics—Edited by E. F. Murphy
Sensory Aids—Edited by H. Freiburger

Related Items of Interest

How to Purchase Previous Issues:

Still available for purchase from the Superintendent of Documents are:

- BPR 10-13 Spring 1970 at \$1.50 each
- BPR 10-14 Fall 1970 at \$1.25 each
- BPR 10-17 Spring 1972 at \$1.25 each
- BPR 10-18 Fall 1972 at \$2.35 each
- BPR 10-19 Spring 1973 at \$2.05 each

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THE MANAGEMENT OF MUSCULO-SKELETAL PROBLEMS IN THE HAEMOPHILIAS, by R. B. Duthie, J. M. Matthews, C. R. Rizza, and W. M. Steel, Blackwell Scientific Publications, Osney Mead, Oxford OX2 OEL, England, 179 pp. £ 5. [In the U.S. and Canada, order from J. B. Lippincott Company, P.O. Box 7, Philadelphia, Pennsylvania 19105, \$20.00]

The "bleeding" disease has been disastrous to dynasties. It can also be disastrous to families. For most sufferers in developed countries, the fear of bleeding to death from minor trauma has

been largely removed by the treatments developed over the past forty years. The fear of progressive and disastrous crippling has remained and indeed becomes greater with the survival into adult life. The proper use of blood derivatives which are now available should now prevent severe musculoskeletal complications in all but exceptional circumstances. This needs constant supervision and skilled care.

A recent survey (1972) by the U.S. National Heart and Lung Institute showed that there are approximately 25,500 moderate to severe haemophiliacs in the United States. An estimated 10,800 physicians were treating these patients of whom over 60 percent had only one patient.

Other countries may have better management than this; but until all sufferers from haemophilia are under expert care, it will remain a gross crippling disease.

Oxford has been in the forefront of research into the cause and care of these diseases. This book is a distillate of their experience of the management of musculoskeletal sequelae in over 1,000 patients.

The first three chapters review the etiology and medical management. Following chapters discuss the management of acute episodes such as bleeding into joints, muscles, nerves and the management of fractures. A chapter on cysts and pseudotumors provides a bridge between the acute and chronic. Chapters on chronic arthropathy and reconstructive surgery follow. Finally, there is a chapter on physiotherapy.

There will be minor differences of opinion about some aspects of treatment such as the use or abuse of blood derivatives in long-term prophylaxis, particularly self-administered in the home. There are those who would not agree with the policy of aspiration of haemarthrosis.

There is no reference to orthotics principles, either of a temporary or permanent material or for intermittent or prolonged use. The index gives two references to calipers and a number of references to splints, but the text gives no detail of fit or structure.

The layout and printing are of high quality. The illustrations are well reproduced and opposite to the text. The uninformed should not be treating haemophilia. The informed will find much in this book to supplement their knowledge, and it will surely find a place in their libraries.

E. E. Harris, M.R.C.S.

PUBLICATIONS AVAILABLE FROM CPRD/CPOE

The following is a partial list of reports of workshops, symposia, etc., sponsored by the Committees on Prosthetics Research and Development and Prosthetic-Orthotic Education (CPRD-CPOE), National Academy of Sciences—National Research Council, which are currently available.

Individual copies of these reports are available as long as the supply lasts without charge unless otherwise indicated. Address requests to Committee on Prosthetics Research and Development, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

Annual summary report, activities for year ending June 30, 1973, Committee on Prosthetics Research and Development, National Academy of Sciences.

Below-knee and above-knee prostheses, report of a workshop held January 27-29, 1973, in Seattle, Washington.

Below-knee prosthetics, report of a symposium held December 16-18, 1968, in New York City.

Bracing of children with paraplegia resulting from spina bifida and cerebral palsy, report of a workshop held October 2-4, 1969, in Charlottesville, Virginia.

The cane as a mobility aid for the blind, report of a conference held September 10-11, 1971, Washington, D.C.

Cast-bracing of fractures, report of a workshop held January 27-28, 1971, in Denver, Colorado.

The child with an acquired amputation, report of a symposium held June 9-11, 1970, in Toronto, Ontario, Canada. Available from: National Academy of Sciences, Printing and Publishing Office, 2101 Constitution Avenue, N. W., Washington, D. C. 20418. Price \$5.50.

Clinical evaluation of the Ljubljana functional electrical peroneal brace, Report E-7, 1973.

Clinical evaluation of a comprehensive approach to below-knee orthotics, Report E-6, 1972.

Comprehensive management of musculoskeletal disorders in hemophilia, report of a symposium held October 12-14, 1972, in Miami Beach, Florida. Available from: National Academy of Sciences, Printing and Publishing Office, 2101 Constitution Avenue, N. W., Washington, D.C. 20418. Price \$6.25.

Cosmesis and modular limb prostheses, a report of a conference held March 3-7, 1971, in San Francisco, California.

The effect of pressure on soft tissues, a report on a workshop held September 21-22, 1971, in Houston, Texas.

Eighth workshop panel on lower-extremity prosthetics fitting of the Subcommittee on Design and Development, December 14, 1964, Miami Beach, Florida.

Evaluation of sensory aids for the visually handicapped, a report on a conference held November 11-12, 1971, in Washington, D.C.

Evaluation of synthetic balata for fabricating sockets for below-knee amputation stumps, Report E-3, 1970.

Functional neuromuscular stimulation, report of a workshop held April 27-28, 1972, at Bethesda, Maryland.

The geriatric amputee: principles of management, proceedings of a workshop held June 9-10, 1969, in Washington, D.C. Available from: National Academy of Sciences, Printing and Publishing Office, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. Price \$3.50.

Internal structural prostheses, report of a workshop held April 13-15, 1972 in Charlottesville, Virginia.

A preliminary evaluation of the Bionic Instruments—Veterans Administration, September 1973.

Pressure and force measurement, report of a workshop held May 27-28, 1968, in New York City.

Rehabilitation engineering: a plan for continued progress, April 1971, Washington, D.C.

Selected lower-limb anomalies—surgical and prosthetics management, report of a symposium held May 8-9, 1969, in Washington, D. C. Available from National Academy of Sciences, Printing and Publishing Office. 2101 Constitution Avenue, N.W., Washington, D.C., 20418. Price \$2.95.

Seventh workshop panel on lower-extremity orthotics of the Subcommittee of Design and Development, March 9-12, 1970, Downey, California.

Seventh workshop panel on upper-extremity prosthetics of the Subcommittee on Design and Development, Externally Powered Terminal Devices July 30-31, 1969, Santa Monica, California.

Spinal orthotics, report of a workshop held March 28-29, 1969, in San Francisco, California.

The Veterans Administration Prosthetics Center patellar-tendon-bearing brace-clinical applications, Report E-2, 1970.

Workshop on knee-disarticulation prosthetics of the Subcommittee on Design and Development, held June 22-23, 1970, San Francisco, California.

INFORMATION FOR AUTHORS
ORTHOTICS AND PROSTHETICS
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2. **BIBLIOGRAPHY.** This should be arranged alphabetically and cover only references made in the body of the text.
3. **LEGENDS.** List all illustration legends in order, and number to agree with illustrations.
4. **ILLUSTRATIONS.** Provide any or all of the following:
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 - b. Original drawings or charts
 Do not submit:
 - a. Slides (colored or black & white)
 - b. Photocopies

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1. Manuscripts must be **TYPEWRITTEN, DOUBLE-SPACED** and have **WIDE MARGINS**.
2. Indicate **FOOTNOTES** by means of standard symbols (*).
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4. Write out numbers less than ten.
5. Do not number subheadings.
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2. On the back indicate the top of each photo or chart.
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- Authors will be supplied with 25 reprints.

RESOLUTION CONCERNING THE METRIC SYSTEM

The following resolution was adopted by the Board of Directors of the American Orthotic and Prosthetic Association at its meeting in San Diego October 3, 1973:

WHEREAS by Act of Congress it has been determined that the United States should proceed towards adoption of the metric system as used almost universally throughout the rest of the world, and

WHEREAS the technological professions and many segments of the health professions have commonly used the metric system over an extended period of time, and

WHEREAS it is important for members of the orthotic/prosthetic professions to interact with their colleagues in the medical and technological communities for optimum patient service be it hereby

RESOLVED that the American Orthotic and Prosthetic Association endorses the use of the metric system by its members and other orthotic and prosthetic practitioners in the United States, and in witness of this endorsement and Association urges the editors of its journal *Orthotics and Prosthetics* to commence the dual reporting of weights and measurements in both the English and metric systems at the earliest possible date with the objective of employing the metric system solely by the time of the 29th Volume in 1975.

METRIC SYSTEM Conversion Factors

LENGTH

Equivalencies

angstrom	= 1×10^{-10} meter (0.0 000 000 001 m)
millimicron*	= 1×10^{-9} meter (0.000 000 001 m)
micron (micrometer)	= 1×10^{-6} meter (0.000 001 m)

To Convert from	To	Multiply by
inches	meters	0.0254†
feet	meters	0.30480†
yards	meters	0.91440†
miles	kilometers	1.6093

AREA

To convert from

square inches	square meters	0.00063616†
square feet	square meters	.092903

VOLUME

Definition

1 liter = 0.001† cubic meter or one cubic decimeter (dm^3)
(1 milliliter = 1† cubic centimeter)

To convert from	To	Multiply by
cubic inches	cubic centimeters	16.387
ounces (U.S. fluid)	cubic centimeters	29.574
ounces (Brit. fluid)	cubic centimeters	28.413
pints (U.S. fluid)	cubic centimeters	473.18
pints (Brit. fluid)	cubic centimeters	568.26
cubic feet	cubic meters	0.028317

MASS

To convert from	To	Multiply by
pounds (avdp.)	kilograms	0.45359
slugs‡	kilograms	14.594

FORCE

To convert from	To	Multiply by
ounces-force (ozf)	newtons	0.27802
ounces-force (ozf)	kilogram-force	0.028350
pounds-force (lbf)	newtons	4.4732
pounds-force (lbf)	kilogram-force	0.45359

*This double-prefix usage is not desirable. This unit is actually a nanometer (10^{-9} meter = 10^{-7} centimeter).

† For practical purposes all subsequent digits are zeros.

‡ For practical purposes all subsequent digits are zeros.

STRESS (OR PRESSURE)

To convert from	To	Multiply by
pounds-force/square inch (psi)	newton/square meter	6894.8
pounds-force/square inch (psi)	newton/square centimeter	0.68948
pounds-force/square inch (psi)	kilogram-force/square centimeter	0.070307

TORQUE (OR MOMENT)

To convert from	To	Multiply by
pound-force-feet	newton meter	1.3559
pound-force-feet	kilogram-force meters	0.13826

ENERGY (OR WORK)**Definition**

One joule (J) is the work done by a one-newton force moving through a displacement of one meter in the direction of the force.

$$1 \text{ cal (gm)} = 4.1840 \text{ joules}$$

To convert from	To	Multiply by
foot-pounds-force	joules	1.3559
foot-pounds-force	meter-kilogram-force	0.13826
ergs	joules	$1 \times 10^{-7} \dagger$
b.t.u.	cal (gm)	252.00
foot-pounds-force	cal (gm)	0.32405

TEMPERATURE CONVERSION TABLE

$$\text{To convert } ^\circ\text{F to } ^\circ\text{C} \quad ^\circ\text{C} = \frac{^\circ\text{F} - 32}{1.8}$$

$^\circ\text{F}$	$^\circ\text{C}$
98.6	37
99	37.2
99.5	37.5
100	37.8
100.5	38.1
101	38.3
101.5	38.6
102	38.9
102.5	39.2
103	39.4
103.5	39.7
104	40.0

\dagger A slug is a unit of mass which if acted on by a force of one pound will have an acceleration of one foot per second per second.

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Bostock, Frank H.
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Butler, Vernon H.
Campbell, John W.
Cash, Lewis W., Jr.
Craig, John G.
Daniels, Frank S.
Dettmer, Mark S.
Erskine, Stevan A.
Finger, Joe M.
Griffith, Steven T.
Guenther, Galen G.
Hall, Michael T.
Hardcastle, David D.
Hooper, Clarence R.
Kincer, Richard D.
Koch, Larry D.
Lamberty, Eugenio A.
Long, Danny E.
Luri, Alan E.
Mattingly, Leslie G.
McCulloch, Robert S.
Newton, Timothy J.
Palumbo, Robert L.
Pascavage, Joseph L.
Quirantes, Alberto
Ramcharran, Sooklall
Roman, Donald A.
Sanchez, Teofilo
Schulte, John F.
Showers, David C.
Sims, Terry T.
Strasser, Jarl V.
Supan, Terry J.
Tazawa, Eiji
Thompson, Harold E., Jr.
Topolewski, Ralph T.
Tosoonian, Ronald F.
Trexler, Gary S.
Tucker, Lonnie B.
Weintrob, Joan C.
Whiteside, Steven R.

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Barnhart, David W.
Barton, Calvin C.
Berman, Kenneth M.
Byers, James L.
Chadwell, Benjamin E.
Chagnon, Kenneth L.
Chang, Chung-Woo S.
Chang, Thomas C.
Cummings, William L.
Dillard, John C.
DiPompo, Michael
DiSanto, Anthony R.
Doran, Robert E.
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Dralle, Alan J.
Ellepola, Wijegupta M.B.
Elliott, Gene
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Garcia, Manuel R.
Garrett, James A.
Goff, James B.
Goodman, Donald O.
Guth, Thomas
Gruman, Gregory S.
Hall, Larry J.
Hall, Robert C.
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Tirimacco, Philip S.
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Warren, Jonathan P.
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Brace, David A.
Brelsford, Bill B.
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Caspers, Carl A.
Conner, Roger D.
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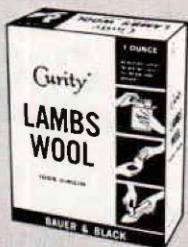


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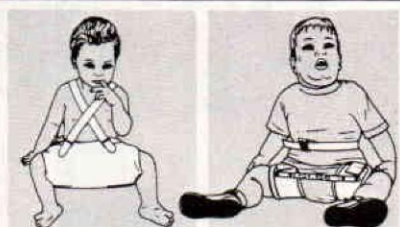
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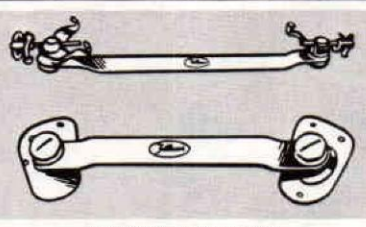
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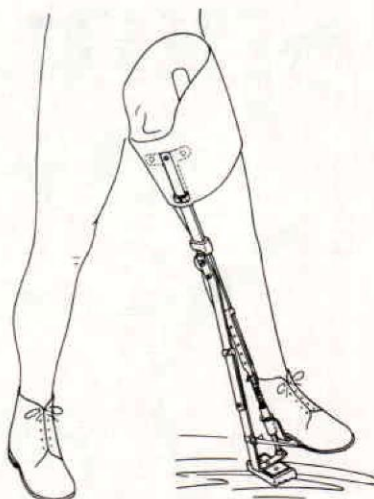
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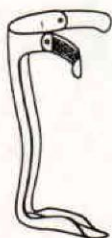
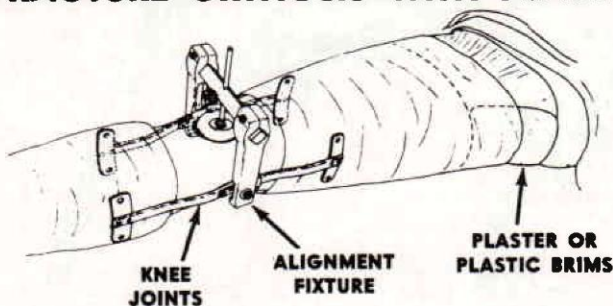


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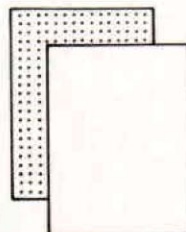


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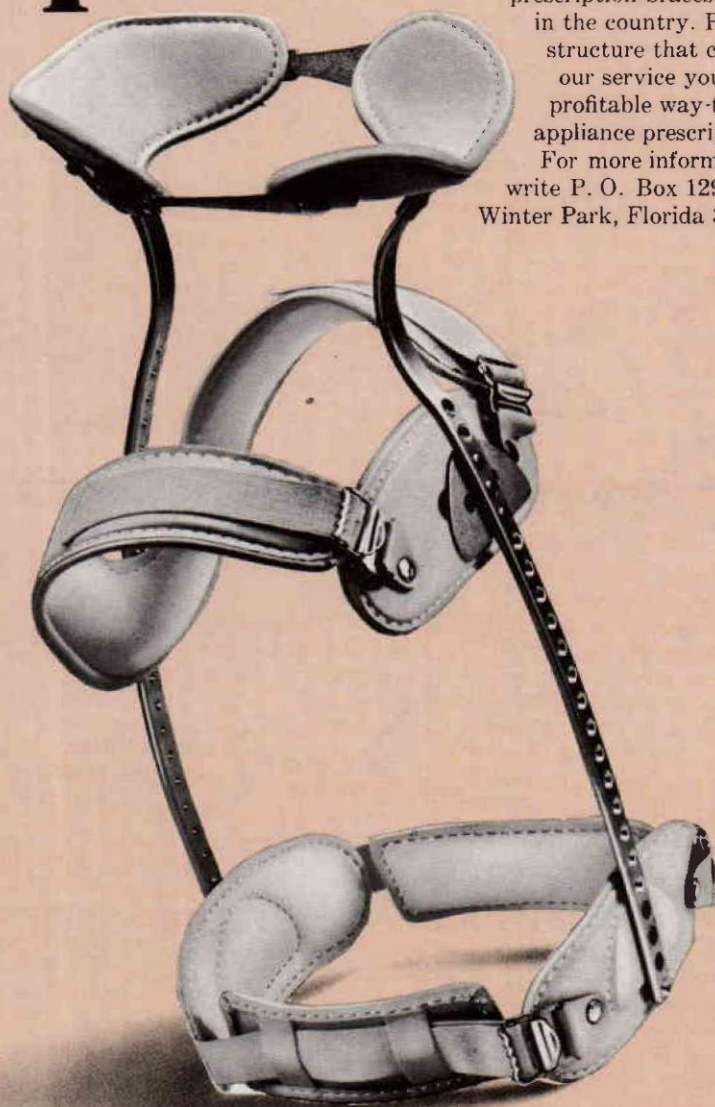
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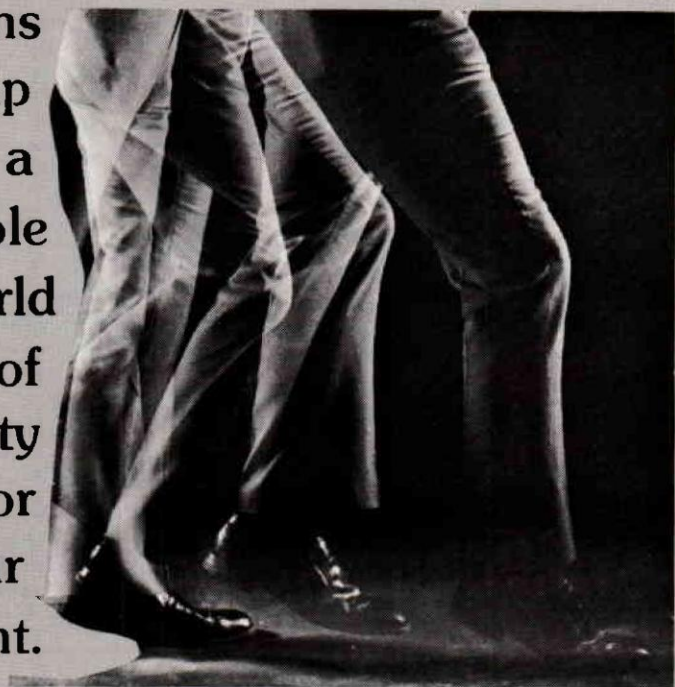
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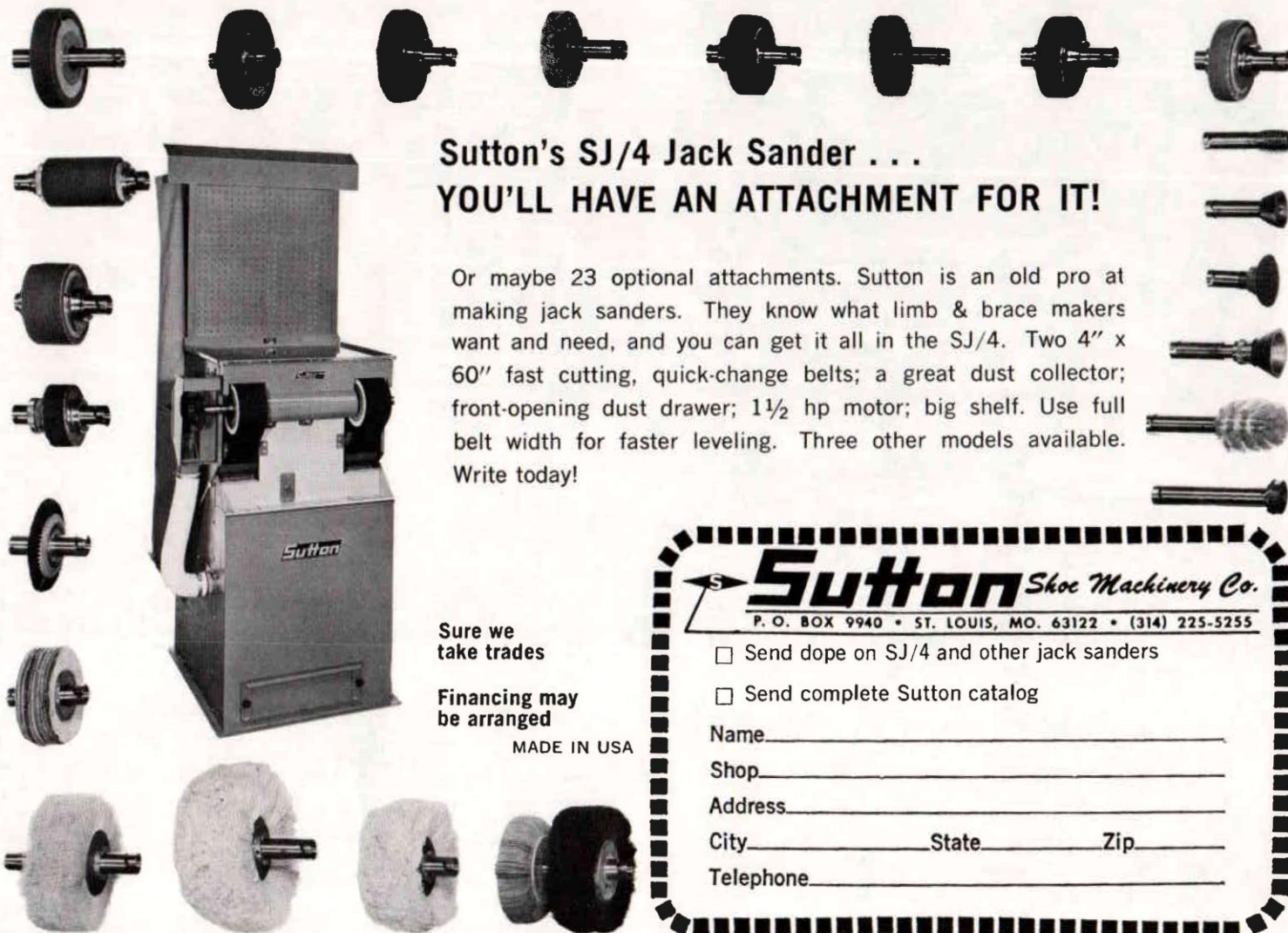
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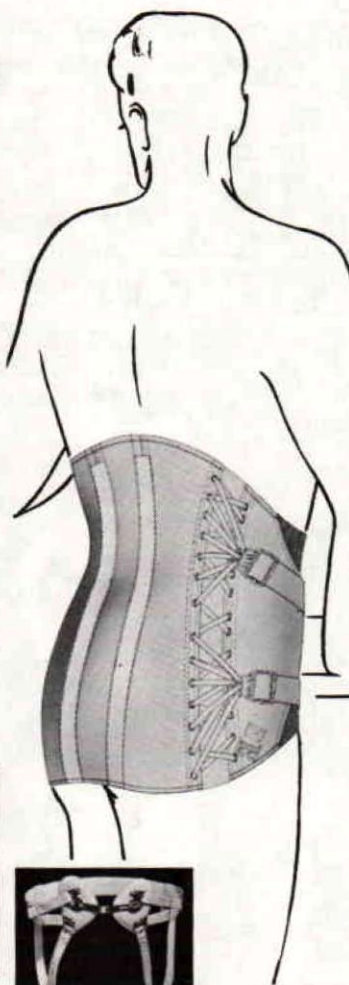
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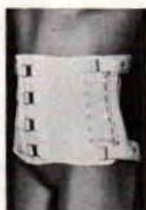
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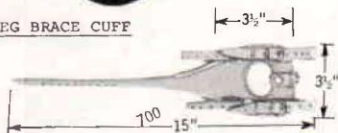


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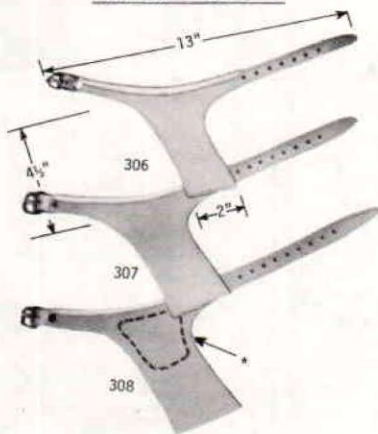


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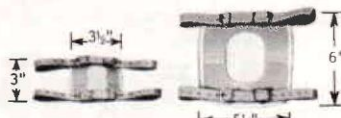
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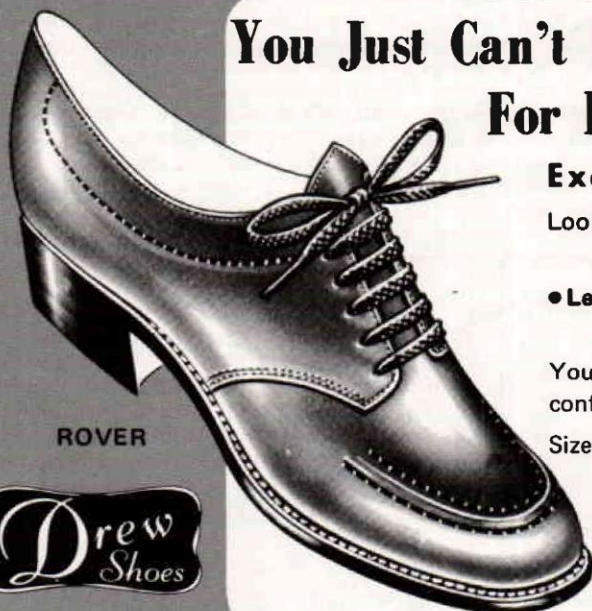
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