Spring 1965

Artificial Limbs

A Review of Current Developments

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Whither Prosthetics and Orthotics?

George T. Aitken, M.D.[1]

The publicity concerning scientific and technical advances keeps us constantly aware of man's increasing competence to master his environment. The technologies available make possible a wide variety of mechanisms that expand man's sphere of activity and make possible comfortable living in environments previously considered undesirable. Some of the modern techniques, when applied in the biological fields, have eliminated some diseases, controlled others, and have made possible medical and surgical procedures that extend the life expectancy of persons of all ages. Continuing research undoubtedly is going to demonstrate eventually the etiological factors in other disease entities and thus permit the development of a nonsymptomatic approach to therapy.

Many of the current scientific advances have been the result of interdisciplinary effort, where two or more separate disciplines have worked together, hopefully synergistically. This interdisciplinary effort in prosthetics and orthotics has produced what is often described as a bioengineering effort. In the past twenty years increasing emphasis has been placed on the engineering aspects of this specific problem. These years have witnessed a rapid advance in the development of new industrial materials and hardware that have been readily applicable to artificial limbs and braces. Many improvements in previous fabrication techniques and components were facilitated by using these newly available industrial developments, and thus some advances were made in upgrading the quality of prosthetic and orthotic devices.

There have been varying degrees of concurrent fundamental research in the biological aspects of this interdisciplinary approach.

It seems at times, though, that the glamour of technology has overshadowed the purely biological problems. Research activities involving these glamour areas have been more attractive to many, and funds for such research have been more available in these sometimes esoteric areas.

At times it would seem that many involved in prosthetics and orthotics

[1] Chairman, Committee on Prosthetics Research and Development, July 1, 1962-June 30, 1965. Upon completion of his term as Chairman of CPRD, Dr. Aitken will continue to serve as a member of CPRD.

research and development have failed to see the entire problem. Basically, it is the problem of achieving the optimum man-machine interface. The ultimate resolution of the problem is the production of designs that result in comfort, maximum function, and reasonable cosmetic restoration.

There is little question that much has been accomplished. Certainly we have available currently biological and engineering techniques that are capable, in a high percentage of cases, of producing improved function and cosmesis. Continuing intelligent modification of techniques and components produces more and more improvement in all of these areas. It is fair to assume that amputees and others with orthopaedic impairments are now better served than ever before.

Unfortunately, many in the field of prosthetics and orthotics research and development seem to have a tendency to relegate the patient to a secondary position. They appear to be bent on the perfection of the machine without due consideration to the education or alteration, or both, of the man to perfect the interface.

It seems timely to give consideration to some of the areas in which continuing, accelerated investigation is desirable.

Research in amputation surgery to provide more functional stumps and consequently more comfort to the patient has been significantly lacking. There is a multiplicity of amputation techniques. Myoplastic and osteoplastic techniques either alone or in combination have been recommended to promote comfort and improved function. In this country there has been no well-organized clinical evaluation of these claims made primarily from abroad. It seems logical that such procedures be investigated and evaluated thoroughly. There are good theoretical reasons to justify consideration of these procedures so that they not be simply rejected because of dissimilar training and experience.

Cineplastic procedures were critically investigated, and well-established criteria have been developed for their use. A similar review should be made of some of the other surgical problems.

The immediate postsurgical fitting of sockets with or without early weight-bearing currently is being investigated. Undoubtedly, the results of this well-organized investigation will develop proper indications and techniques for this procedure. Hopefully, such techniques will be of positive value in influencing the man aspect of the man-machine interface.

There are in addition many areas of basic biological research that need further investigation. The problem of biological signal sources for control of external power comes to mind immediately. Other, perhaps less exotic, problems, such as analysis of joint motions to permit more satisfactory alignment and construction of braces, or the metabolic problems incident to amputation and use of prostheses as well as analogous problems in the orthotics field, need further investigation. These are but a few of the many fundamental problems that need clarification.

In the truly engineering area, there is a large volume of continuing research and development of systems, components, and techniques to produce better artificial limbs and better braces. Much of this work is in the newer areas of technology and has increasing emphasis on the problems related to the use of external power in prostheses and orthotic devices.

There may be a need to review some of our accepted designs in the light of our recent progress and perhaps an effort should be made to determine whether previously acceptable items are really the best that can be developed in relation to some of our improvements in materials and techniques. It may be the time to review terminal-device design. It is possible that we now need (particularly in the light of external power) to redefine the functional requirements of a terminal device and arrive at some design criteria that will permit more efficient utilization of our technical improvements in power sources and transmission.

With an increasing emphasis on prosthetic restoration in congenitally limb-deficient children, it may develop that there must be a redefinition of goals, in the case of the upper-extremity patient, as related to age, rather than as related to the needs of an adult. Possibly a careful analysis of the functional needs of pre-school and primary and secondary school children would permit us to develop components for a system that would be more effective than simply using scaled-down adult components and systems.

An overall review of research and development in prosthetics and orthotics over the past twenty years cannot help but emphasize that people requiring prostheses and orthotic devices are being increasingly better served. There seems little question but that the efforts of our schools of prosthetics and orthotics education have produced a marked upgrading of the skills in prescribing and fitting these devices as well as greater competency in the training of the patient in the use of such devices.

As a clinician, I am very pleased with the improvement of patient care in these areas. As an interested participant in research and development endeavors, I am increasingly aware that there is much more that remains to be done. There exist the technical facilities to do both better research and better development. What is needed is the wisdom to direct our efforts in such a way that we adequately explore all areas of this man-machine problem and so correlate our activities that the result—the functioning man-machine combine—is a continually improving biomechanical unit.

The Patellar-Tendon-Bearing Prosthesis for Below-Knee Amputees, a Review of Technique and Criteria[1]

JAMES FOORT, M.A.Sc.[2]

At a recent meeting of the Workshop Panel on Lower-Extremity Fitting (2), which is sponsored by the Subcommittee on Design and Development of the Committee on Prosthetics Research and Development, there was prolonged discussion of below-knee prostheses. Questions were raised concerning the adequacy of the PTB design for many patients, especially patients who were longtime users of the joint-corset, below-knee limb. The view was expressed that the expenditures of time and money in achieving a successful PTB fit did not justify the selection of the PTB prosthesis or a conversion to it, and that the use of a joint-corset prosthesis initially would shorten the prosthetic restoration process for most patients.

It was recognized that the private practitioner is often forced to elect the simplest and least expensive procedure for his patient. Institutional facilities, on the other hand, can take more of the patient's time, without having the often-required succession of visits reflected in direct cost to the patient or to the sponsor. Yet, the panel was of the opinion that some prosthetists probably are still committing errors in fitting PTB prostheses, resulting in deterioration of the stump, excessive shrinkage, or edema. Moreover, criteria for use of the joint-corset prosthesis are still misunderstood.

Fortunately, the Workshop Panel on Lower-Extremity Fitting had the benefit of the counsel of James Foort, formerly of the University of California {Berkeley) but now of the Prosthetics-Orthotics Research and Development Unit at Manitoba Rehabilitation Hospital, Winnipeg, Canada Mr. Fool spoke at length on the PTB design and then agreed to put his comments in writing for the benefit of clinicians the world over. Presented below is his helpful review of the subject.

We are indeed indebted to Mr. Foort for his contribution. The clear expression of certain axioms will, hopefully, solve some of the problems experienced in the fitting of this very important prosthetic appliance.

Anthony Staros[3]
Chairman, Workshop Panel
on Lower-Extremity Fitting

The patellar-tendon-bearing (PTB) prosthesis has been in use for more than five years. It was fully discussed in the June 1962 issue of *Artificial Limbs (1).* Although experience suggests that approximately 90 per cent of all below-knee amputees can benefit from the use of the PTB prosthesis, a substantial number of prosthetists continue to fit joint-corset prostheses to a large proportion of their patients. Apparently, these prosthetists and their clients have found that maintenance and replacement costs outweighed the fabrication and functional advantages of PTB prostheses. Difficulties developing from the use of the PTB prosthesis are said to be edema, stump breakdown, and stump shrinkage. With these difficulties in mind, the purpose of this review is to examine the fitting technique for PTB's, emphasizing factors to be considered in avoiding or overcoming the difficulties and outlining criteria for use of joint-corset prostheses.

PTB FITTING TECHNIQUE

The most common error made with a PTB socket is an excessively tight fit in the popliteal area of the stump. Too large a bulge in the popliteal area can be constrictive, affecting circulation, causing edema, and in turn leading to deterioration of the stump end. *Posterior pressure needed to balance the posteriorly directed*

[1] An outgrowth of the discussions of the principles of PTB fittings at the Third Workshop Panel on Lower-Extremity Fitting conducted under the auspices of the Subcommittee on Design and Development of the Committee on Prosthetics Research and Development at Hollywood Beach, Fla., November 4, 5, and 6, 1964.

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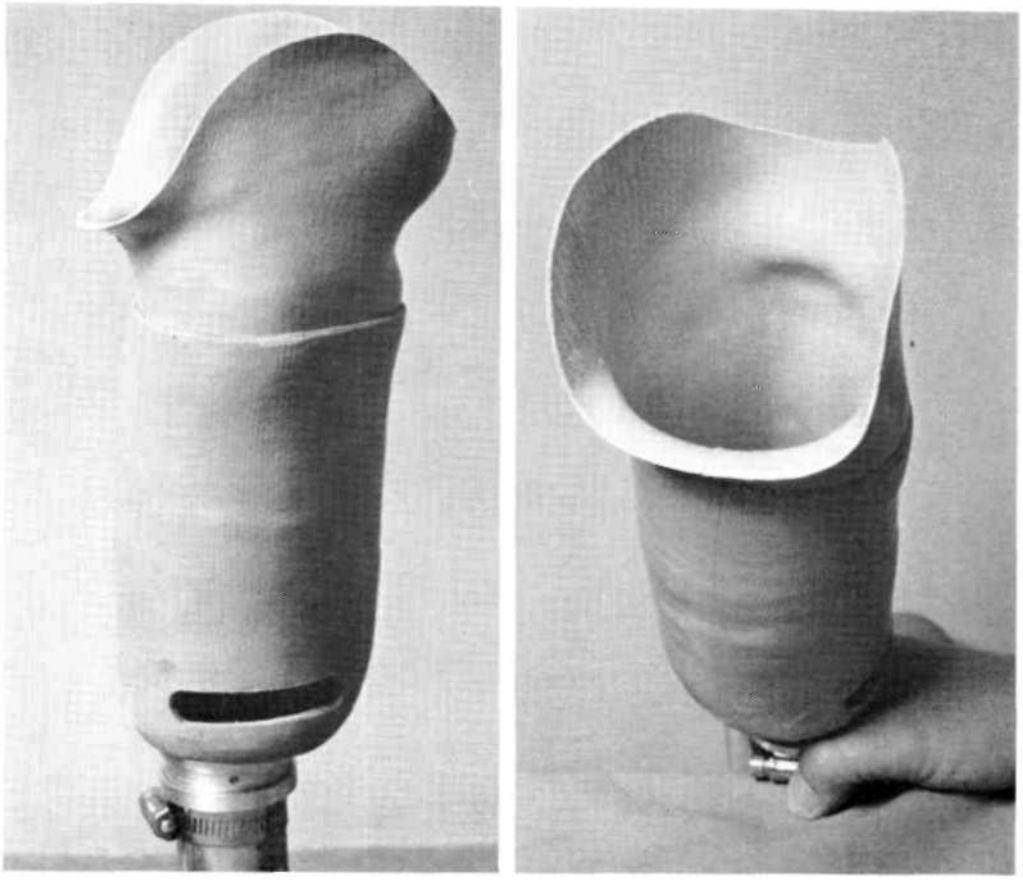

Fig. 1. Two views of a temporary plastic PTB socket showing the flared posterior brim.

force against the patellar tendon by the weight-bearing bar of the socket must be provided by the posterior and posteromedial aspects of the tibial condyles and the overlying tendonous structures, as well as by the popliteal area of the stump. {First factor.)

Emphasis on the patellar tendon as a weight-bearing structure has contributed to constriction of the stump in the popliteal area. *The posterior and posteromedial aspects of the tibial condyles and the overlying tendonous structures are important weight-bearing surfaces of the stump. (Second factor.)*

In order to make the area for pressure against the popliteal surface of the stump larger, many prosthetists have extended the back of the socket up into the space between the hamstring tendons, cutting grooves to relieve the tendons during knee flexion. This design can contribute to constriction of circulation in the popliteal area when the amputee stands or sits. *The back brim of the socket should be formed into a broad, flared surface against which the hamstring tendons can rest when the amputee sits. (Third factor.)* So shaped, the back brim of the socket can be made sufficiently high to provide the large support area needed to minimize pressure while holding the patellar tendon in position on the weight-bearing bar and still ensure sitting comfort (Fig. 1). When the back brim is made higher, as for a short stump, the flare also lifts the stump out of the socket and supports it when the amputee sits.

Edema is also caused by constriction at the mid-stump level, and such constriction can result from the cumulative effects of modifying the plaster stump model. The least desirable

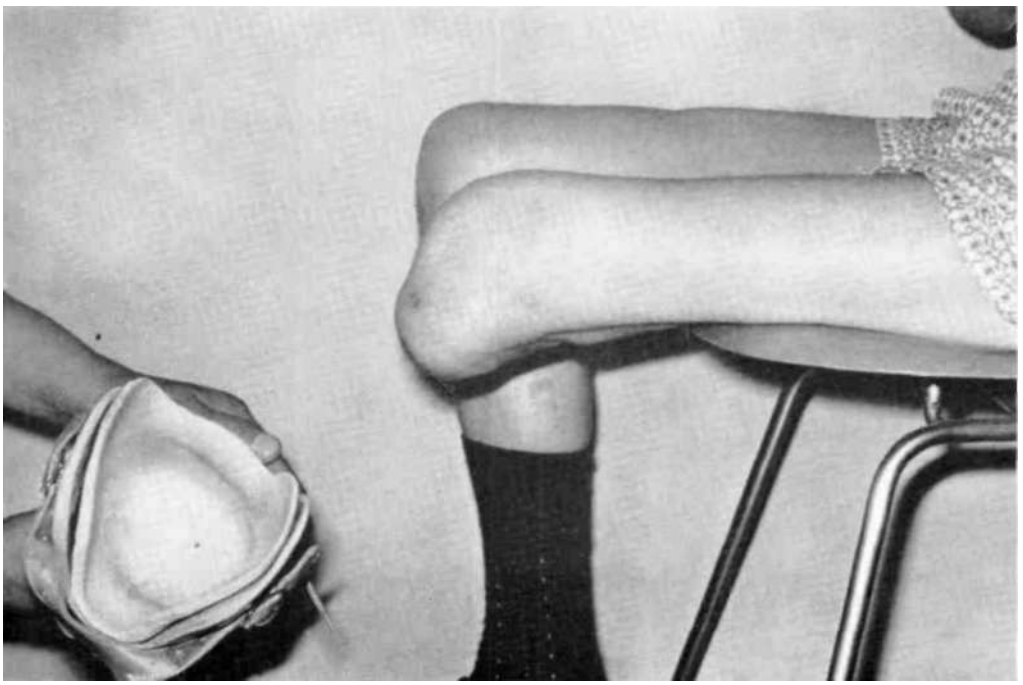

Fig. 2. A very short stump which is capable of bearing considerable weight on the end.

modification is that made in the lateral fibula area. This modification is meant to help stabilize the stump mediolaterally in the socket, but the fibula is a poor structure against which to stabilize. *To achieve mediolateral stability of the stump in the socket, the socket should fit securely against either side of the tibial crest and against the medial and lateral surfaces of the knee joint. (Fourth factor.)* Mediolateral stability is a problem only if the foot is set in or out too far. *The socket should be placed over the foot so that there is little tendency for the prosthesis to tilt medially or laterally on the slump as the amputee walks. {Fifth factor)*

Although breakdown at the end of the stump is sometimes attributed to pressure on the end, a more likely cause is constriction at the mid-stump level. Tightness around the middle third of the stump gives the amputee the feeling that the end is contacting the bottom of the socket or that the tissues are being pulled up against the end of the bone. There are, however, circumstances in which end pressure is damaging and painful. *The socket should support distal tissues with sufficient pressure to aid venous and lymphatic return without pressing against the bone ends. (Sixth factor.)* If the stump has been amputated through cancellous bone, however, the bone end may be an important weight-bearing surface (Fig. 2).

Frequently, the anterodistal tibia area is painful because of the thin cutaneous covering; it is also vulnerable to excessive pressure because of poor circulation. Hollowing out the socket in this region usually does not give the expected relief. Foot alignment, as viewed from the side, and a stiff heel action can be the causes of difficulty. *The foot should be pliant and aligned to give a smooth rolling action as the amputee walks, as though the foot were a segment of a wheel run. (Seventh factor.)* If, so to speak, the "hub of the wheel" is too far back, the end of the stump is forced forward painfully against the socket as the amputee attempts to control the prosthesis at heel contact by active extension of the knee. This problem is especially pronounced with recent amputees who have not become skilled at regulating the forces against the stump by appropriate coordination of knee and body

actions. A softer heel wedge, increased plantarflexion of the foot (or extension of the socket), or moving the foot forward (least likely) can reduce discomfort at the anterodistal end of the stump resulting from these causes.

General tightness is sometimes considered a source of trouble—and may be initially. But a socket should fit snugly, especially for a recent amputee or one who has not worn a PTB prosthesis before. The newly fitted amputee may have to remove the insert from the socket shell, put it on the stump, powder it, and force it back into the socket shell, even when he is wearing only a cast sock over the stump. One should be sure, however, that the socket bears weight evenly on the main support areas and that it also supports the distal tissues. If the socket does provide proper support, the imprint of the stump sock on the skin will be even in appearance, with the important support areas on the stump somewhat reddened. During the early phases of walking, the amputee should not use the prosthesis excessively. Soon his stump will become accommodated, and then he will be able to use a wool sock. *Tissues which are snugly pressed in a socket will shrink until pressures are reduced to suitable levels. (Eighth factor.)* Sometimes when the stump is fitted snugly, a vacuum develops during the swing phase and has a tendency to produce edema. To correct this problem, holes —sufficiently large to prevent hissing noises— may be drilled into the prosthesis, or the suspension system should be made more effective.

All these factors must be kept in mind when an impression is made over the stump and the plaster model of the stump is shaped for use as a socket mold.

TAKING THE PLASTER IMPRESSION

It is not easy to outline a specific procedure for taking a plaster cast of an amputee's stump. Stumps vary in the amount and resiliency of tissue covering the skeletal frame to be fitted. Moreover, the size, strength, and shape of prosthetists' hands and their sense of pressure—all unique to the individual—vary considerably. But if the impression is made tightly over the weight-bearing areas of the stump, these areas will be better defined than if the cast is made looser, regardless of these other differences.

1. The impression should be started at the knee. The plaster-of-Paris bandage is wrapped tight, starting at the superior edge of the patella. As each pass is made around the knee, the plaster is formed up higher on either side of the knee by guiding it upward with the fingers of the left hand (Fig. 3). At the back, the cast should cover the knee crease by about two finger widths. Wrapping continues in this manner down to the level of the tibial tubercle.

2. Next, an effort must be made to obtain an accurate imprint of the medial flare of the tibia (Fig. 4). The plaster-of-Paris bandage is pulled up against the medial flare with even tension, and each turn is anchored to the lateral surface of the knee. Thus tissue tension is prevented from driving the plaster away from this important support area.

3. The rest of the stump is wrapped with less tension.

4. The plaster is smoothed over the entire stump and worked around the bony areas. As the plaster is worked, the stump is palpated to determine how it should be held for shaping.

5. Just before the plaster begins to set, the thumbtips are positioned on either side of the patellar tendon,

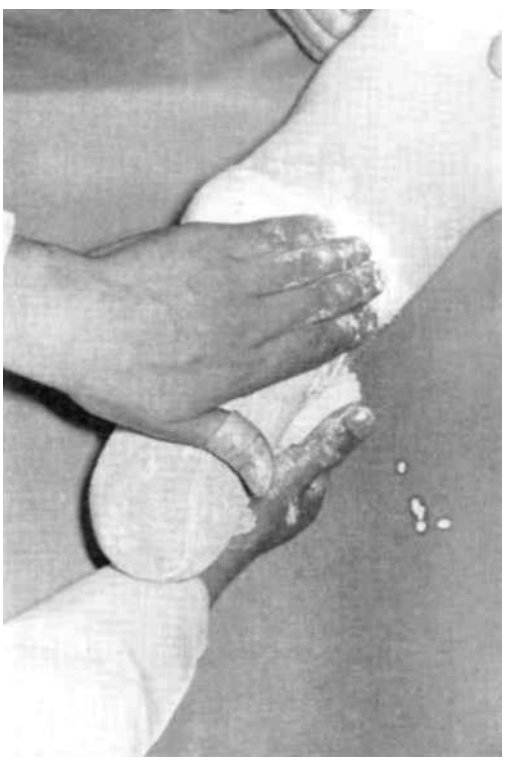

Fig. 3. Starting the plaster impression and guiding the plaster upward along the sides of the knee.

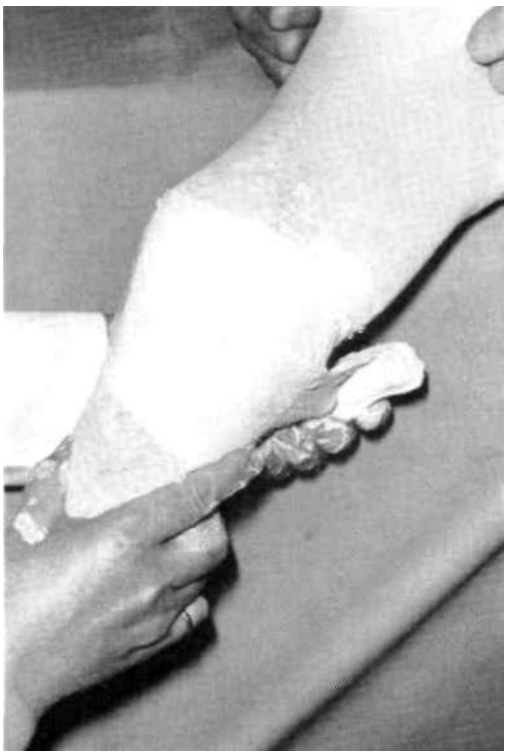

Fig. 4 Pulling the plaster-of-Paris bandage against the medial flare of the tibia to obtain an accurate impression of this important support area.

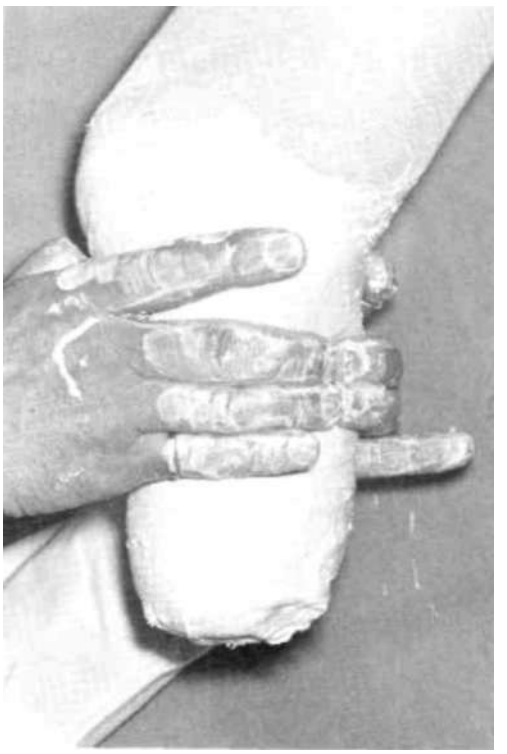

Fig. 5. Holding the cast with moderate pressure and with the fingers flat across the back.

close to its edges, so that the plaster-of-Paris bandage is pulled in against the tendon as pressure is applied. This position of the thumbs precludes intrusion into the spaces under the edge of the patella medially and laterally. The fingers are placed around the media] flare of the tibia and held flat against the back of the stump. It is important *not* to push into the popliteal space with the fingertips. Where the fingers encircle the lateral side of the stump, they are not in contact, Across the back of the stump, they are straight and exert pressure against the posterior aspects of the lateral tibial condyle and the popliteal area. Very little force should be used. The cast has been wrapped tight at the top to obtain an imprint of the stump close to the required shape, and the cast is held to ensure that the required support areas will be well defined when it sets (Fig. 5).

6. When the plaster impression can hold its shape, the thumbs are used to obtain a clear imprint of the anterior crest of the tibia by moderately caving in the semi-set plaster along a 3/4-in. strip on each side of the tibia to within an inch of the end (Fig. 6). The impression will now be wedge-shaped in front. Just before the plaster sets firmly, the hands are returned to the holding position, and the cast is held until it can be taken from the stump. This holding-squeezing action flattens the back and ensures retention of the required anteroposterior width.

MODIFYING THE MODEL

It is desirable to modify the plaster stump model as soon as possible after the impression is taken, while the recollection of details is still strong.

1. A groove is carved in the patellar-tendon ridge with a 1/2-in. self-cleaning rasp to a depth of about 1/2 in. The groove is made halfway between the inferior edge of the patella and the tibial tubercle. The groove should be about 3/4-in. wide between the upper and lower edge, and the edges should be smoothly curved toward the patella and toward the tibial tubercle (see Fig. 7).

2. Modifications on either side of the crest of the tibia are made in the usual way *(3).*

3. The medial flare area is smoothed first with a curved self-cleaning rasp to make the flare blend in with lower sections of the model and then with wire screening, which should be swept around the natural contours of the flare extending into the posterior area and even over the hamstring tendons (see Fig. 8).

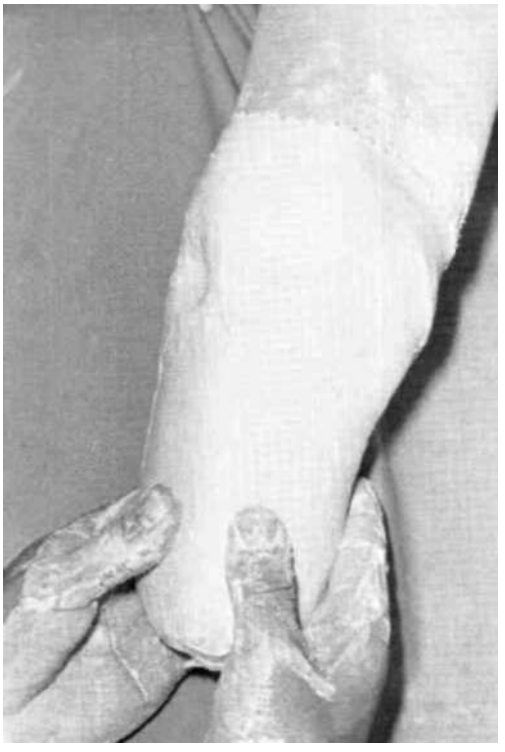

Fig. 6. Caving in the plaster on either side of the tibial crest.

4. The back of the model is flattened and smoothed over the popliteal area; care must be taken *not* to indent this area.

5. The flattened surface at the back of the model is extended downward and blended in with the more distal parts of the model by shaving off small amounts of plaster.

6. The model is smoothed on either side of the knee. If necessary, material is carved away to reduce the model to the measured width of the knee. This area is important, because it contributes to stabilization of the stump in the socket. The lateral side of the socket stabilizes the medial flare of the tibia against its weight-bearing surface in the socket. Sometimes a very slender amputee will find that when he sits, the wide part of his femoral condyles binds against the socket at the top. To correct this, the socket should be heated in that area and forced outward to give relief.

7. Plaster is added to the model in bony areas such as the head of the fibula, the crest of the tibia (especially toward the distal end), and the ends of the fibula and tibia. If the crests of the tibial condyles are prominent, extra space should be provided for them in the socket. They and the tibial tubercle seldom present problems if the patellar-tendon shelf has the proper dimensions, because then the socket is forced away from those prominences.

8. Before constructing the posterior flare on the plaster model, it is necessary to mark the socket trim lines on the model. First, a line is drawn circumscribing the model at the mid-patellar-tendon level and perpendicular to the long axis of the model. This line defines the back brim for the average type of stump. *A* shorter stump will be fitted higher at the back, depending on how short it is. Next, a line drawn through the middle of the patella and upward on either side gives the shape of the medial and lateral extensions of the socket. On the lateral side, the line will pass straight down through the posterolateral corner of the model to cross the posterior reference line. The corner can be rounded so that the lines join with a 1/2-in. radius. On the medial side, the trim line should be further in from the side so that the posteromedial curve is retained in the socket to help provide posterior support to the stump. This is possible because the medial hamstring tendons are toward the midline of the stump. After the model has been secured in a vise with the popliteal area up and the long axis of the model horizontal, plaster is poured above the trim line at the back (Fig. 9). When the plaster has set slightly, a 3/4-in. flare is formed by smoothing the plaster with wet fingers and thumb. It is seldom necessary to adjust the fit of the flare for relief of the low-set medial hamstring tendons, even though the socket curves around to the back on that side, because the flare allows the tendons to support considerable pressure comfortably. (For a medial view of the modified model, see Fig. 10.)

STUMP SHRINKAGE

Even the seasoned stump can shrink. To the prosthetist this is a problem of economic significance, because his guarantee provides for repair or replacement. The worst of it is that when the socket of a PTB prosthesis is no longer satisfactory and must be replaced, there is little the prosthetist can do but rebuild the prosthesis completely. The least that can be done is to lay in material between the socket shell and the insert or to cast RTV Silastic resin under the stump. This sometimes affects alignment, which then must be adjusted. If the weight-bearing area can be modified easily, it is good practice to take a new cast of the stump, prepare a new model, and make a new insert over it. The new insert will support the stump distally, while the modified brim area gives satisfactory weight support and stabilization.

Actually, what is needed is a different approach to the provision of prostheses. The recent amputee should be provided with a well-fitted limb to which a series of sockets can be easily attached until the stump has become stable. Then a final fitting can be made. At

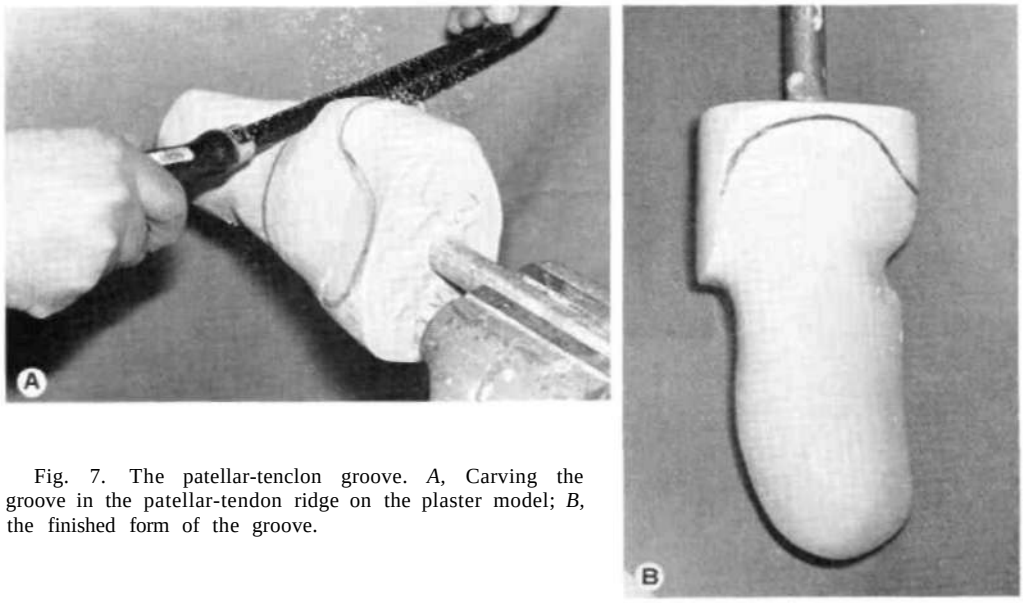

Fig. 7. The patellar-tenclon groove. *A,* Carving the groove in the patellar-tendon ridge on the plaster model; *B,* the finished form of the groove.

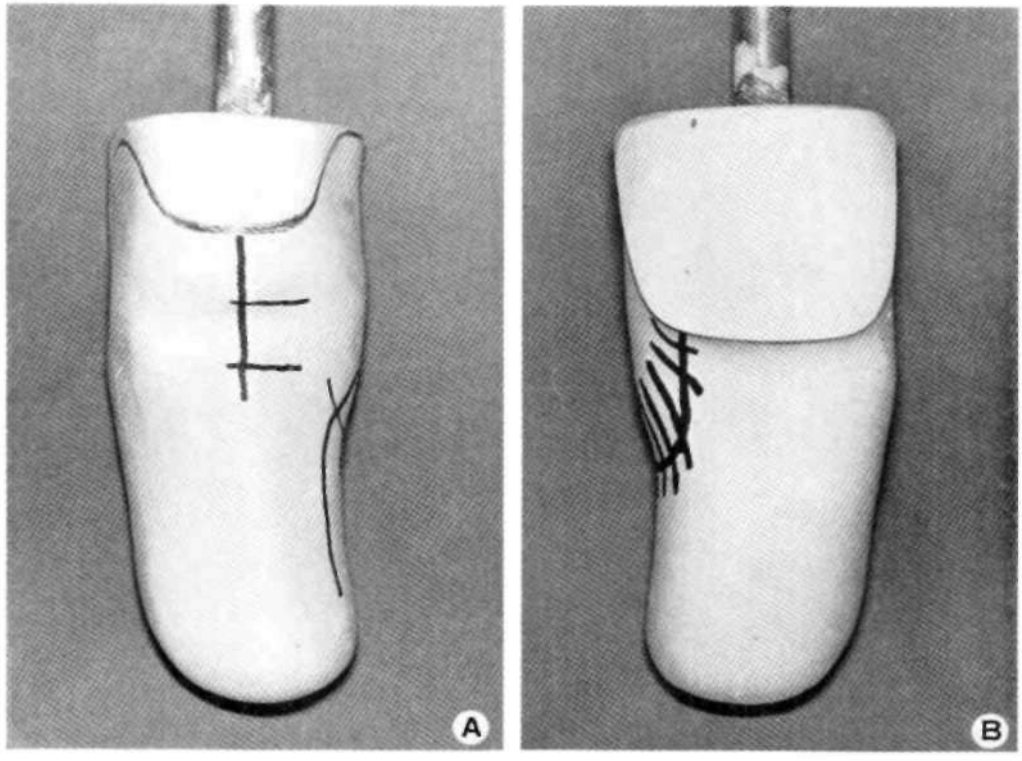

Fig. 8. The finished form of the medial flare area on the plaster model. *A,* An anterior view; *B,* a posterior view.

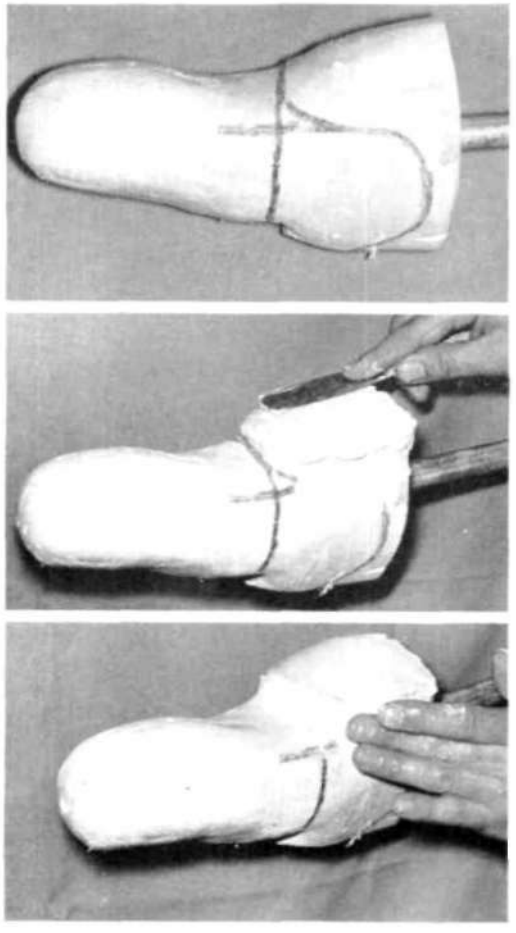

Fig. 9. Marking and forming the posterior flare on the plaster model, which has been secured in a vise with the popliteal area up. *Top,* the line circumscribing the model at mid-patellar-tendon level defines the level of the back brim of the socket. *Center,* plaster is poured onto the model above the trim line and allowed to set slightly. *Bottom,* wet fingers and thumb are used to form the posterior flare

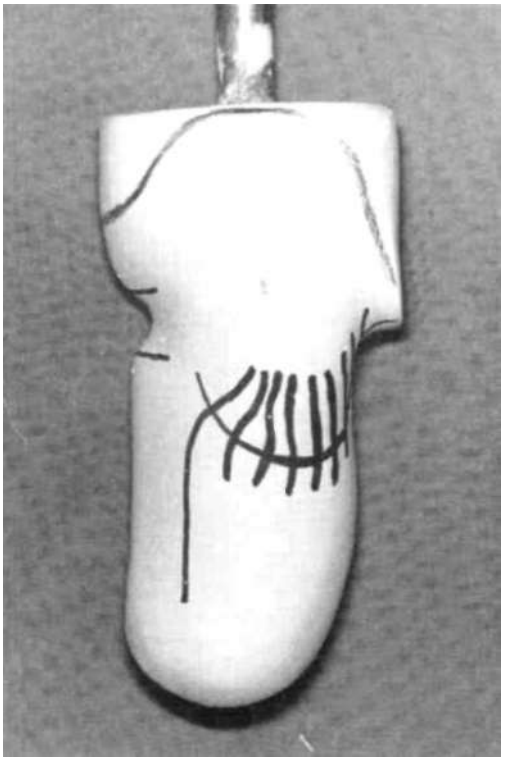

Fig. 10. Medial view of the modified model.

present, the permanent limb is often fitted as soon as the shrinker bandage treatment has been completed. The forces imposed on the stump by the prosthesis are much greater than can be developed by the shrinker bandage. Also, the socket forces are different in location. In addition to the loss of control and harmful forces that develop between the stump and the prosthesis, the reduced bulk of distal tissues leaves them unsupported and prone to edema.

When the stump is fitted tightly, as recommended here, the initial discomfort will diminish as the stump shrinks and molds into shape. Finally, the amputee will be able to don his prosthesis while wearing a wool stump sock.

PERSPIRATION AND MACERATION OF THE STUMP

There have always been amputees who have suffered maceration of the stump end as a result of accumulation of perspiration in their sockets. Contributing to the heat in a PTB prosthesis are the rubber-leather insert, the thick plastic shell and surrounding materials, the closed end of the socket, and the tightness of fit. Ventilation is poor, even when holes are drilled through the walls of the socket. Use of a valve system, such as that designed at the Navy Prosthetics Research Laboratory, which

allows air to enter slowly and forces it to escape up through the sock, could be helpful provided noise is avoided; and porous plastic laminates, such as have been developed at the Army Medical Biomechanical Research Laboratory, may be of some use as a solution to the problem. The most likely immediate solution is to make the socket thin, somewhat pliable, perforated, and without an insert. Such a socket must be titled with care, since there is no soft insert to provide a margin for error and to permit easy modification of the socket. A socket constructed of four to six layers of stockinet laminated with two turns of glass-cloth covering from the top to the tibial tubercle will serve. The socket, supported in a plastic receptacle (Fig. 11), can easily be replaced without seriously affecting the entire prosthesis.

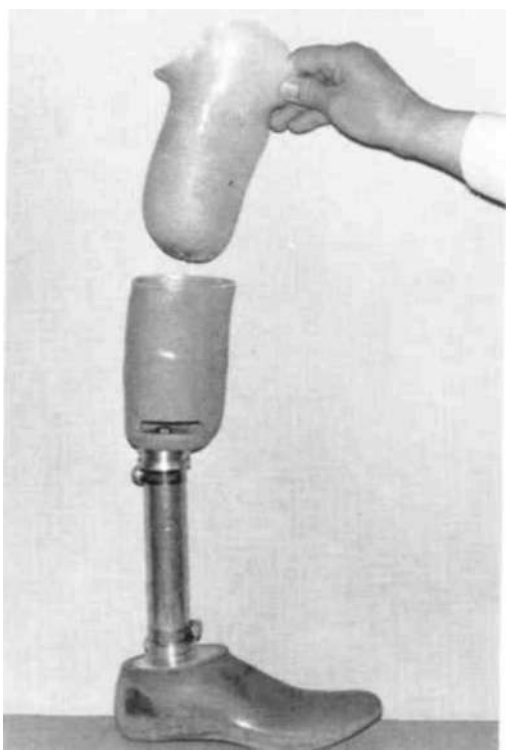

Fig. 11. Temporary plastic socket and the receptacle into which it fits.

USE OF JOINT-CORSET PROSTHESES

Under ideal conditions, the percentage of amputees who use joint-corset prostheses might be as low as 10 per cent. There is no doubt that the joint-corset system can make up for deficiencies in the fit of the socket and thereby serve as a safety factor when the proper lit of a PTB prosthesis is not achieved or maintained. Hut there are definite criteria which can be used for the prescription of a joint-corset prosthesis.

Sometimes the amputee's occupatjon requires him to use his prosthesis under heavy-duty conditions; he may be required to pry up or lift heav\ objects. *When the amputee must place a force on his prosthesis which is considerably greater than the weight of his body, a joint-corset prosthesis aids him by permitting part of the weight to be borne on the thigh. (First criterion*) The joint-corset system is especially effective when the knee is slightly flexed so that forces are borne by the back of the thigh and are transmitted to the shank through the side joints. When the thrust on the prosthesis is along its axis, the amputee can prepare for it by temporarily tightening his thigh corset.

Many amputees kneel, climb ladders, or climb stairs frequently. Such activities may be especially difficult or troublesome to the bilateral amputee because of rotation of the PTB prosthesis on the stump. *The joint-corset system prevents the prosthesis from rotating about the amputated leg when the joints are flexed. (Second criterion.)*

There is the rare amputee whose knee is unstable, or whose musculature is so weak that the joint-corset system is required. *The joint-corset system can stabilize an unstable knee against extreme mediolateral motions; against dislocations; and, when a back-check is used, against hyperextension of the knee. (Third criterion.)*

For the amputee with a stable knee, however, the corset is functionally limited as a mediolateral stabilizer because of the thinness of the joints, the fleshy nature of the thigh, and the pliability of the leather corset. Only if the amputee also bears weight on the corset", or has an extremely atrophied thigh against which he laces the corset tightly, or the corset

extends to the peroneal level with cross braces between the side joints, will the corset be of much value as a mediolateral stabilizer.

Also rare are amputees who cannot bear weight effectively either on the stump or through the femur. *An amputee who cannot bear weight on the stump should be fitted with a quadrilateral ischial-gluteal weight-bearing support and have straps connecting the thigh to the side joints above the knee for control of flexion and extension and for suspension of the prosthesis. {Fourth criterion.)*

Sometimes an amputee is mentally retarded or senile. In such an event, especially if there are no qualified helpers to ensure that the prosthesis is donned correctly, the joint-corset system should be used. *The joint-corset system is an aid in ensuring that a prosthesis is correctly placed on the amputated limb when the amputee's judgment is questionable. (Fifth criterion.)*

A problem often faced by the prosthetist fitting a PTB prosthesis to an experienced wearer of a joint-corset prosthesis is that the amputee is not prepared to make the change, either because he doubts that he can do so successfully or easily, or because he has a definite bias toward the joint-corset prosthesis. *The joint-corset system should be used when there are definite psychological pressures favoring it. (Sixth criterion.)*

CONCLUSIONS

Probably many prosthetists who fit the PTB prosthesis successfully have discovered for themselves, or have learned from previous experience with other prostheses, how to deviate from established procedures. For those who have difficulties, this review may be of assistance. But it may be necessary to have those who are successful demonstrate to those who are not. Short-term or immediate success should not mislead those who are trying to establish improvements. Often it is only after a year or so that results can be judged. Meanwhile, encouragement should be given to those who seek to develop devices and techniques which will eliminate as many as possible of the craft-oriented tasks needed to fit amputees, thereby increasing reliability and uniformity.

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Experiences with the PTB Prosthesis

Georg Bakalim, M.D.[1]

The original patellar-tendon-bearing (PTB) prosthesis was constructed at the Biomechanics Laboratory of the University of California. For details regarding the anatomical and physiological considerations (J), the biomechanics *(4),* and the construction *(2),* the reader is referred to the June 1962 issue of *Artificial Limbs.*

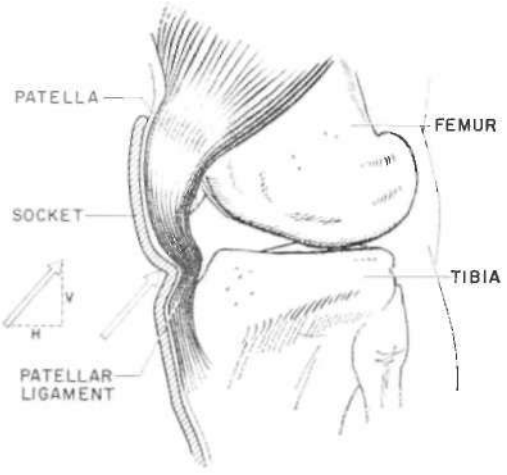


Fig. 1. Vertical cross section of anterior portion of PTB socket. The supporting force, as shown by the arrow, acts on the lower patellar ligament.

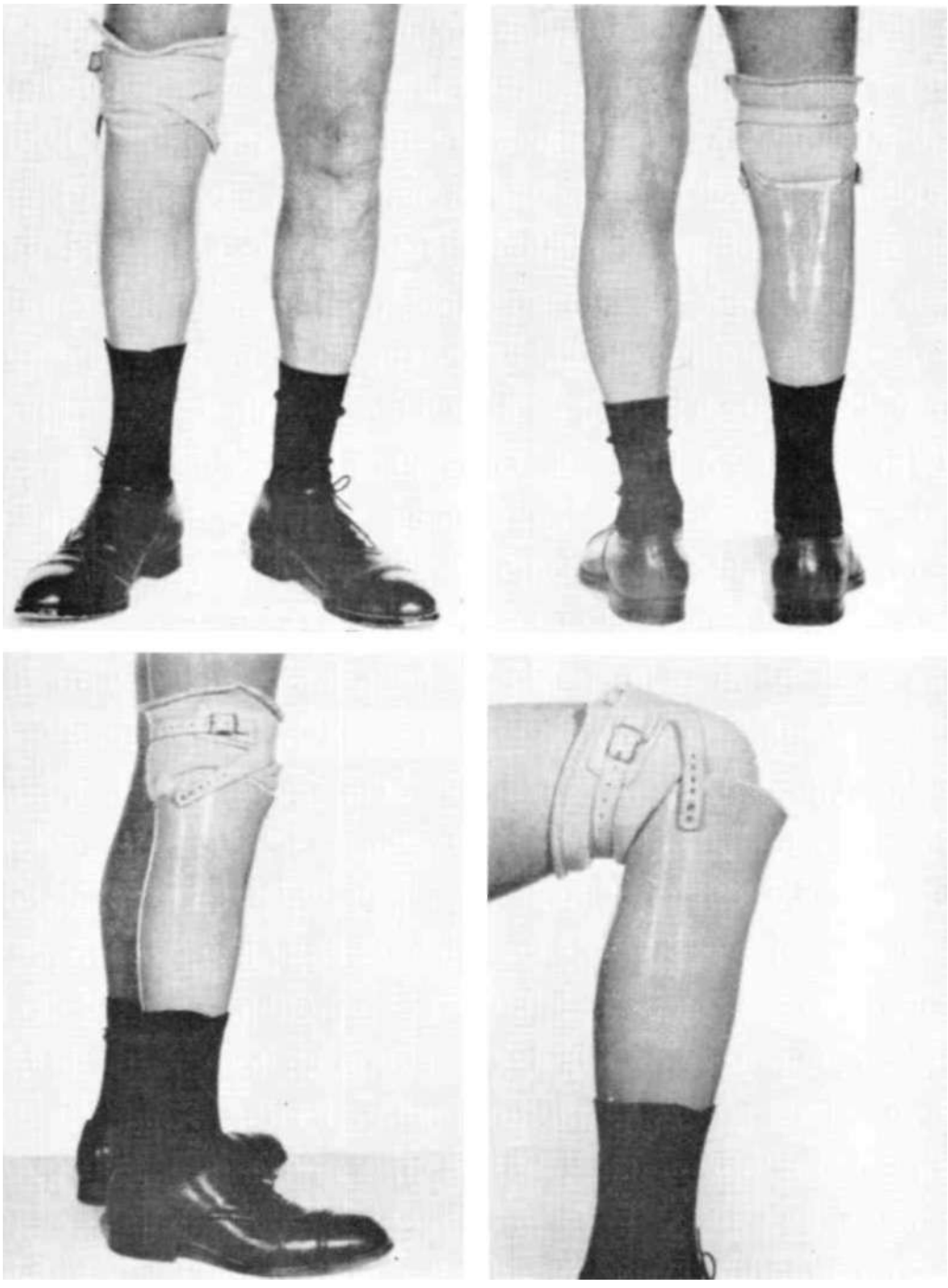
In Finland about 1,000 PTB prostheses have been manufactured since 1959. Although the name of these prostheses and the main principle of their construction imply that weight is borne on the lower patellar ligament (Fig. 1), this is not the only weight-bearing area. Both tibial condyles and, to some extent, the distal end of the stump share the weight. The distribution of weight in these areas necessitates truly individual fitting.

For technical details of fabrication of PTB prostheses, the reader is referred to the issue of *Artificial Limbs* which has been cited. Here it is sufficient to say that a plaster cast of the stump is taken first. Then an intimately fitting, distally closed socket of hard plastic and a socket insert of sponge rubber are made. Distally, the socket is joined to a wooden shank, to which a SACH foot is attached (see Figure 2 for views of a finished prosthesis). It is not essential that the socket be made of plastic, but at present this seems to be the best material available. It is relatively easy to laminate a plastic shell from a plaster model. The plastic socket withstands moisture and is, therefore, relatively resistant to perspiration, and it is readily cleaned. The drawbacks are the airtightness of the material, the risk of its causing allergic reactions, and, perhaps, the poorer heat insulation in cold weather compared with materials previously used. These points will be discussed later.

In the Department of the State Supervisor of Prosthetic Services of the Ministry of Social Affairs, a follow-up study has been made of amputees fitted with PTB prostheses. Initially, the amputees are given, for trial, prostheses which are not quite finished, although fit for wear. After three weeks the patients and their prostheses are examined at the Department of the State Supervisor, where either the prostheses are approved, or some modification, correction, or repair is prescribed. Only after this examination are the prostheses given their final finish. This applies to all prostheses paid for by the state. Six months after the patients have been fitted with their PTB prostheses a questionnaire is sent to them. At the Department of the State Supervisor, record cards are kept for all amputees, on which are entered notations concerning modifications and repairs. Thus it is easy to check on what happens to the various prostheses.

This article is based on the examinations of

[1] State Supervisor of Prosthetic Services, Ministry of Social Affairs, Helsinki, Finland.



I 'ig. 2 Finished PTB prosthesis using supracondylar cuff as only means of suspension.

the amputees and their prostheses three weeks after the initial issue, data obtained from the questionnaires distributed to the amputees when they have worn their prostheses for six months, and data obtained from the record cards.

The study covers 228 amputees fitted with PTB prostheses. Prostheses from different workshops differ somewhat from each other, since standardization of the products is a problem in Finland, as it is elsewhere, perhaps. Therefore, only genuine PTB prostheses have been included in this study.

Figure 3 shows the ages of the amputees, disclosing that the age group of 40-54 years is the largest. The youngest patient was 20, while the oldest was 75. Ex-servicemen account for 94.3 per cent of the series. The remainder are insured civilians. Only one of the cases in the series was a recent amputee whose initial fitting was with a PTB prosthesis. This does not imply that recent amputees are fitted for theoretical reasons with so-called "conventional" prostheses. On the contrary, it should be an advantage to be fitted from the outset with a PTB prosthesis, although it goes without saying that recent amputees offer special problems because of the longer duration of stump changes.

Table 1 shows the occupations of the patients in the series. From the standpoint of prescription, it is of major interest to ascertain

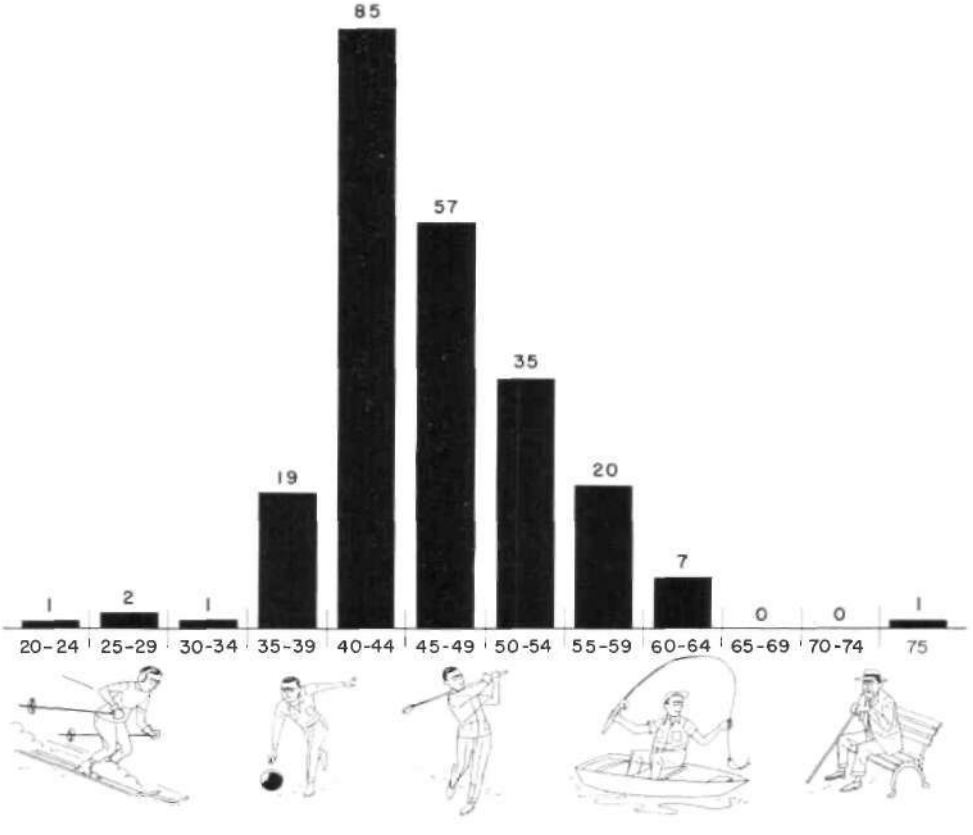


Fig. 3. Ages of the amputees when they were fitted with PTB prostheses.

TABLE 1. THE OCCUPATIONS OF THE PATIENTS

Agriculturalist	2
Architect	1
Building contractor	4
Building supervisor	1
Building worker	2
Businessman	1
Caretaker	1
Carpenter	2
Chauffeur	9
Community secretary	1
Craft-school teacher	2
Customs supervisor	1
Disabled, retired	5
Doorkeeper	2
Draftsman	1
Economist	2
Electrical worker	12
Elementary-school teacher	3
Engineer	3
Farmer	55
Farmhand	2
Foreman	10
Filer (machine shop)	4
Goldsmith	6
Housewife	2
Industrial worker	3
Insurance agent	1
Insurance supervisor	1
Journalist	1
Lawyer	1
Lumberman	2
Managing director	1
Metal worker	2
Molder	2
Music teacher	2
Night watchman	2
Noncommissioned officer	2
Painter	7
Physician	2
Porter	2
Shopkeeper	6
Smallholder	4
Storekeeper	5
Technician	9
Turner	5
Unskilled worker	19
Vulcanizer	1
Watchmaker	1
Welder	2
Workhouse internee	1
Unknown	10
Total	228

whether the PTB prosthesis can be worn while performing heavy labor, considering the absence of a thigh corset and the greater stress on the knee joint.

Table 1 discloses that the series includes 59 farmers or smallholders, 21 industrial workers, two lumbermen, and 7 painters. It stands to reason that amputees, whenever possible, choose labor that is not very heavy. Many farmers admitted that they had abandoned the heaviest tasks. However, others in the series mentioned lumbering as a part-time occupation. It was learned that some amputees had worn the PTB prosthesis without a thigh corset while walking on soft, uneven ground and on snow; in other cases, a short above-knee corset had been added almost immediately or when the PTB prosthesis had been worn for some time. It is apparent that stump length and the stability of the knee are important factors.

Figure 4 shows the lengths of the stumps in the series. In general, cases with a stump length of less than 12 cm. required a thigh corset, the length of which was about one-half or one-third the length of the thigh corset of a conventional prosthesis. The shortest stump in the series measured 6 cm., and the longest 35 cm. The series includes nine bilateral amputees (3.9 per cent).

Replies to the questionnaire are presented below:

1. Have you worn your prosthesis regularly; if not, for how long have you worn it? According to the replies, 210 amputees (92.1 per cent) had worn their prostheses regularly from the outset.

2. Why have you not been able to wear your prosthesis regularly? When the replies were compared with the record cards, it appeared that 18 (7.9 per cent) had not been able to wear their prostheses regularly. In three cases the cause could not be elicited. In 15 cases the causes were as follows:

The skin became irritated in three cases, and in one case an allergy set in.

In two cases the socket became too loose.

The stump did not tolerate the pressure; it became tender.

There was pressure on the stump when the patient drove his car.

Ulceration of the stump occurred in three cases.

The prosthesis was cold in the winter, and it slipped off when the patient walked in the snow.

The stump swelled when the patient was riding a bicycle.

Stairs were a problem.

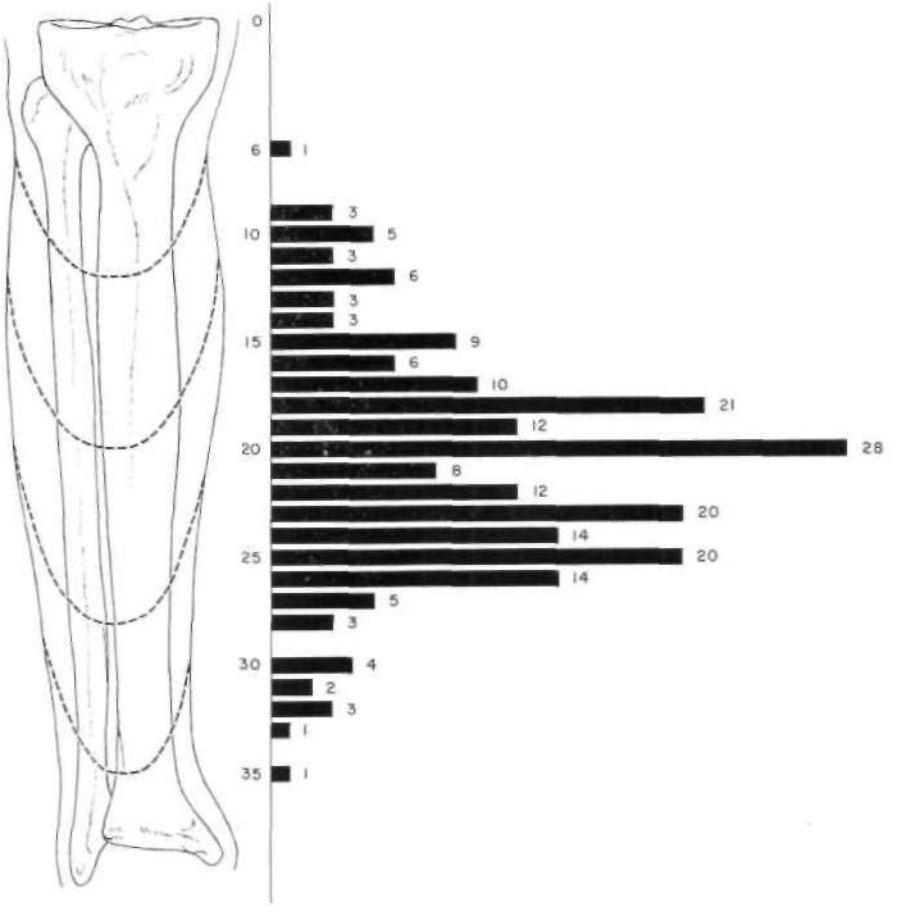


Fig 4. Lengths of the amputation stumps.

The closed socket caused excessive perspiration of the stump.

3. Have you worn your prosthesis (a) *when working indoors, (b) when working outdoors, (c) when working outdoors in very cold weather?* A total of 223 (97.8 per cent) had worn their prostheses while working indoors; 208 (91.2 per cent), while working outdoors; and 140 (61.4 per cent), while working outdoors in very cold weather.

4. Have you worn your prosthesis in some additional—part-time—occupation? (The intention was to elicit data regarding incidental jobs, recreation, and hobbies.) Only 21 replies were obtained on this point. One patient was a chauffeur, two were building their own houses, one was building a summer cottage, two fished, five were doing agricultural work, three did lumbering, six did gardening, and one was a night watchman.

5. *Have you previously used a prosthesis of some other material (wood, leather, or light metal)?* The majority had used conventional prostheses of wood or leather. Only a few had worn prostheses of light metal. Some amputees had had prostheses of all three materials in the course of years.

6. Have you been satisfied with your prosthesis? There were 206 (90.4 per cent) satisfied wearers. Only 22 (9.6 per cent) complained.

7. Do you think this prosthesis is {a) better than, (b) just as good as, (c) not as good as your previous limb? The replies were as follows:

Better than previous prostheses	207	(90.8 per cent)
Just as good as previous prostheses	8	(3.5 per cent)
Not as good as previous prostheses	12	(5.3 per cent)

First prosthesis (recent amputee)	1 (0.4 per cent)
Total	228 (100.0 per cent)

The great majority were satisfied with the PTB prosthesis. What appealed to them most was its lightness and the freedom from a thigh corset. This enabled the development of the thigh muscles in a short time. However, not all the amputees were able to manage without a thigh corset.

8. What defects or drawbacks have you observed in your PTB prosthesis? Listed below are the complaints of 26 amputees (12.3 per cent). In eight cases the complaints apply mainly to the stump, and in 18 to the prosthesis, but it is not always possible to distinguish sharply between the two.

Amputation stump	Prosthesis
Allergic reaction	Cold in the winter (two cases)
Circulatory disturbance	Socket closed and too warm (three cases)
Ulceration	Socket became too loose (two cases)
Itching	Socket pressed on the stump
Stump shrinkage	Flexion of the knee during work impossible because socket extends above knee
Perspiration	Unstable on slippery ground and without a thigh corset
Edema	Unstable in soft snow
Fatigue	Unstable on soft ground
	Excessive strain on the knee without a thigh corset
	Insert wears out too rapidly
	Heel of the SACH foot is too soft
	Toe of the SACH foot gradually bends upward
	Toe wears out too rapidly
	Difficult to ski

9. Has perspiration in the amputation stump constituted a problem? The replies were as follows:

Perspiration a problem	161 (70.6 per cent)
Perspiration not a problem	39 (17.1 per cent)
Initially excessive perspiration, later not	19 (8.3 percent)
Less perspiration than with other prostheses	9 (4.0 per cent)
Total	228 (100.0 per cent)

Owing to the closed, air-tight socket, perspiration was a major problem, particularly in the summer. It should be borne in mind, however, that this problem also occurs with conventional prostheses, although perhaps not to the same degree. The possibilities for reducing the perspiration problem are discussed later.

10. Has the skin on the stump tolerated the prosthesis? The skin tolerated the prosthesis well in **190** cases (83.9 per cent), better than with other types of prostheses in 14 cases (6.5 per cent), and not so well as with others in 24 cases (9.2 per cent).

11. Have reddening of the skin and eczema occurred? A total of 75 amputees complained of reddening and eczema, while 153 had no such symptoms.

12. Did reddening, eczema, or ulceration of the stump occur before you started using a PTB prosthesis, and, if so, for how long? In 157 cases (68.9 per cent) such symptoms had arisen from the use of conventional prostheses of wood, leather, or light metal.

13. What are your experiences with the new prosthesis outdoors in cold weather? A total of 142 amputees had worn their prostheses outdoors during the winter, and temperatures of -20 to -40 deg. C had caused no problem. Many had skied as much as 30 km. Only five (3.5 per cent) had found the new prosthesis too cold. Replies were as follows:

No complaints	111 (78.2 per cent)
Better than previous prostheses	5 (3 . 5 per cent)
Somewhat colder than previous prostheses	21 (14.8 per cent)
Very cold	5 (3 . 5 per cent)
Total	142 (100.0 per cent)

It developed from the replies that the vast majority of the patients had been able to wear their PTB prostheses regularly from the outset. Eighteen amputees had experienced discomfort of various kinds. In many cases there were only minor complaints, and the source of the trouble was readily dealt with. Sometimes the complaints related to phenomena always associated with the manufacture and fitting of prostheses.

It is noteworthy, too, that the patients wore their prostheses while performing hard labor.

The vast majority of the patients were satisfied. The dissatisfied wearers numbered 22 (9.6 per cent). The causes for complaint are specified in Table 2. The ages and stump lengths of these patients are indicated in the tabulation to permit evaluation of their possible influence. Data regarding all the modifications needed to make the prostheses fit for use, even the smallest repairs, were obtainable from the amputee cards.

TABLE 2. CAUSES OF COMPLAINT AND DISSATISFACTION WITH THE PTB PROSTHESIS

Case No.	Age yrs.	Stump Length cm.	Cause	Treatment
1	62	20	Unknown	No measure needed
2	54	15	Became too loose	Socket shell tightened
3	53		Ulceration	Socket insert exchanged
4	47	20	Became too loose	Socket shell tightened
5	49	15	Poor fit of socket shell	Socket shell tightened
6	54	20	Became too loose	Both socket shell and insert exchanged
7	49	15	Poor fit of socket shell	Both socket shell and insert exchanged
8	37	25	Knee was excessively strained	Thigh corset with sidebars supplied
9	44	19	Knee was excessively strained	Thigh corset with sidebars supplied
10	50	18	Stump shrinkage	Both socket shell and insert exchanged
11	59	21	Stump shrinkage	Both socket shell and insert exchanged
12	41	17	Inflammation of the stump	No measure needed
13	50	28	Became too loose	Socket insert exchanged twice
14	47	22	Circulatory disturbances in the stump	No measure needed
15	52	14	Became too loose	Socket shell tightened
16	45	13	Became too loose	Thigh corset with sidebars supplied, socket insert exchanged twice
17	46	28	Became too loose	Both socket shell and insert exchanged
18	61	15	Knee excessively strained	Thigh corset with sidebars supplied
19	41	16	Became too loose	Socket insert exchanged twice
20	49	12	Skin problems due to perspiration	First a thigh corset with sidebars was made, then a leather prosthesis
21	43	12	Unknown	No measure needed
22	46	23	Became too loose	Socket insert tightened

It is a characteristic feature of the PTB prosthesis that it immediately starts remodeling the stump, because of the intimate fit of the socket. During the first few weeks the stump shrinks, so that the socket becomes too loose. It can be seen in Table 2 that this occurred in 11 cases, or 50 per cent of the dissatisfied wearers. These patients were fitted with a new socket insert, and occasionally also with a new socket shell, which implies that a large part of the prosthesis had to be rebuilt. In many cases the insert had to be modified several times. These possibilities must be reckoned with when this type of prosthesis is prescribed.

The regeneration of the thigh muscles in those who managed without a thigh corset has already been mentioned. This phenomenon results from the greater muscular activity required to control the movements and the stability of the knee with the PTB prosthesis. After three weeks none of the wearers was able to use his old prosthesis with a thigh corset, because the corset had become too tight.

The genuine PTB prosthesis is furnished with only a narrow strap fixing it above the knee. In six cases it was necessary later to provide a thigh corset with sidebars, but the length of the corset was one-third to one-half of what is usual for conventional prostheses. These amputees had stumps which measured 12,13,15,19, 22, and 25 cm., respectively. Only half of these can be said to be particularly short. Obviously, the need for a thigh corset depends not only upon the length and shape of the stump, but also upon the stability of the knee. In three of the cases the knee had been strained. In one case the PTB prosthesis, even after being furnished with a thigh corset and sidebars, had to be replaced with a conventional prosthesis, but this was an exceptional case.

Excessive perspiration in the stump, particularly during the summer, constituted a major

problem. The closed socket insert and the air-tight material are its main causes, but the muscular atrophy because of inactivity and the resultant poor circulation contribute. A gradual decrease in perspiration might be expected to occur, considering the development of the musculature and improved circulation resulting in all amputees who manage without a thigh corset, and considering also the pump effect exerted on the stump by the tight-fitting socket. A similar effect has been observed as a result of placing a sponge-rubber pad at the bottom of conventional prostheses of patients with chronic eczema and ulceration of the stump (*1*). In the present series, however, a later decrease of perspiration was observed in only 8.3 per cent of the cases. In addition, four per cent reported that perspiration has all the time been less of a problem with the new prostheses.

When perspiration of the stump is excessive, skin complications—eczema and ulceration—are likely to occur. Data on skin symptoms in the present series were compared with corresponding data relating to the use of conventional prostheses. The comparison is hampered by the fact that the observation time is shorter for the PTB prostheses than for the older types. Results of the comparison were as follows:

	PTB	Conventional Prostheses
Reddening, eczema, ulceration	75 (32.9 per cent)	157 (68.9 per cent)
No complications	153 (67.1 per cent)	71 (31.1 per cent)
Totals	228 (100.0 per cent)	228 (100.0 per cent)

It appears that with the PTB prosthesis skin complications were about half as common as with conventional prostheses.

In cold winter weather, the PTB prosthesis is somewhat colder than prostheses made of leather or wood, but nonetheless satisfactory and fit for use.

In general, the difficulties arising in the present series were due mainly to reduction in the volume of the amputation stump, instability of the knee, and, in some cases, shortness of the stump, which necessitated the construction of a thigh corset. Also, skin complications sometimes occurred as a result of the excessive perspiration caused by the closed-socket insert. The first-mentioned circumstances were easy to cope with, while the skin changes constituted a real problem. In some cases, an opening was made in the distal end of the socket insert, or a number of small holes were drilled in the socket. In certain cases, a sponge-rubber pad was utilized, partly to exert a continuous light pressure on the stump and partly to absorb the moisture accumulating in the bottom of the socket insert.

When the PTB prosthesis was first introduced into Finland, we hesitated to prescribe it to amputees who move about much outdoors on soft ground; for instance, on fields and meadows, in the forest, and on snow. This group of persons consists mainly of farmers and lumbermen and the population of northernmost Finland. Our apprehensions have been confirmed only in occasional cases, and the general impression of the PTB prosthesis is favorable. The advantages far outweigh the drawbacks. In particular, the lightness of this prosthesis, the hygienic properties of the plastic material, and the regeneration of the thigh muscles should be emphasized.

Reference to the literature shows that others have encountered the same problems that are described here. Frank A. Witteck (5), writing in the June 1962 issue of *Artificial Limbs*, warned against prescribing the PTB prosthesis in cases with instability of the knee, to very heavy amputees, and in bilateral cases. However, if the stumps have been satisfactory, we have even fitted bilateral cases with PTB prostheses, and no special problems have occurred.

In our experience, the PTB prosthesis is contraindicated only in cases with instability of the knee and with very short stumps or with stumps of unsatisfactory shape.

Because numerous, careful fittings are required in these cases, it is desirable that a prosthetist's shop be within easy reach. The PTB prosthesis makes heavy demands on the skill of the manufacturer.

SUMMARY

This study was carried out on 228 amputees fitted with PTB prostheses. It is based on per-

sonal follow-up examinations, replies to questionnaires, and data obtained from record cards kept on the amputees.

The age group 40 through 54 years is the largest. War veterans comprise 94.3 per cent of the series, the remainder being insured civilians. In some cases the prostheses were worn by amputees engaged in heavy labor under difficult conditions. Of the amputees, 92.1 per cent were able to wear their prostheses regularly from the outset, and 90.4 per cent were very satisfied. In particular, they emphasized the lightness of the prostheses and the absence of tight thigh corsets, resulting in a sense of ease and freedom.

In some cases, complications were caused by a decrease in stump volume, a result of the intimate fit of the socket. This necessitated a change of socket insert, which is readily accomplished, and sometimes of the socket shell as well, which in effect amounts to making a new prosthesis. In certain cases, instability of the knee, the shape of the stump, and a stump length less than the optimum gave rise to symptoms which could be alleviated only by giving the amputee a thigh corset. The series includes four such cases (1.8 per cent).

PTB prostheses were also prescribed in bilateral cases, of which there were nine (3.9 per cent).

The study shows that the PTB prosthesis has been successfully worn in cold winter weather, although it is somewhat colder than prostheses made of wood or leather.

In all the amputees the thigh muscles developed enormously within a few weeks.

Excessive perspiration in the stump was a problem in many cases. This phenomenon is due to the intimate fit of the plastic socket. A gradual decrease of the perspiration was noted in 8.3 per cent. However, four per cent stated that, from the outset, perspiration had been less of a problem than with their previous prostheses. It should be borne in mind that during the warm season perspiration tends to be a problem with all prostheses.

The PTB prosthesis without a thigh corset is contraindicated in cases with instability of the knee and in cases with a very short stump or with a stump of unsatisfactory shape. Furthermore, caution is indicated in the prescription of this prosthesis to farmers, lumbermen, and others who move on soft and slippery ground.

The PTB prosthesis requires very careful fitting, and extreme care must be exercised in its manufacture. In cases where there is a long distance between the place of residence and the prosthetics facility, this is not perhaps the most appropriate type of prosthesis.

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Inverted V-Strap Suspension for PTB Prosthesis

Jack L Caldwell, C. P.[1]

The leather cuff-suspension strap described in *The Patellar-Tendon-Bearing Below-Knee Prosthesis (2)* and in the June 1962 issue of *Artificial Limbs* has been found satisfactory in the majority of cases (Fig. 1). However, in certain cases with short stumps suspension problems have arisen. One particular case (Fig. 2), a patient having a very short stump

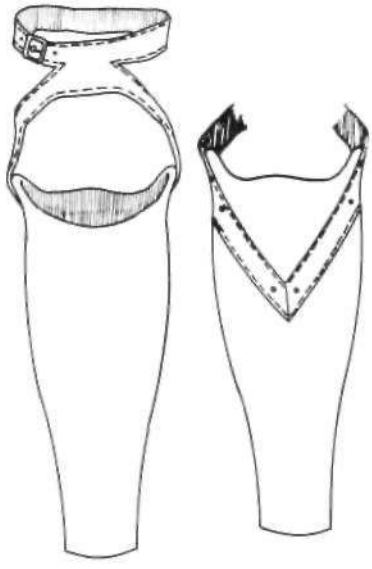

Fig. 1. Anterior and posterior views of typical cuff-suspension system for PTB prosthesis.

(2 3/4 in.), presented such a critical suspension problem that other means of achieving suspension were attempted. The first approach was a figure-eight dacron strap with Velcro for adjustment (Fig. 3). A continuous strap encircling the thigh was crossed over the patella. The ends of the strap were attached to the socket. Socket retention was improved, but some disadvantages were noted. When tightened sufficiently to provide good suspension, the strap caused a circumferential constriction above the knee impairing stump circulation (Fig. 4). Furthermore, this type of suspension did not provide an adequate extension stop for the knee.

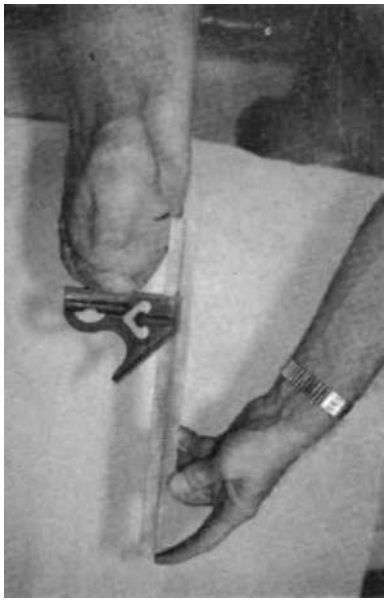

Fig. 2. Very short below-knee stump.

Continued experimentation led to the use of the present suspension system using two straps looped through a ring for socket suspension (Fig. 5). The suspension system consists of two straps 1 in. wide and approximately 16 in. in length. When looped through a stainless steel ring, these straps form two inverted V's with the apex of each inverted V passing through the ring. The ends of the V-straps are attached

[1] J. E. Hanger, Inc., of Florida, 938 South Orange Ave., Orlando, Fla.

Fig. 3. Continuous-strap suspension arranged in a figure-eight with Velcro for adjustment.

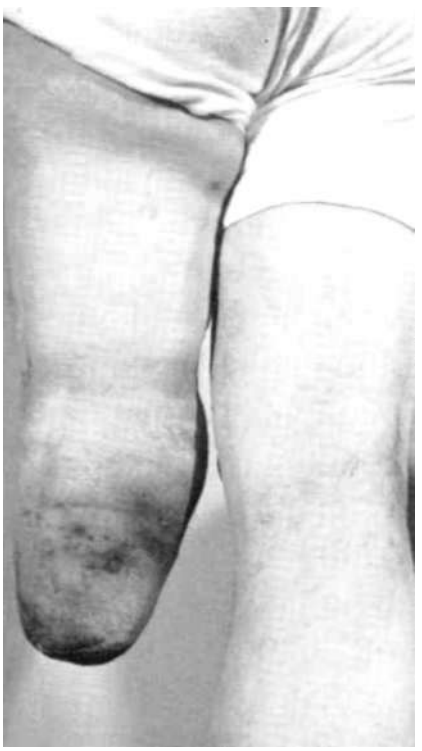

Fig. 4. Effect of circumferential constriction above the knee.

to the socket. Each strap has one end anteriorly and one end posteriorly attached to the proximal socket, thereby providing a four-point suspension. The ring joins both straps and is attached to a flexible waist belt by an elastic thigh strap. No circumferential strap is used about the thigh; a waist belt and a thigh suspension strap, plus the free-sliding characteristics of the two V-straps through the ring, provide firm suspension in all positions of knee extension or flexion.

The strap attachments to the socket should be placed so as to prevent knee hyperextension. The proper sites for strap attachment to the socket are related to the length of the stump. Usually, the shorter the stump the more anterior and proximal are the sites for attachment of the anterior suspension strap. The average short stump of 3 to 4 in. requires that the anterior attachments be located approximately 1 in. above the patellar-tendon contour of the socket and at each side of the patella,

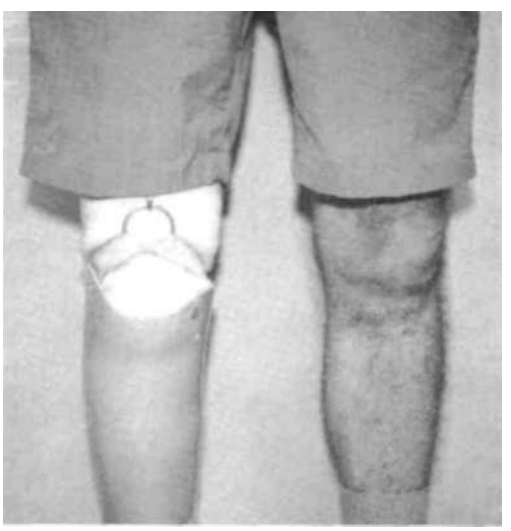

Fig. 5. Anterior view of two inverted V-straps looped through a ring and attached inside a hard socket close to the brim.

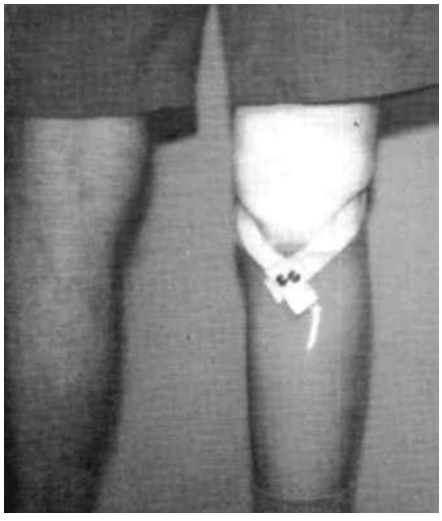

Fig. 6. Posterior view showing a common attachment point for the posterior straps. The attachment points may be either together or separate, and the straps may be attached either inside the socket or outside. Care must be taken to prevent the strap from rubbing against the (iliotibial) tendons on the lateral side of the thigh.

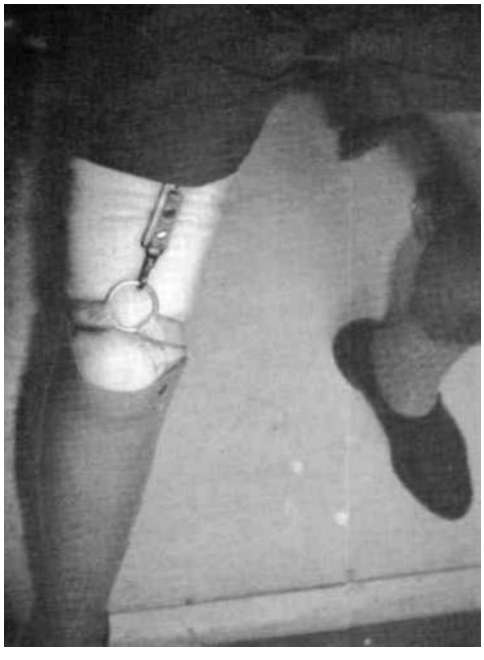

Fig. 7. Top view of the V-straps with the knee extended.

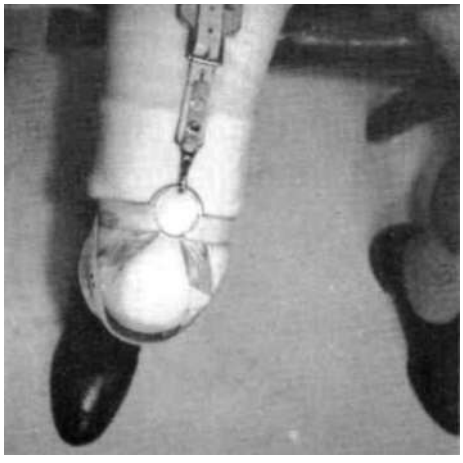

Fig. 8. Top view of the V-straps with the knee flexed.

Fig. 9. Posterior-oblique view showing retention of the prosthesis to the slump while the knee is flexed.

with sufficient space for the patella to pass between the straps as the knee is flexed. The posterior socket attachments may be located in the popliteal section of the posterior socket as shown in Figure 6. If the socket wall is thick, the posterior straps should be permitted to pass between the stump and the inner socket walls as illustrated in Figures 5, 6, and 7.

The V-straps must be sufficiently short to hold the ring down firmly against the superior margin of the patella. The elastic thigh strap may be adjusted for proper tension above the knee to prevent the ring from slipping down upon the patella.

The ring must be sufficiently large to permit two 1-in. dacron webbing straps to slide through it without overlapping one another (Figs. 7, 8, and 9). The ring shown in the illustrations accompanying this article is the Northwestern University upper-extremity harness ring described in the June 1962 issue of *Artificial Limbs.* It is an O-ring. If a D-ring is used, the flat side should be turned upward. A quick-disconnect snap fastener as illustrated may be used to connect the elastic thigh strap to the ring.

As the knee is flexed, the suspension straps remain comfortable, and strap tension does not change regardless of knee position. Figures 8 and 9 show a knee in full flexion. The dark areas on the V-straps demonstrate the amount of their excursion through the ring as the knee is flexed. When the knee is extended, the ring will slip forward over the shadowed areas, returning to the position shown in Figures 5 and 7.

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Orthopaedic Shoes for Bilateral Partial Foot Amputations[1]

ANTHONY STAROS, M.S.M.E.,[2] and
EDWARD PEIZER, Ph.D.[3]

MOST physicians and competent orthotists recommend the use of orthopaedic shoes in cases requiring shoe modifications or braces. However, in practice, the term "orthopaedic" is loosely applied to a variety of shoes of widely different cost, construction, function, durability, and appearance. Orthopaedic shoes are distinguished from stock or nonorthopaedic shoes by a steel shank, a long, high, reinforced counter and internal corrections; prescribed modifications are incorporated as elements of the shoe construction rather than added externally. These are clear differences, and the superiority of orthopaedic shoes is generally recognized.

Although related, there are two vastly different types of shoes labeled "orthopaedic." One is the kind of shoe described above, which is usually referred to as the *custom* orthopaedic shoe; the other is the *stock* orthopaedic shoe. The latter usually contains a steel shank, and in certain instances it also includes a long medial counter and Thomas heel. At this point, however, the similarity to custom orthopaedic shoes ends. Additional corrections which are prescribed must be added externally. They do not include the reinforcement required to prevent "breaking" of the sole at undesirable points and to prevent lateral bulging of the uppers.

Despite these disadvantages, stock orthopaedic shoes are frequently prescribed or selected by patients. Cost is probably a significant if not decisive factor since typical costs for stock orthopaedic shoes average half or less than half the cost of custom orthopaedic shoes. On analysis, however, cost differences tend to narrow, as the useful life of custom orthopaedic shoes is longer. In our opinion, the functional and cosmetic advantages of custom orthopaedic shoes far outweigh the cost differential.

Apart from considerations of cost, stock orthopaedic shoes may be selected because the appearance to the untutored eye of a new pair seems adequate, and because the patient may seem initially to walk in much the same manner when wearing equally new custom orthopaedic and stock orthopaedic shoes. Not immediately apparent are the quick deterioration and shorter life of the stock orthopaedic shoe and the functional value of the custom orthopaedic shoe. Because of adaptive measures employed by the patient to overcome deficiencies in the stock shoe and to present a normal appearing gait, the external appearance of the gait pattern with the custom shoe may not always be superior. Adjustments made by the patient to adapt himself to the shoes are revealed in the interaction of forces between the foot and the ground during the stance phase of walking. It is primarily to these forces that the wearer of custom shoes reacts when expressing a preference for the function of one shoe over another, even though improvements by a reduction in gait deviations may go undetected during visual observation.

A recent experience illustrates these points. A young man with congenital deformities of the feet, for whom orthopaedic shoes had been prescribed, was tested in our laboratory. (He also had congenital deformities of the hands.)

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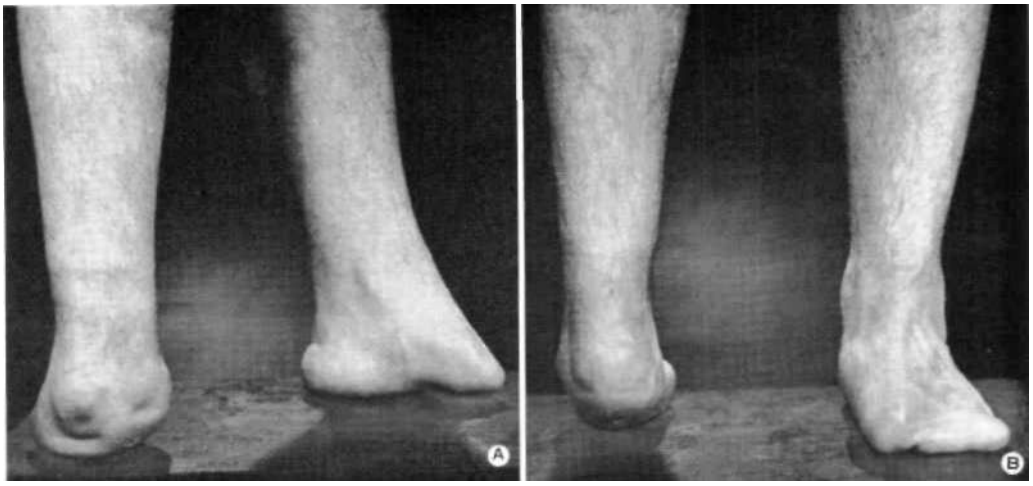


Fig. 1. Congenital bilateral amputations with absence of tarsals in the right foot and presence of tarsals in the left. *A,* Lateral view; *B,* frontal view.

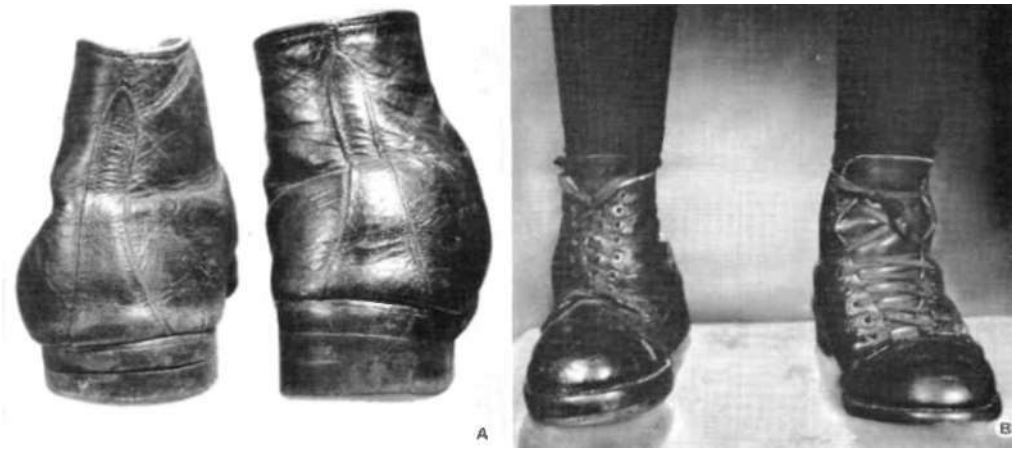


Fig. 2. Stock shoes showing deformation after 12 months' wear. *A, B,* Externally added heel and sole extensions can be seen.

He was considered an excellent subject for this type of analysis because of the remarkable adaptations he had made to his deformities. Despite their severity, he was an extremely adept walker with a nearly normal gait whether he wore shoes or not. We believed that his high adaptability would tend to mask, to an unusual extent, any gross differences in his gait and that, therefore, detectable differences could be attributed to the function offered by the shoe.

THE SUBJECT

The subject for this study was a 19-year-old congenital amputee with partial hands and feet (Fig. 1). At the initial examination he was wearing previously prescribed stock orthopaedic shoes with steel shanks as the only special feature. Added externally were sole and heel extensions (Fig. 2). After approximately 12 months of wear a severe break in the tarsal region of the right shoe and another, though

Fig. 3. Stock shoes showing: *A,* break in tarsal region; *B,* uncosmetic external corrections; C, protruding short steel shank and a wear pattern indicative of lack of support in the metatarsal and toe areas.

less severe, of the left shoe were exhibited. The lateral walls of both shoes bulged excessively, resulting in permanent deformation and reduction of support. The short steel shank protruded through the sole at a point corresponding to the break, and the wear of the soles revealed a pattern of little or no support anterior to the shank which terminated at a point corresponding to the tarsometatarsal joint line (Fig. 3).

He was fitted at a commercial establishment with a prescription for custom orthopaedic shoes recommended by the Veterans Administration Prosthetics Center (Fig. 4). These shoes were specially reinforced with long, flat steel springs and steel shanks installed between inner and outer soles to increase the resistance to dorsiflexion after mid-stance and to shift the "toe break" further forward. They also featured stiff, high, long counters and a wider heel base with a reversed Thomas heel on the right shoe to increase lateral support. An inside cork extension was prescribed to accommodate leg shortening. After four months of use the wear pattern of the soles indicated that the patient was receiving support; that is, resistance to dorsiflexion or "shoe break" extended all the way out to the toe (Fig. *4B).*

PROCEDURES

To record the gait performance of the patient as completely as possible, several methods were employed. Thirty-five mm. motion pictures were taken in both the anteroposterior and the mediolateral planes as the patient walked with his old shoes and with his new shoes. Similarly, cyclographic recordings were made of angular and linear displacements at the hip, knee, and ankle. Force plates were used to record the ground reaction forces during stance phase. Finally the patient's opinions were recorded.

RESULTS

A motion-picture analysis showed that the subject walked very well with both stock and custom orthopaedic shoes. He was able to make small but significant compensations in his body alignment and in the timing of his movements with the result that the total body

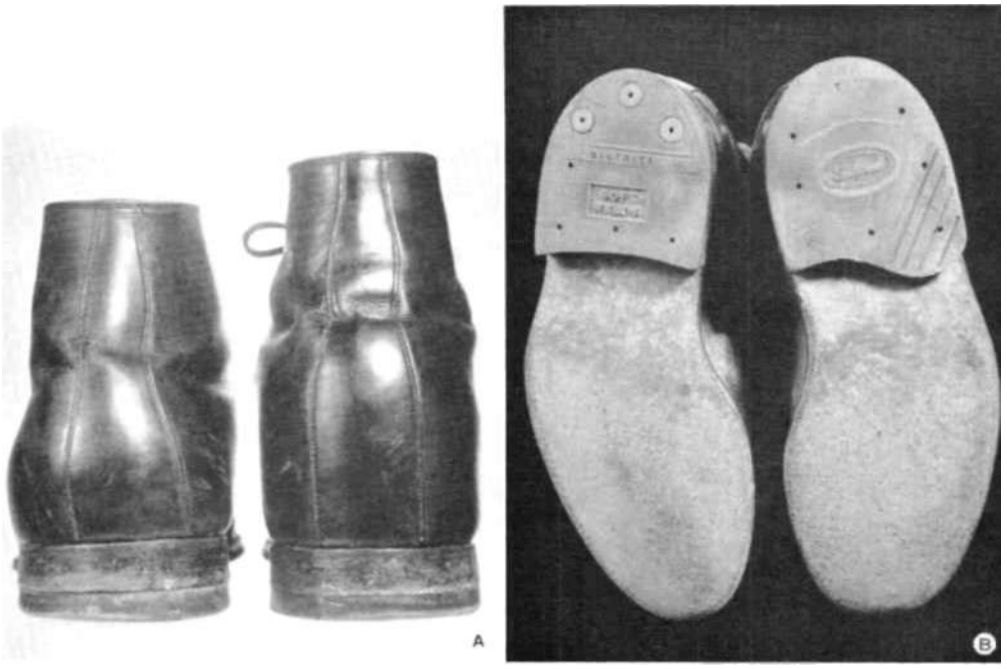


Fig. 4. Custom shoes after four months' wear showing: *A,* cosmetic advantage; *B,* **reversed Thomas** heel and an even wear pattern indicative of support provided over entire surface.

center of gravity maintained a smooth translatory path.

In general, the more detailed cyclographic recordings clearly demonstrated a remarkable ability on the part of the patient to maintain a reasonably normal gait pattern despite differences in functional losses between right and left leg and substantial differences in the height and functional character of the shoes.

As shown in Figures 5 and 6, displacement patterns—that is, the motions of the hip, knee, and ankle in space—were essentially similar with both stock and custom shoes. The consistently higher elevation of each of the major joints with the custom shoe was due simply to differences in the elevation of the shoes.

Although knee-flexion patterns with custom and stock orthopaedic shoes were generally similar, flexion of the left knee during the early stance phase was reduced substantially with the custom shoes (Fig. 7). This was attributed to the increased support provided by the custom shoes in the tarsometatarsal region with a consequent reduction of the "drop off" on the right leg during late stance. As a result of the excessive "drop off" due to the "break" of the stock orthopaedic shoes, the hip remained at a lower elevation than it would otherwise have attained. The lower hip elevation necessitated additional compensatory flexion of the left knee by the patient in order to walk in a reasonably symmetrical manner. Reducing the "drop off" maintained the hip at a higher elevation and made this additional knee flexion unnecessary.

A computation of the actual forces applied to the ground was made by resolving both vertical and horizontal force components. Indicated in the following tabulation are the peak forces applied to the ground during the period of heel contact to foot flat and between the instant of heel off and push off in two trial runs with the stock shoes and in two trial runs with the custom shoes.

Axial load (lb.) in two typical trials

		Heel Contact to Foot Flat		Heel Off to Push Off		Differences	
	Trial	Right	Left	Right	Left	Right	Left
Stock shoes	1	225	263	185	192	40	71
	2	219	252	184	192	35	60
Custom shoes	1	211	258	195	192	16	66
	2	212	251	188	193	24	58

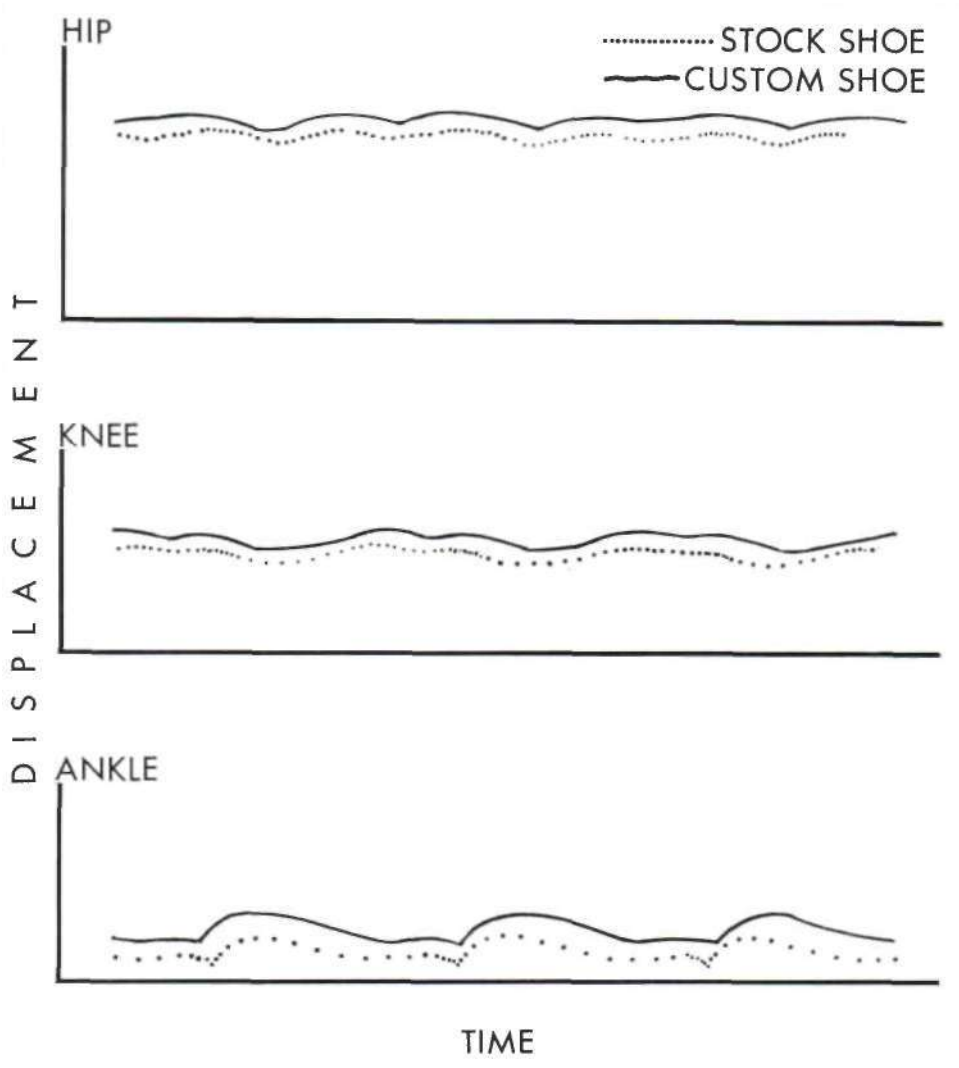


Fig. 5. Horizontal displacement of targeted points on the subject's right lower extremity during ambulation,

As the patient weighed 196 lb., it may be seen that the differences between the first and second peaks were substantially lowered on the right foot and somewhat less diminished on the left foot when the custom shoes were worn, demonstrating a more nearly equal application of forces to the ground. These differences were due primarily to his ability to maintain higher fractions of his body weight on the supporting foot after heel off.

Figure 8 graphically illustrates, for comparative purposes, the average peak magnitudes of the axial load during heel contact to foot flat, and during heel off to push off. The most significant effect on gait of the custom shoes was to diminish the magnitude of the force with which the heel was initially applied to the ground and to increase the force applied to the ground during the portion of stance corresponding to the period between heel off and push off. Although the absolute values of these changes are small, they had highly significant

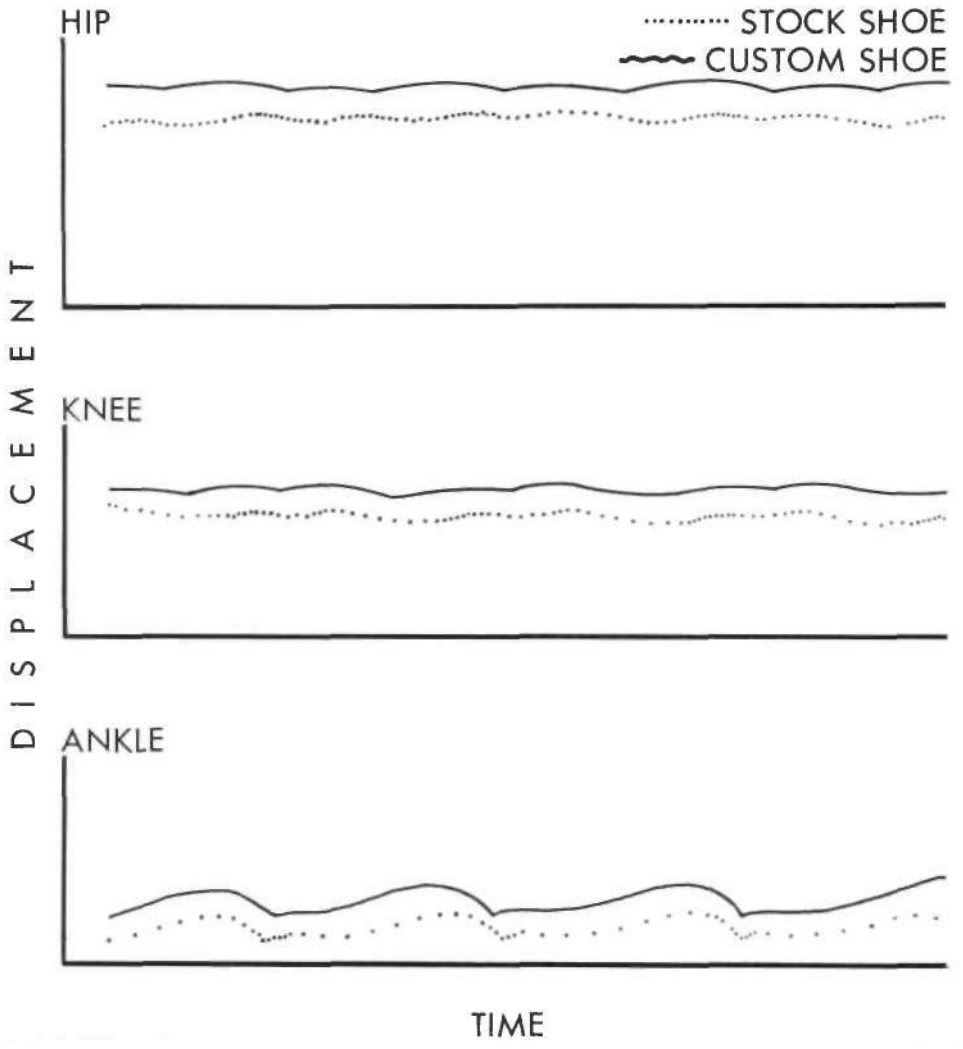


Fig. 6. Horizontal displacement of targeted points on the subject's left lower extremity during ambulation.

effects in reducing the patient's adaptive efforts and in reducing shoe wear. As might be expected in the complete absence of plantarflexion in the right foot, the effects were greater on the right side.

SUBJECT'S OPINION

The subject stated unequivocally that the custom orthopaedic shoes were far superior to the stock shoes that he had previously worn. They were more comfortable, they provided better support, and the inside buildup was more cosmetically desirable. The subject wore the custom shoes home and refused to take the stock shoes with him, discarding them on the spot.

SUMMARY

There is very little question in our minds of the superiority of custom orthopaedic shoes over stock orthopaedic shoes. Even in the case

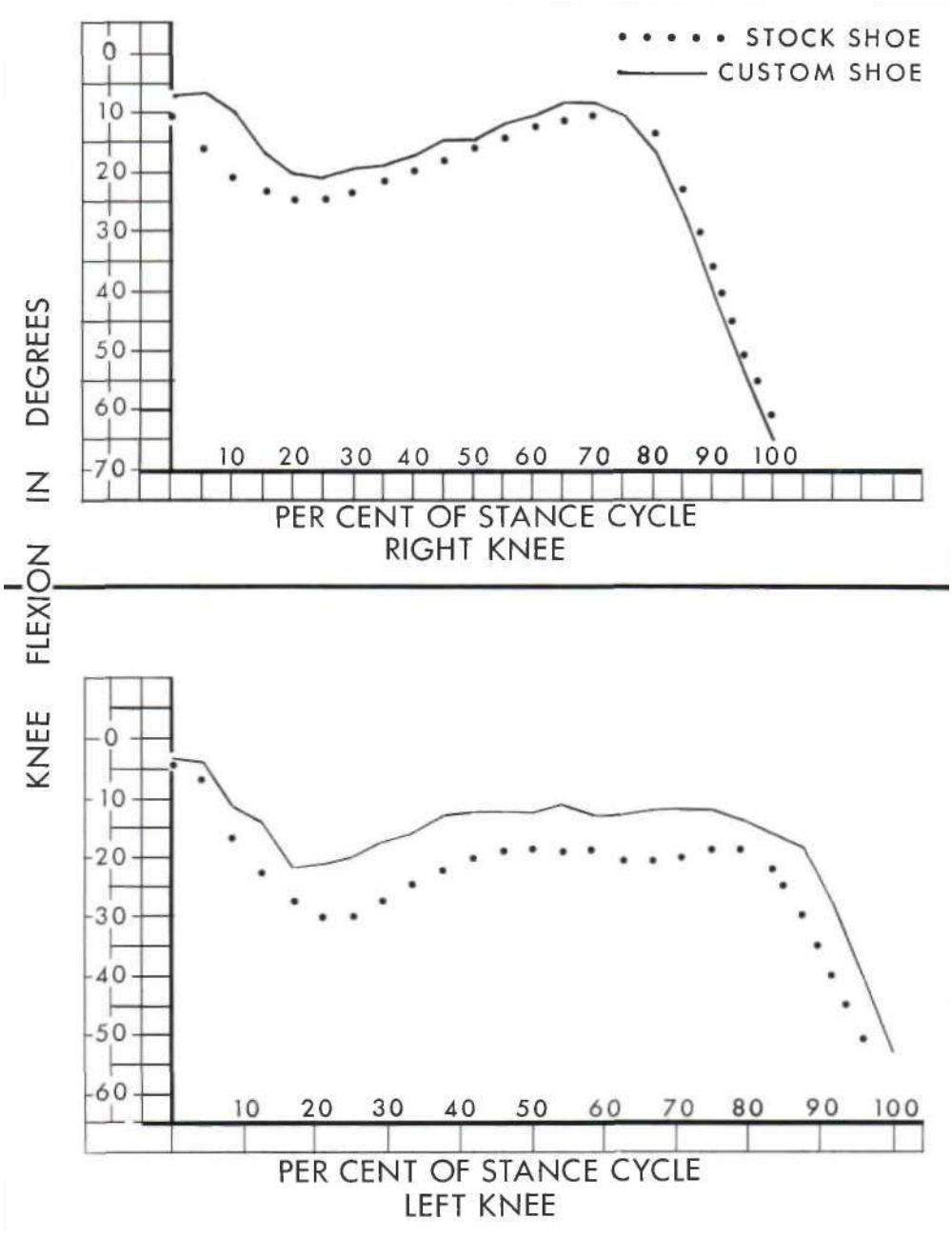
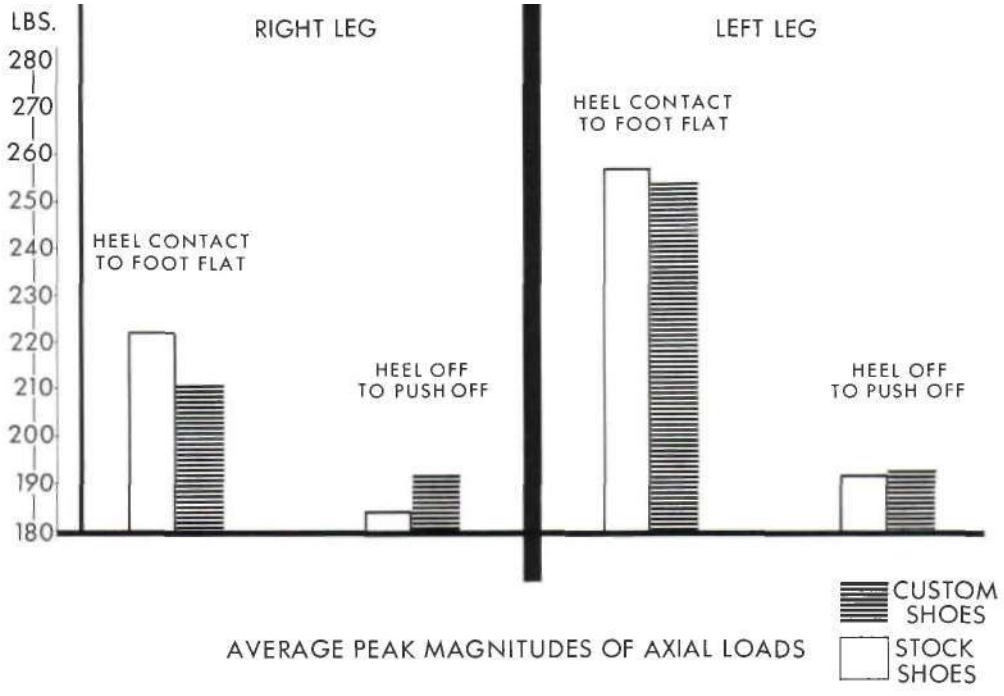


Fig. 7.

described in this article when, at first glance, the need might be considered minimal, clear advantages were provided. On this functional basis alone preference should go to custom orthopaedic shoes. Further study of the life expectancy of custom and stock orthopaedic shoes should serve to clarify objectively where real economy in this matter lies.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HEEL OFF
TO PUSH OFF
HEEL CONTACT
TO FOOT FLAT
HEEL OFF
TO PUSH OFF
CUSTOM
SHOES
STOCK
SHOES
AVERAGE PEAK MAGNITUDES OF AXIAL LOADS

Fig. 8.

Application of the Veterans Administration Prosthetics Center Below-Knee, Weight-Bearing Brace to a Bilateral Case[1]

ANTHONY STAROS, M.S.M.E.,[2] and
EDWARD PEIZER, Ph.D.[3]

The Veterans Administration has many beneficiaries who suffer from an inability to bear weight on their feet. Etiologies include gunshot wounds, crushing injuries, painful ankylosis, arthritis, and other conditions which produce pain upon bearing weight. For many years, these patients have been fitted with long leg (leg-thigh) braces in an attempt to unweight the leg at the level of the ischium, or they have been required to use crutches and braces. Either method results in the loss of knee function in order to treat a condition of the feet, ankles, or tibiae.

In an effort to provide more effective orthotic treatment, the Veterans Administration Prosthetics Center developed[4] a brace designed to unweight the foot at the level of the patella and tibial condyles, an adaptation of the patellar-tendon-bearing prosthesis. It consists essentially of a PTB-type prosthetic socket modified to permit donning by means of a posterior "door," or hinged section, which is closed with Velcro fasteners. Attached to the hinge and sandwiched between the layers of the laminate is a framework which permits vertical adjustment of the socket on the sidebars. Conventional stirrups are used with sidebars which insert into channels provided in the socket. In general, ankle joint motion is completely restricted in dorsiflexion and limited in plantarflexion. The shoes are modified to include a resilient heel pad (SACH foot principle) and a rocker bar. Details of the construction have been reported previously *(2,3).*

During the past four years, approximately 80 veterans have been fitted with this device. On a clinical basis, this treatment is considered successful because patients continue to wear and prefer the below-knee, weight-bearing brace, returning at regular intervals for replacement. The Veterans Administration Prosthetics Center has not attempted an objective evaluation of its own development, but the Orthotic Study Group of New York University is now independently evaluating the cases that have been fitted in an attempt to determine the general utility of the brace. The Veterans Administration Prosthetics Center is participating in this study only to the extent of providing the electronic instrumentation to measure the loads borne by the braces, or the degree to which the brace unweights the leg.

Until recently, all the patients fitted with this brace at the Center were unilateral brace wearers. However, in July 1964 a veteran was fitted bilaterally, and the results were highly successful, if not dramatic.

The patient, first examined at the Veterans Administration Prosthetics Center in July 1964, was 46 years old, 5 ft. 4 in. tall, and

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[4] This development was stimulated by a difficult case referred to the Veterans Administration Prosthetics Center by Dr. G. Rubin, of the Veterans Administration Brooklyn Outpatient Clinic, who suggested that his patient "be fitted as a below-knee amputee."

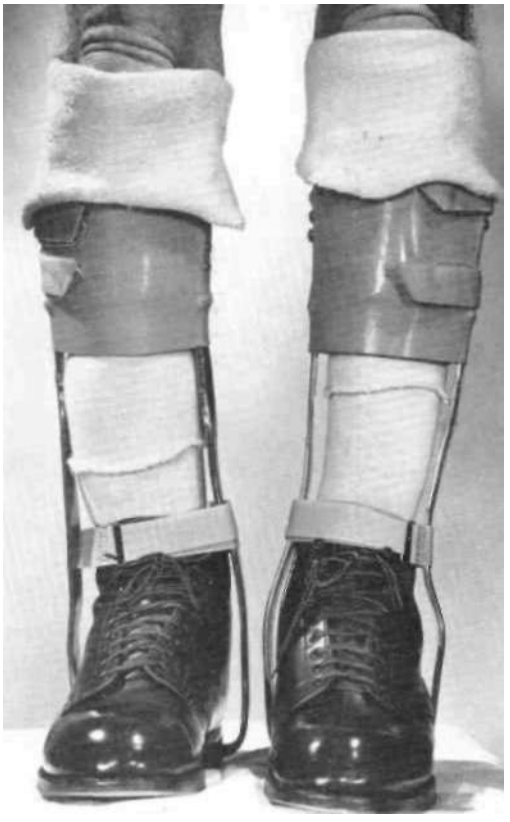

Fig. 1. Anterior view of VAPC below-knee, weight-bearing braces, showing the alignment of sidebars to conform to deformities of the legs and the elevation of The patellae as weight is borne by the patellar tendons.

weighed 129 lb. with braces. Although unemployed, he was active in working around his home and the community. Both legs were deformed as a result of an explosion in 1944, during World War II. The severe damage included incomplete union of the right tibia, with bone spurs, shortening of the left leg, complete ankylosis of both ankles, and loss of muscle power in the thighs, due to disuse atrophy. He experienced severe pain when he bore more than a small fraction of his body weight on his feet.

He had been fitted in 1957 with bilateral, short leg braces consisting of molded leather cuffs with anterior lacing, one-piece sidebar-stirrups without ankle joints, and custom orthopaedic shoes. For 17 years he walked with the aid of his two braces and two axillary crutches, using the swing-through gait.

PRESCRIPTION

The clinical evaluation resulted in a prescription for bilateral below-knee weight-bearing braces with unitary sidebar-stirrups providing no ankle motion. Also prescribed were orthopaedic shoes with high quarters, soft inner molds, soft-cushion heels, and rocker bars (Figs. 1, 2, and 3).

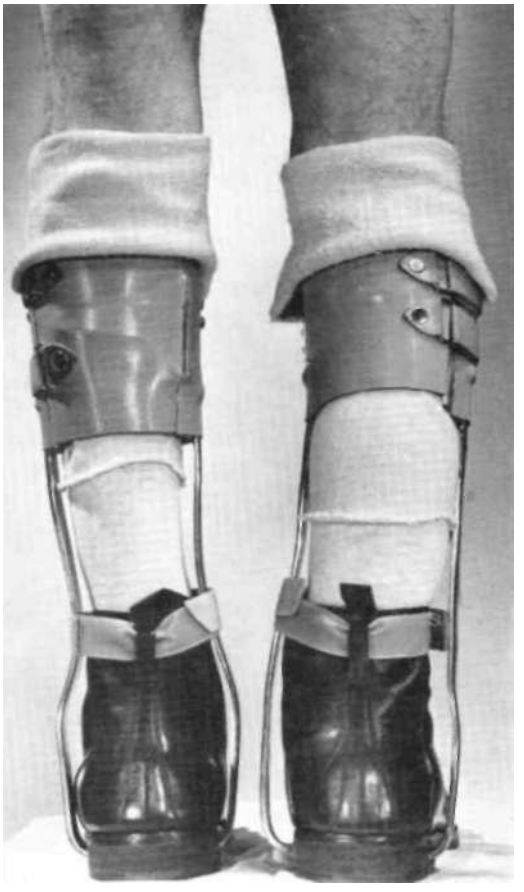

Fig. 2. Posterior view of VAPC below-knee, weight-bearing braces, showing the rear openings. The detachable stirrups are provided with ankle straps for added safety.

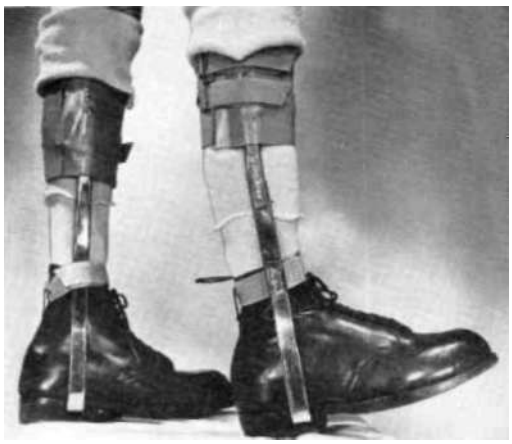

Fig. 3. Lateral view of VAPC below-knee, weight-bearing braces, showing the Velcro fastenings, the absence of ankle joints, the resilient heel pads, and the rocker bars.

PROGRESS

The below-knee braces were delivered in August 1964, whereupon it was observed that the patient could walk for short distances without the aid of crutches. He was cautioned to try to walk without crutches gradually in order to avoid excessive and unaccustomed stresses. In addition, physical therapy was recommended to improve the strength of the knee flexors and extensors. One month later, in September 1964, he reported swelling of the right leg, and the socket was relieved slightly to reduce constriction. The clinic team report during that visit revealed that:

1. The patient had been wearing the below-knee weight-bearing braces 12 hours per day, every day.
2. He walked for approximately three to five hours per day with the assistance of one axillary crutch.
3. He had used the below-knee braces without crutches during the first three to five days after delivery.
i. Walking without crutches for a distance of approximately 80 feet caused fatigue. But after a two- to three-minute rest, he was able to continue.
5. He commented to the effect that "These are the best braces. . . ."

During the next three months the patient reported no significant difficulties and indicated great satisfaction and substantially improved mobility, with less dependence on his crutches. The relatively dramatic change in this case gave rise to several significant questions:

1. To what extent was the below-knee brace unweighting the foot during the period from heel contact to toe off?
2. What was the character of the gait pattern without crutches in relation to standards of normal locomotion?
3. What were the patient's reactions and experiences?

In January 1965, after approximately four months of continuous wear of the below-knee braces, the subject's performance was evaluated in a series of biomechanical analyses conducted by the Bioengineering Research Service of the Veterans Administration Prosthetics Center in an effort to answer these questions.

EVALUATION

This study was not designed on the "before-and-after" model of a comparative analysis since there is no basis of comparison between

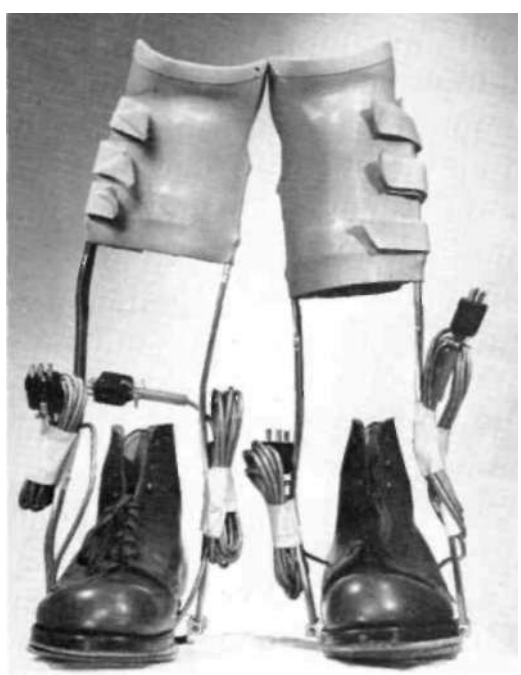

Fig. 4. VAPC below-knee, weight-bearing braces equipped with instrumented stirrups to measure amount of body weight applied to the ground via the brace sidebars.

walking with crutches and unaided gait. It was primarily planned to measure the forces transmitted to the ground as the patient walked and, in order to determine the extent to which the brace "unweighted" the leg, to identify the portion of body weight that bypassed the tibia and was applied to the ground via the brace sidebars. A second purpose was to describe the character of the gait exhibited by the patient in relation to normal locomotion patterns. The first purpose was accomplished by means of a specially designed, instrumented brace stirrup (Fig. 4) and the second by means of conventional force plate and cyclographic recording techniques previously described in *Artificial Limbs (1,4)* and elsewhere.

The stirrup of the instrumented weight-bearing brace consists of two cantilever, rectangular, prismatic beams (Fig. 5). The ends of the beams are connected to the sidebars of the brace by means of low-friction pin joints. Equidistant from the center line on each beam surface are two SR4, A-7 Constantin wire strain gauge grids.

When the sidebars bear weight, the beams bend causing a resistance change in the gauges and producing a voltage potential directly proportional to the force. Under torsional bending (twisting action equivalent to plantarflexion or dorsiflexion) all four gauges are equally affected causing no voltage change; only the axial force is recorded. Calibration studies indicated that variations in linearity and repeatability did not exceed 0.50 per cent.

By means of the instrumented stirrup it was possible to measure the portion of body weight carried by the brace during the stance phase. As the patient walked across the force plates, the axial loads borne by the sidebars and the total vertical and shear forces applied to the ground were recorded simultaneously. Linear displacements of the ankle, knee, and hip, the angular displacement about the knee, and the time spent in the stance and swing phases were recorded by means of the cyclograph.

RESULTS

UNWEIGHTING THE LEG

Depicted in Figure 6 (for the left leg) and Figure 7 (for the right leg) are curves representing ground reaction forces resulting from the application of the patient's body weight to the ground during a typical stance-phase portion of the walking cycle. The vertical and the fore-and-aft shear components of the ground reaction forces are shown in the upper portion of each figure, and their orthogonal projections into axial loads are shown in the lower portions. The axial load borne by the sidebars of each brace is shown under the axial component of the ground reaction force.

Figure 6 indicates that the brace on the left leg carried approximately 96 per cent of the total axial load applied to the ground during the first 20 per cent of the stance-swing cycle, a point well past foot flat and within the region of mid-stance. Thereafter, the distribution of axial load changed with the brace bearing decreasing loads through the next 20 per cent of the cycle (just past heel off), where it bore about 60 per cent of the axial load. Sixty per cent of the diminishing axial load was carried by the brace for the remaining 20 per cent of the cycle until swing phase began.

Figure 7 indicates that the brace on the right leg continuously supported approximately 25 per cent of the axial load during the entire stance phase of the stance-swing cycle.

From the foregoing it can be seen that the subject was capable of tolerating approximately 75 per cent of the load on his right foot and loads ranging from 4 per cent to 40 per cent on the left leg. This distribution of loads (body weight plus inertial forces) between the foot and the brace permitted him to walk comfortably and in a reasonably normal manner. Adjustment of the load distribution between the foot and the brace can be accomplished by changing the length of the sidebars, or by changing the resiliency or the depth of the innersole.

GAIT PATTERN WITHOUT CRUTCHES

In addition to unweighting the patient, these braces also permitted him to walk with a reasonably satisfactory, normal-appearing gait. To describe his gait pattern several techniques were employed. Motion pictures of his walking performance were analyzed to identify deviations from the normal gait pattern. Cy-

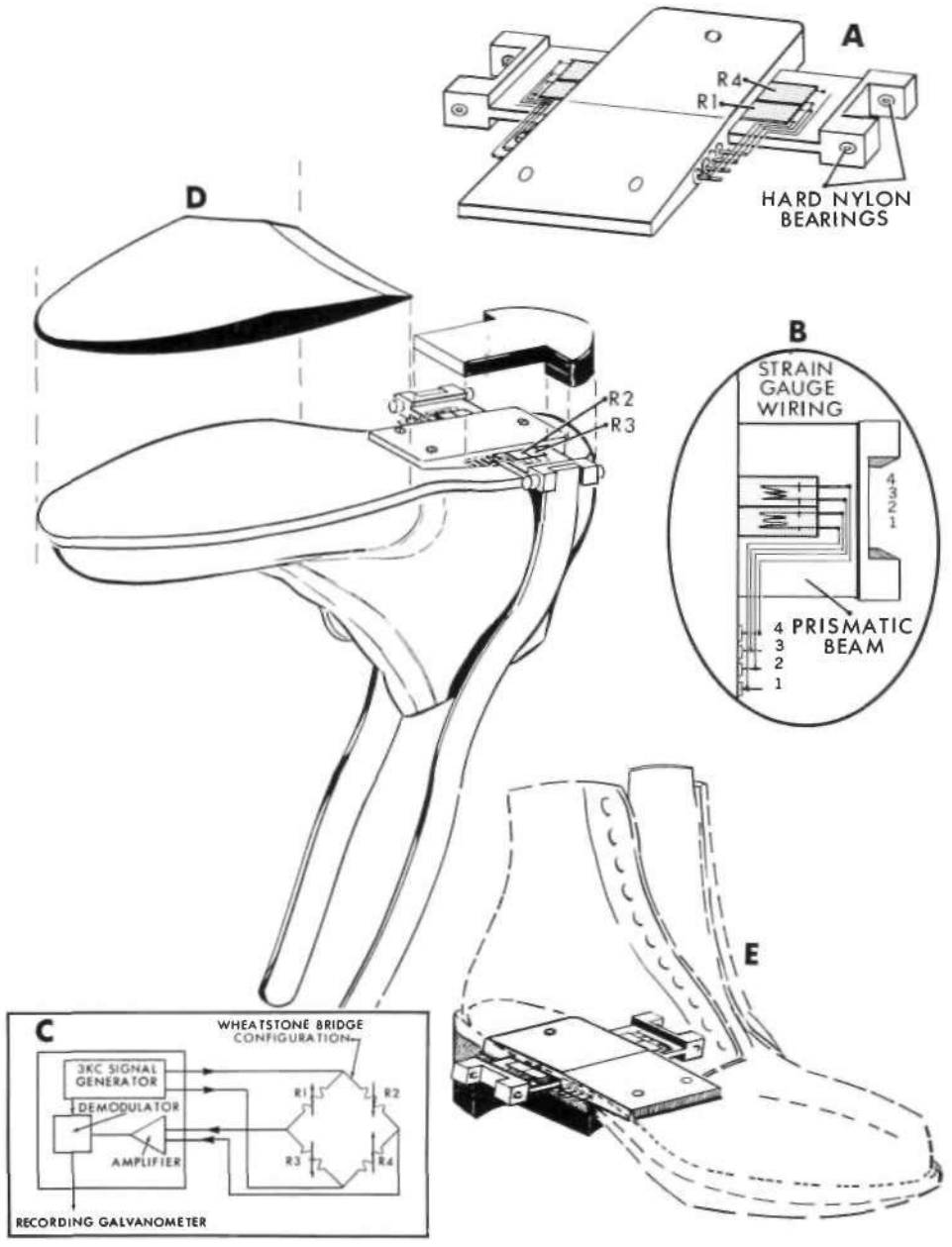

Fig. 5. Schematic representation of instrumented weight-bearing braces. *A,* Cantilever beam with strain gauges attached; *B,* close-up of the strain gauges on the beam; C, strain-gauge circuitry; *D, E,* installation of instruments in orthopaedic shoe.

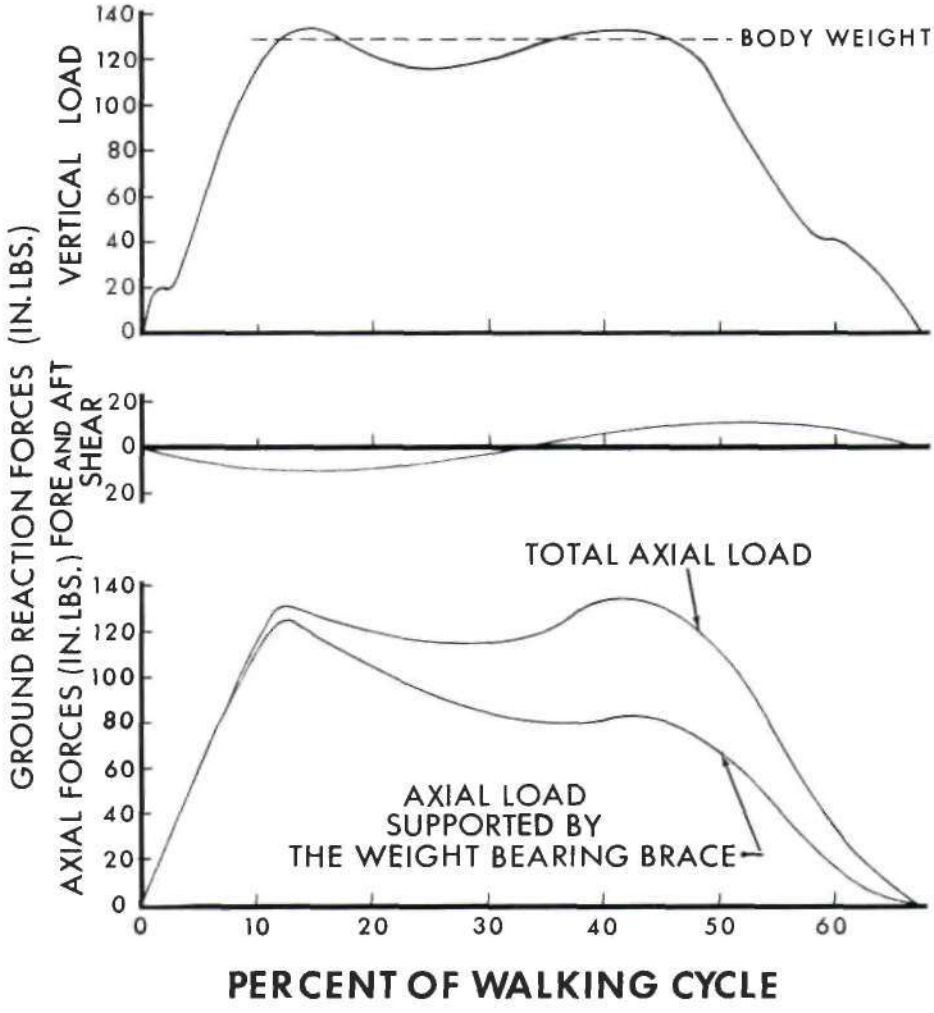

Fig. 6. Curves representing ground reaction forces during the stance phase of the left leg.

olographs were analyzed to provide a more objective analysis of the temporal and kinematic aspects of gait.

Gait Analysis

Motion-picture studies revealed that the subject walked more slowly and deliberately than the normal nonbrace-wearing subject and exhibited the following gait deviations: moderate abduction, slight sidesway, and excessive knee flexion during the stance phase. Neither the abduction nor the sidesway were of a magnitude to detract substantially from the

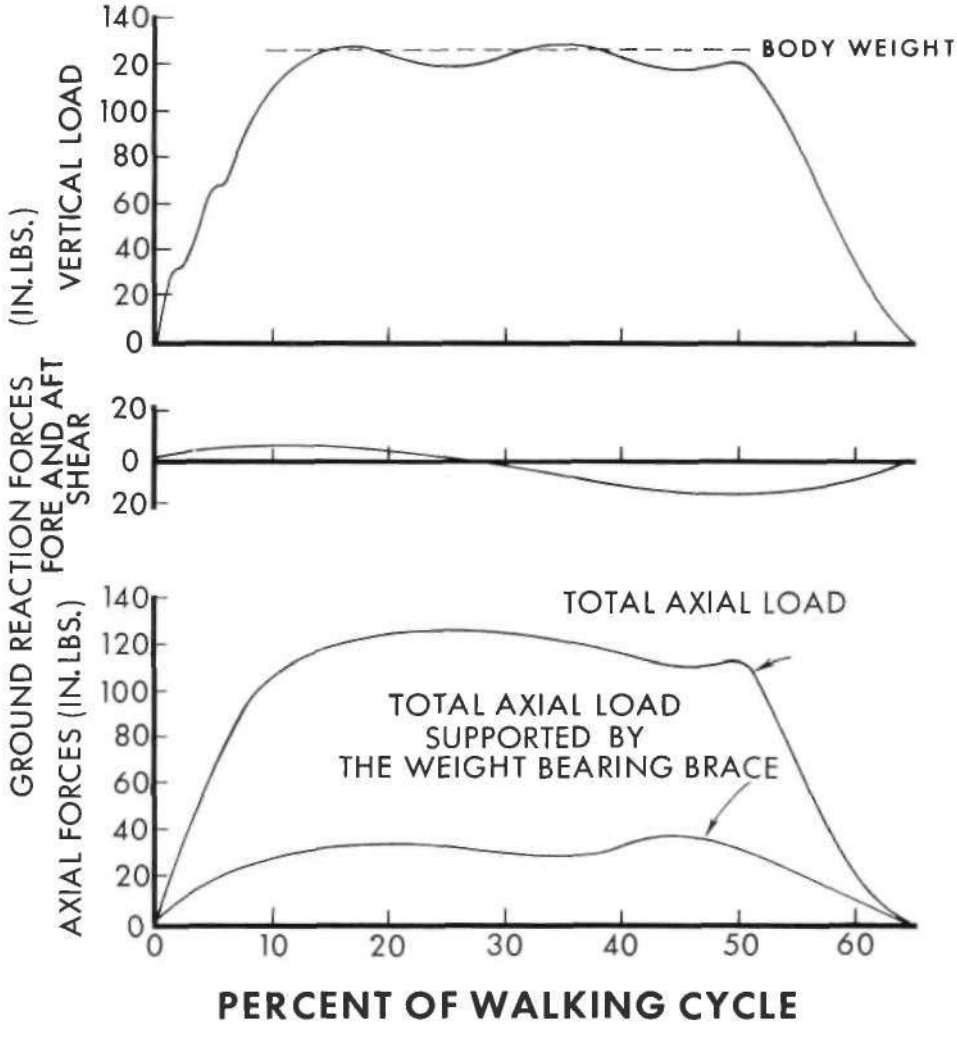

Fig. 7. Curves representing ground reaction forces during the stance phase of the right leg.

normality of his appearance. The excessive knee flexion was quite noticeable. However, in the absence of ankle-joint function and the inability to plantarflex the ankle, this adaptation permitted him to achieve a smoother transition from heel contact to foot flat.

Timing and Symmetry

A major determinant of the normality of gait is the time relation between the swing and the stance phases. A normal individual walking at approximately 80 steps per min. spends 0.53 sec. in the swing phase and 0.94

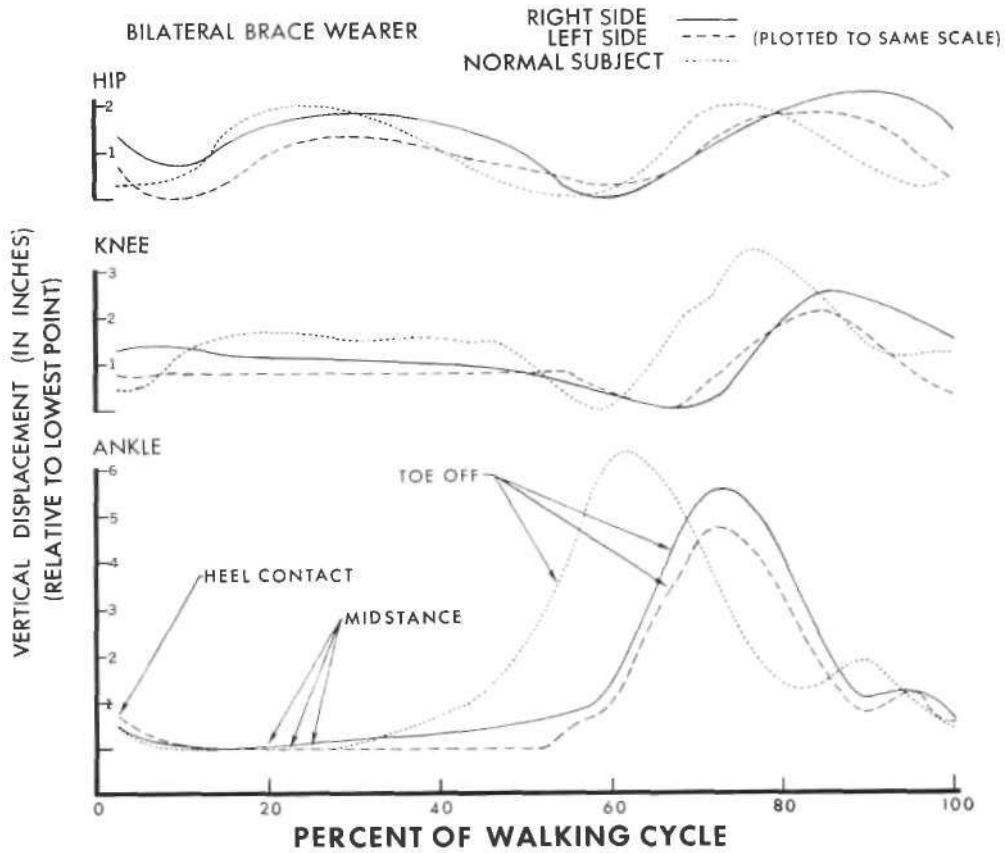

Fig. 8.

sec. in the stance phase. The subject of this study, walking at approximately the same speeds, displayed a gait pattern not significantly different from the normal. At 83 steps per min. he spent 0.52 sec. in the swing phase and 0.92 sec. in the stance phase; at 77 steps per min. he also spent 0.52 sec. in the swing phase but increased his stance-phase time to 1.04 sec.

A comparison between the swing and stance times of the right and left legs provided a measure of the symmetry of his gait; that is, the degree of similarity between the timing and rhythm of each leg. This was expressed as a ratio of swing-to-stance time for each leg, as follows:

Ratio of Swing-Phase Time to Stance-Phase Time	Strides per Min	Subject.	Normal
Left leg	83	.562	.552
Right leg	77	.493	.575

It may be seen that the subject walked with reasonably equal, normally timed steps. At 83 steps per min., swing and stance times were quite normal, and the ratio 0.562 was quite close to the normal ratio 0.552. However, at 77 steps per min. the patient's swing- to stance-time ratio fell to 0.493, demonstrating the effect of increased stance time at 77 steps per min. (1.04 sec. as against .92 sec. at 83 steps per min.). Thus, he attained optimum symmetry as regards swing and stance times at approximately 83 steps per min.

Although not necessarily a temporal factor, stride length also provided a good measure of gait normality. Stride length is the horizontal distance between successive heel contacts by the same leg. Variations in the length of stride reveal asymmetrical patterns as well as deviations from the normal which may not be shown in a study of the swing and stance times. The following is a comparison of the patient's stride length with that of a normal person at comparable cadences.

Stride Length in Inches

Strides per Min.	Subject	Normal
83	42.5	54.0
77	43.8	53.0

Clearly indicated is the shorter-than-normal stride length typical of this patient's gait. Although the minor variation in stride length with changing cadence is quite comparable to the normal variation, it tends to change inversely; that is, normal stride length increases slightly with cadence while the subject's stride length decreased slightly with increased cadence. This was attributed to the effect of an increased stance time at the lower cadence permitting a longer step to be taken with the opposite leg.

Kinematic Factors

In general, the displacements of hip, knee, and ankle were not substantially different from the normal, as shown by the similarity of the waveforms depicted in Figure 8. Differences in phase—that is, in the occurrence of significant events such as toe off—were primarily due to variations in cadence and to the inability of the patient to plantarflex his ankle. In order to achieve a smooth transition from heel contact to foot flat, he flexed his knee excessively with respect to normal values, and extended slowly through the range until toe off. The net result was to prolong stance phase.

PATIENT REACTIONS AND EXPERIENCES

Time of Wear

The subject wore both braces approximately 13 hr. a day, five of which were spent in activities involving walking. With the old braces, he used axillary crutches and a swing-through gait, resting every 10 to 15 min. With the new braces he did not use crutches in the house or for walking short distances outside the house. He did use crutches and a swing-through gait for longer distances, traveling continuously (without intervening rest periods), up to one and a half hr.

Comfort

With the old braces he was subjected to constant pain and ache; the weight-bearing braces gave no pain but caused swelling and considerable itching, particularly of the right leg.

Activity

With the old braces and crutches he was completely dependent on others for carrying packages, as when shopping or handling chores around the house. The below-knee, weight-bearing braces allowed him to discard the crutches and to carry small packages, to shovel snow off his sidewalk, and to carry out trash. The subject attached a great deal of importance to this type of activity as it represented a level of independence which permitted him to contribute substantially to the management of his home.

Disadvantage

With the old braces he could kneel in church; with the new braces he was not able to flex his knees sufficiently to kneel.

SUMMARY

This analysis revealed that the below-knee, weight-bearing braces unweighted the subject's left foot to an extent varying with the phase of the walking cycle between 96 per cent and 60 per cent of his total body weight. The load on the right leg was reduced by 25 per cent of the body weight throughout the stance phase. This adjustment permitted the patient to discard his crutches for reasonably long distances and to walk without them in a fairly normal manner. As a result of his increased mobility and freedom from crutches, his activity patterns broadened, and his sense of independence improved.

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Northwestern University Intermittent Mechanical Friction System (Disk-Type)[1]

ANTHONY STAROS, M.S.M.E.,[2] and EDWARD PEIZER, Ph.D.[3]

The Northwestern University intermittent mechanical friction system was recently approved by the Veterans Administration for use by its above-knee amputee beneficiaries when appropriately prescribed. This device, developed at Northwestern University Prosthetics Research Center under Veterans Administration contract, is now in production. An extensive period of testing preceded its approval.

In December 1963 the first production prototypes were received by the Veterans Administration Prosthetics Center in New York City. These models, based on a Northwestern design previously tested in a limited laboratory setting, were then distributed to a number of research facilities in the Artificial Limb Program. Clinical trials followed, disclosing a number of defects which required the redesign of several parts of the system.

The manufacturer of the production prototypes made design changes to solve the problems noted in the clinical trials and in the laboratory studies conducted concurrently at VAPC. By March 1965 sufficient progress had been made to warrant placing the Northwestern University intermittent mechanical friction system in the "approved" category.

DESCRIPTION OF THE UNIT

Figure 1 shows the present system placed in a cutaway of a wood above-knee setup. Basically, the Northwestern University unit is a simple, multiple-disk friction brake installed in a conventional wood knee block and a shank of an above-knee prosthesis. Figure 2 shows the assembly of the unit to the setup.

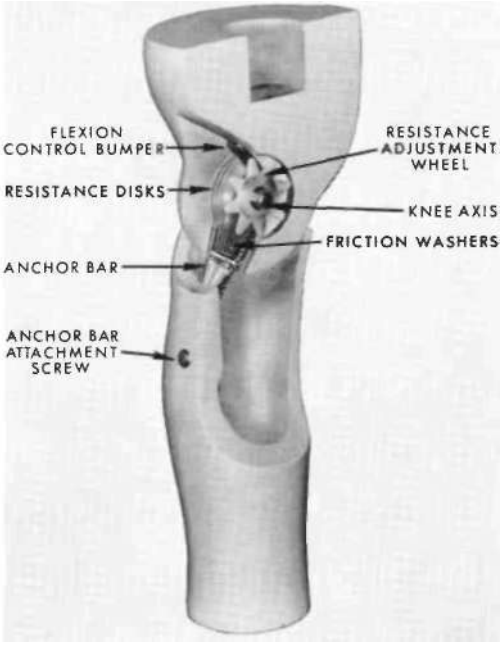

Fig. 1. Cutaway of knee block and shank assembly showing most recent (January 1965) version of Northwestern University disk-friction system.

The several disks have different angular sizes and thus provide a stepped alteration of the resistance pattern during the swing phase (Fig. 3). A particular disk contributes to the overall resistance to flexion and extension depending on its angular size: the larger the

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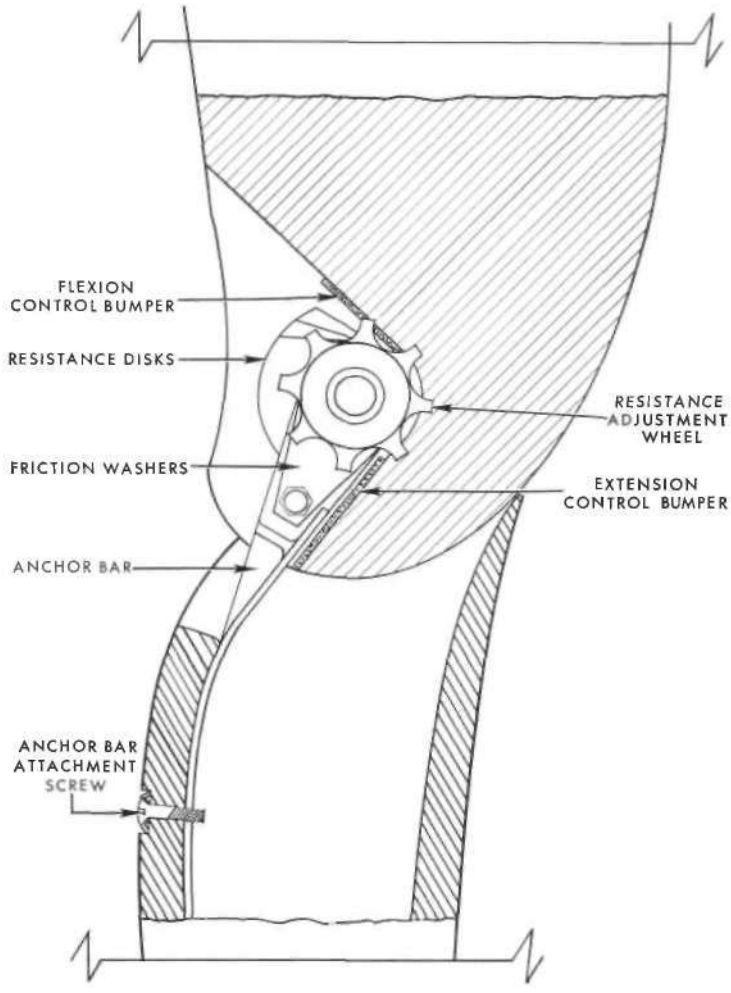


Fig. 2. Drawing showing position of Northwestern University disk-friction system in setup.

disk angle, the longer the disk will provide resistance during the swing phase. The edges of the disks anteriorly and posteriorly are driven by mating surfaces in the knee block, one surface rotating the disks in succession during flexion and the other during extension. The anchor bar is attached to the shank with the disk-friction unit placed over the knee bolt. The disks[4] are concentric with the axis of the knee bolt and are driven over friction surfaces also mounted concentric with the knee axis.

[4] In the original models, three disks numbered 1, 2, and 3 were provided in the unit with a fourth (No. 4) as a separate component. The numbers represented angular size, No. 1 being the smallest and No. 4, the largest.

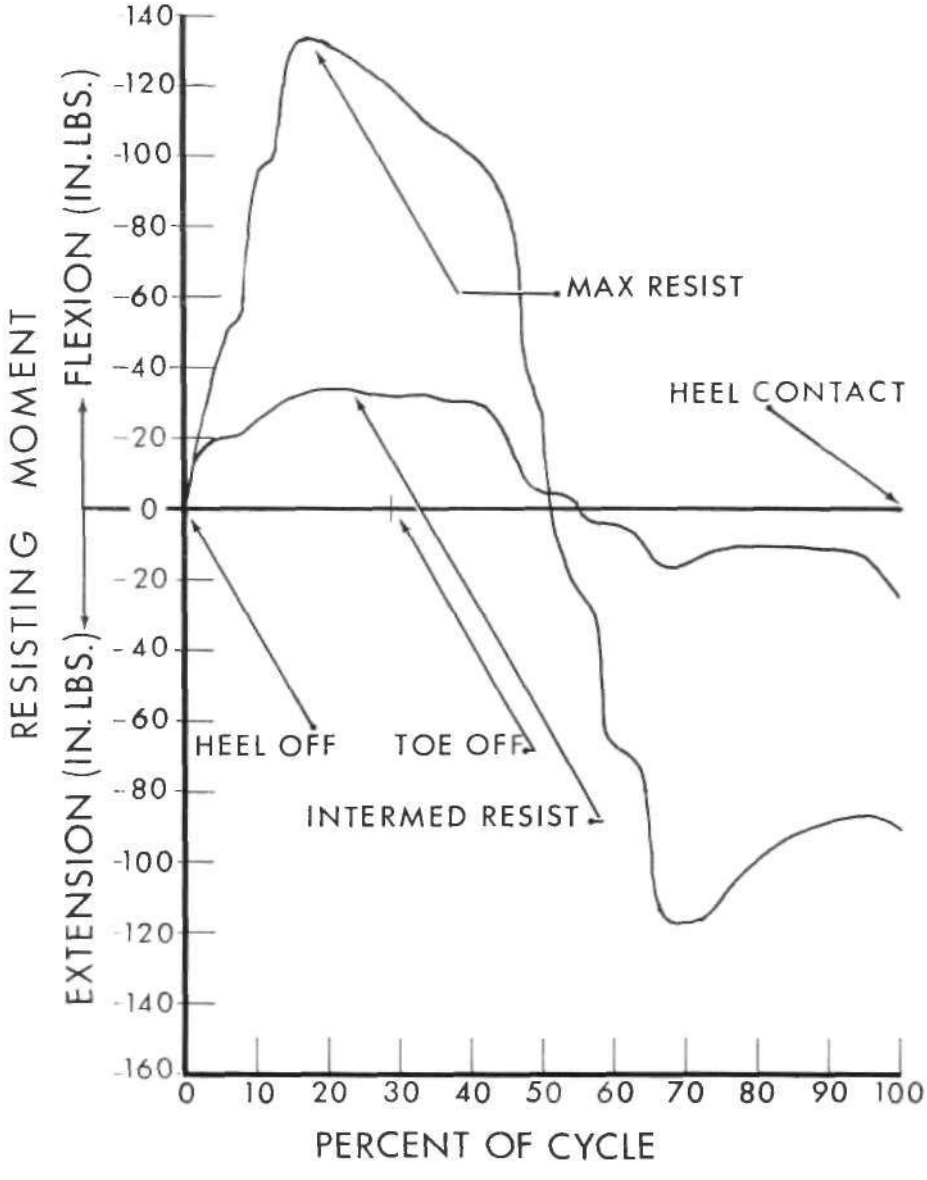


Fig. 3. Graphic record of stepped resistance pattern of Northwestern University disk-friction system during swing phase.

The total factional resistance can also be adjusted by turning a star wheel mounted concentric with the knee axis and thereby increasing or decreasing the force between the disks and the friction surfaces.

CLINICAL TRIALS

In the early clinical evaluations performed at New York University, at the Navy Prosthetics Research Laboratory, at Northwestern University, and at the Veterans Administration Prosthetics Center, uniform results were experienced. A total of nine units had been clinically tested among these groups, with structural failures occurring after approximately two weeks of use. But the frictional resistance pattern provided by the unit was found to be very desirable.

During the clinical trial period, seven of the units showed elongation of the leather friction disks and an eventual loss of friction (Fig. *i).* Four of the units experienced bending or frac-

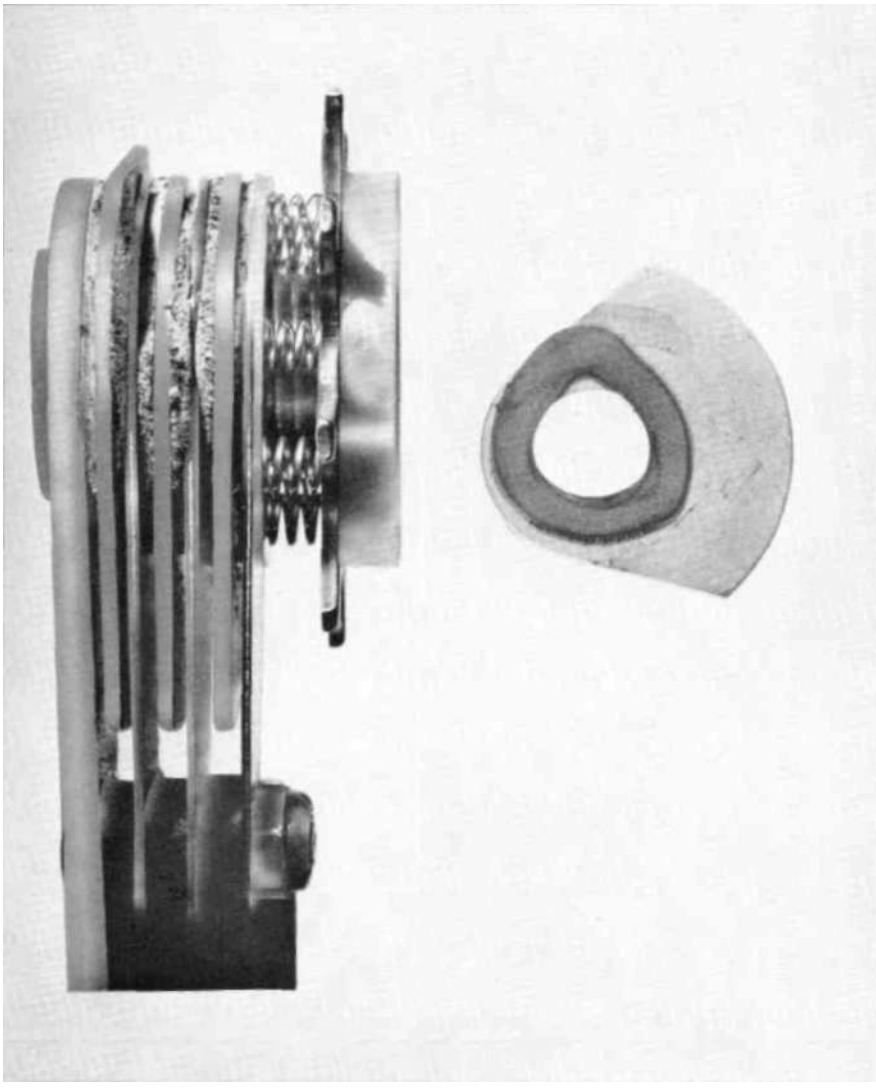


Fig. 4. Typical extrusion and elongation of leather washers in early clinical study.

Fig. 5. Typical failure of anchor bar in early clinical study models of the Northwestern University unit.

ture of the anchor bar (Fig. 5). Four showed deterioration of the control surfaces produced by penetration of the disk edges into the rubber bumpers. In one unit, the posterior aspect of the shank failed because the screw hole in the anchor bar was drilled too close to the posterior proximal brim of the shank. Objectionable noises resulted from these failures.

Recommendations made on the basis of the clinical trials focused on each of these problems.

It was suggested that redesign provide a reinforcing flange on the anchor bar, and a more gradual curve in the whole anchor-bar bend was also recommended. The sharp curve originally provided caused microscopic fractures in fabrication, which were instrumental in the ultimate failure. To help further reinforce the anchor bar, it was suggested that the posterior portion of the wood shank come up higher than on the earlier unit-to-shank assemblies. A larger portion of this posterior section of the shank, especially if a metal plate were inserted internally, then could support the posterior aspect of the anchor bar and significantly reinforce it.

The leather friction washers were totally inadequate. Therefore, it was suggested that the manufacturer employ the findings of the Navy Prosthetics Research Laboratory on a brake-lining material which would not show the extrusion prevalent with the leather. As another possibility, Celastic, with which the Veterans Administration Prosthetics Center had some success, was suggested.

It was noted that the rubber bumpers used in the clinical trial samples were installed in a setup improvised by the prosthetist prior to fitting. It was agreed generally that the setup should not be developed by the local limb shop to accommodate the Northwestern University unit. Rather, setups should be constructed by the manufacturer with placement of the control surfaces properly standardized and dimensionally controlled to accept the unit. In the clinical sample errors were made in the angulation of the control surfaces against which the disks operate, with the result that the disks did not contact these surfaces properly, with disk edge parallel to the control surface. Penetration of the rubber bumpers resulted. Coincidence of the disk angle (when contacting the stop) with the stop angle at the point of contact is not always achieved in the shop-modified setup. The solution to the problem is achieved by having properly angled stops with rubber bumpers (preferably of about 95 durometer) in a preshaped, mass-produced setup. Increasing the width of the disks—but only at the outer edges of the disk segments where they come in contact with the rubber bumpers—would have also helped considerably.

The planes of the disks, during adjustment of the frictional resistance, did not stay parallel at all times. The problem seemed to be partly due to the lower machine screw, around which there were rubber spacers. As the friction adjustment wheel was turned, each of the disks tended to turn, and one or more of the disks engaged threads of the machine screw and bound, preventing parallel displacement of the

disks. It was suggested that this machine screw be replaced with a smooth shaft, with the thread cut only where needed for the machine nut. It was also suggested that the clearance holes in the disk plates be enlarged slightly and that the rubber spacers be of much lower durometer. In addition, it was believed that the multiple spring arrangement on the friction-adjustment wheel could be replaced with a Belleville spring.

Shank failures, of course, can be prevented if the friction units are provided installed in a shank, with appropriate control in locating the anchor-bar screw hole far enough away from the posterior proximal brim of the shank.

It was suggested that a fifth disk (No. 5)—representing the next larger angle, with an angular increment the same as between No. 3 and No. 4—be provided. A wider range of control of the frictional pattern would thus be available to the prosthetist; for example, the combinations 1,2,3; 2,3,4; 3,4,5; or even 1,2,4; 1,2,5, etc.

LABORATORY TESTS

While the manufacturer was attempting to make some of the changes indicated, additional testing was performed by the Bioengineering Research Service at the Veterans Administration Prosthetics Center. These studies focused on two of the major considerations for the redesign: the loading on the anchor bar and the adequacy of various friction materials.

Studies to determine the probable causes of

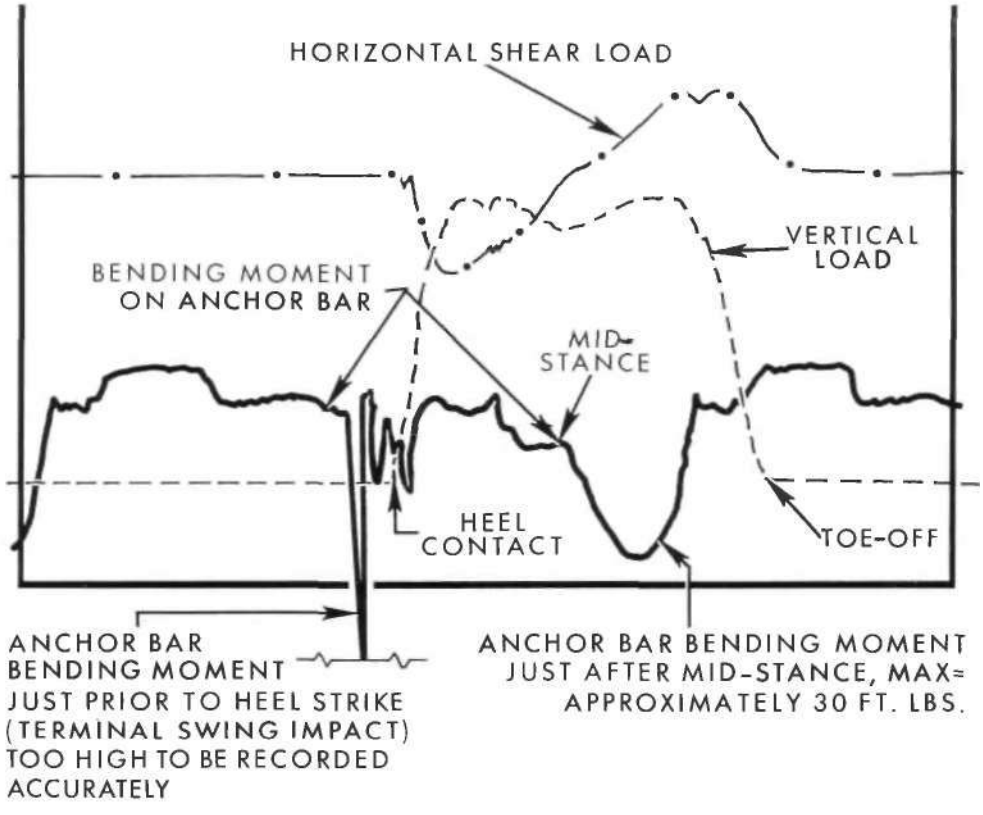


Fig. 6. Graphic record of bending moment on anchor bar of Northwestern University intermittent disk-friction knee.

failure in the anchor bar indicated that substantial forces were applied just after midstance and again at terminal impact in the swing phase (Fig. 6). The maximum bending moment in stance phase was approximately 35 ft. lb., a value which is equivalent to a tension of 5,600 psi at the surface of the bar. If the material of the original model of the anchor bar (unreinforced) approximates that of 4130 steel alloy with a working stress limit of approximately 20,000 psi, it would appear that the stance-phase loading falls well within the structural limits of the material. However, in swing phase, much higher loads may be imposed. Figure 6 shows a barely recorded shock load at terminal impact. Obtaining a true value for this load was impossible with the equipment at VAPC. The faint trace indicates that the galvanometer deflection lagged far behind the very rapid input. Therefore, the recorded spike may be of far lower magnitude than the actual loading. If the terminal shock loading was three or four times as great as the stance-phase loading, as it well may be, the working stress limit of the original material might easily have been exceeded.

To evaluate the utility of the resistance mechanism, a subject was fitted with one unit, and an optimum resistance setting was determined by adjustment of the friction disks. From an initial minimal setting, resistance was increased in increments of approximately one-eighth turn of the adjustment wheel. The subject's gait was observed after each change through the entire range. The optimum was found by backing off from maximum resistance to a point where the subject's best gait was achieved. This setting produced an obvious reduction in the terminal impact and heel rise as compared to that observed with minimum resistance. However, the adjustment range was very narrow, being limited to approximately one-quarter turn.

The optimum resistance setting was indexed, and the unit was removed from the setup and installed in the Veterans Administration Prosthetics Center's testing machine. Drop tests were performed at:

1. The optimum resistance setting.
2. A minimum resistance setting determined by adjusting the friction to the lowest increment above a free-falling knee.
3. A maximum-resistance setting determined by adjusting the friction to the highest increment that permitted motion under the 50 in. lb. of applied torque.

The following times in seconds were recorded:

Minimum		Optimum		Maximum	
Flexion	Extension	Flexion	Extension	Flexion	Extension
.22	.24	.25	.27	.27	.30

These data indicate that there is very little resistance-adjustment range between the minimum and maximum settings. Although not directly comparable but as a matter of perspective, these values fall just below the order of minimum-resistance values provided by several hydraulic units. Among five hydraulic systems, minimum drop times in flexion ranged from 0.20 sec. to 0.32 sec. and in extension, from 0.19 sec. to 0.31 sec.

At the same resistance settings used in the drop tester, the following maximum knee moments in inch-pounds were recorded at 43 cycles per min.[5] on the UCB testing machine.

Minimum		Optimum		Maximum	
Flexion	Extension	Flexion	Extension	Flexion	Extension
4.0	12.5	32.0	25.0	50.0	37 0

The values obtained for minimum-resistance settings of four hydraulic units fell between the optimum and maximum values for the Northwestern University device.

In an effort to determine how a given resistance setting is maintained in use, the unit was cycled 10,000 times at the optimum-resistance setting. After every 500 cycles, drop-test times and knee moments were determined. The data in Table 1 were recorded.

The drop-test results indicate that no significant changes occurred in the resistance values after cycling.

After 10,000 cycles, knee moments at the minimum-resistance setting for flexion and extension were respectively 4.0 and 12.5 in. lb.; at the maximum-resistance setting the values were 50.0 and 37.0 in. lb. These data also indicate the durability of the resistance setting with use.

These results were obtained with the hard-anodized friction disks and a flat, woven, brake-lining material. Other materials, including Nylatron, Celastic, and a laminated brake

[5] Equivalent to a cadence of 86 steps per min.

TABLE 1

No. of Cycles	Time (Sec.)						Knee moment (in. lb.) at 43 cycles per min.	
	Minimum		Optimum		Maximum		Optimum	
	Flexion	Extension	Flexion	Extension	Flexion	Extension	Flexion	Extension
500	.22	.24	.25	.27	.27	.30	32.0	25.0
1,000	.22	.24	.25	.27	.27	.30	32.0	25.0
5,000	.22	.24	.25	.27	.27	.30	32.0	25.0
10,000	.22	.24	.25	.27	.27	.30	32.0	25.0

material, were tested in the same way and found to have serious deficiencies. The woven brake lining provided a higher coefficient of friction and more resistance to bending and tension than all other materials tested.

After the entire series of machine tests, the unit was replaced in the subject's prosthesis at the originally determined optimum-resistance setting. He used the unit in and around the laboratory at the Veterans Administration Prosthetics Center for approximately six hours. Observations indicated that the subject walked as before and that no further resistance adjustments were required. However, the subject commented to the effect that the knee swing was smoother; "high spots" previously noted during the swing phase were absent. This observation was attributed to "wear in" of friction materials and to the earlier misalignment of individual friction components. A poor class of thread tends to "cock" one bearing segment against another; after a certain amount of wear, plastic deformation increases the area of surface in contact and "smooths" performance.

These tests performed late in 1964 substantiated the problem with the anchor bar. The manufacturer was notified that greater strength should be incorporated in the anchor bar; and he provided the flange on the anchor bar shown in Figures 1 and 2.

The magnitude of the frictional resistances available was comparable with other mechanical frictional units and also with a lower range of resistance available in hydraulic units. Resistance settings seemed to be maintained over a reasonably long cycling period with the woven brake-lining material. But since the resistance range was still found to be inadequate, a heavier compression spring was recommended to increase adjustability.

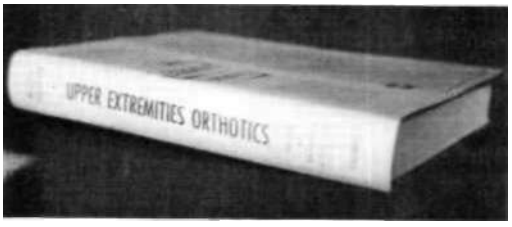
Because of the very high terminal load on the anchor bar, which can affect the durability of the bushings in the setup, a more resilient extension bumper was suggested. In addition, it was strongly recommended that impact load conditions could be improved by placing a resilient material between the anchor bar and the shank at the point of attachment.

As a result of the manufacturer's adoption of these recommendations and the extensive laboratory testing performed on the system, it was concluded that the Northwestern University disk-friction unit would provide a very desirable variable swing-phase control which is simple and, therefore, should be inexpensive compared to other types of units providing similar function. The resistance is easily adjustable, not only in terms of overall magnitude, but also by allowing the prosthetist to vary the number of steps in the resistance pattern. There still may be minor maintenance problems, which are common to mechanical friction systems. Hopefully, the manufacturer can solve these problems if they do indeed occur.

The Veterans Administration has drawings suitable for production purposes which will be made available to recognized component manufacturers upon written request to the Director, Prosthetic and Sensory Aids Service, Veterans Administration Central Office, Washington, D. C.

Upper Extremities Orthotics, a Review

UPPER EXTREMITIES ORTHOTICS, written and illustrated by Miles H. Anderson, Director, Prosthetics-Orthotics Program, University of California, Los Angeles, Calif.; published by Charles C Thomas, Springfield, Ill., 1965. 460 pages. Price: $15.50



Upper Extremities Orthotics covers one particular system of orthotics as applied to the requirements of impaired upper extremities—and it is a very excellent system indeed. Such a book is badly needed, and I know of no other that compares with it. In fact, the only part of the book that I dislike is the title. *Upper Extremities Orthotics* is a possessive tongue twister—and, of course, I personally prefer the term "orthetics" to "orthotics"! In the light of the great value of the contribution made by this book, this is really no criticism at all.

Upper Extremities Orthotics is a greatly expanded version of *Functional Bracing of the Upper Extremities* published in 1958 and a much better all-round text. It is superbly—perhaps even a little extravagantly—illustrated. Its greatest value is that it serves both the student and the expert orthotist. It is primarily an instructional manual for the orthotist, rather than a textbook. The physician and the therapist will have to dig a bit to get the most out of it; however, they will find it to be well organized once the format is understood. Chapter 3, "Functional Arm Braces," is new and particularly well presented.

At first reading I felt that the discussions of functional anatomy were elementary and unnecessary, but they do serve as quick reference and certainly do not detract from the value of the book. I heartily agree with the comments on "gadget tolerance," in which the author emphasizes that patients will not tolerate more than a certain amount of apparatus fastened to their bodies. He points out that, in general, the less the patient's handicap the less tolerant he will be of appliances to offset it.

The standards set in this method of orthotics are high, and not all orthotists have the skill to fabricate and fit these devices—and, I might add, not all orthotics shops can afford to; but this book should be in their libraries and in the libraries of all physicians who accept the responsibility of caring for the physically impaired.

ROBERT L. BENNETT, M.D.[2]

[1] In the letter transmitting this review to *Artificial Limbs*, the reviewer wrote: "Originally I had sketched out a much more elaborate review but found, really, that it consisted of unnecessary small criticisms that would add nothing to the review and really would detract from an excellent method of orthotics. I have attempted simply to point out that this is one system of orthotics. It is not a textbook of all orthotics for the upper extremities by any means, but the method is excellent and the book is organized superbly and really deserves no criticism once its purpose is thoroughly understood."

[2] Executive Director, Georgia Warm Springs Foundation, Warm Springs, Ga. 31830; member, Committee on Prosthetics Research and Development, National Academy of Sciences—National Research Council, Washington, D.C.

News and Notes

Fourteenth Meeting of CPRD

The Fourteenth Meeting of the Committee on Prosthetics Research and Development was held at the Mary Free Bed Guild Children's Hospital in Grand Rapids, Mich., on January 21 and 22, 1965. Dr. George T. Aitken, Chairman of CPRD, presided.

The entire morning of January 21 was devoted to observing Dr. Aitken and Dr. Charles H. Frantz, assisted by their staff and associates, care for severely disabled child-amputee patients of the Child Prosthetics Clinic. For the information of the Committee members, Drs. Aitken and Frantz reviewed the patients' medical histories, showed x-ray pictures, and explained procedures for the care and management of the patients.

Mr. Colin A. McLaurin, Chairman of the Subcommittee on Design and Development, reported that since the Thirteenth Meeting of CPRD there had been two meetings of the Subcommittee and meetings of three workshop panels: the First Workshop Panel on Criteria for External Power, the Second Workshop Panel on Upper-Extremity Components, and the Third Workshop Panel on Lower-Extremity Fitting. Mr. McLaurin then reviewed the work of the panels and of the Subcommittee.

The interest of the Workshop Panel on Lower-Extremity Components, Mr. McLaurin said, has centered around knee-disarticulation, stance-phase, and hip-disarticulation problems. Both the Biomechanics Laboratory of the University of California, San Francisco, and the Ontario Crippled Children's Centre are working on hip-disarticulation prostheses. Mauch Laboratories are concerned with the stance-phase problem. In addition, a number of adjustable legs—for immediate postoperative fittings and for geriatric amputees—are being developed.

The Workshop Panel on Lower-Extremity Fitting, Mr. McLaurin said, has been one of the most active of the panels, concerning itself with new casting methods and techniques and with adjustable sockets and adjustable legs. The members of this panel work together on panel projects.

The Workshop Panel on Upper-Extremity Fitting, Harnessing, and Power Transmission had not met recently, Mr. McLaurin said, but a meeting was planned for the near future.

Mr. McLaurin said that there had been considerable activity in the area of interest of the Workshop Panel on Upper-Extremity Components. He showed CPRD members a number of items recently developed at the Army Medical Biomechanical Research Laboratory: a No. 3 and a No. 5 hand shell, a soft hand, a finger flexion hook, and a spring-loaded terminal device. Work is proceeding on powered devices; for example, feeding arms and the AMBRL electric elbow and electric hand. Mr. McLaurin commented especially on a hook developed by Carl Sumida of the Child Amputee Prosthetics Project of the University of California, Los Angeles, saying that six of the hooks have been procured and delivered for testing on patients.

There has been a demand by developers for the report of the First Workshop Panel on Criteria for External Power.

Mr. McLaurin announced that a Workshop Panel on Lower-Extremity Orthotics was being formed, with Dr. Robert D. Keagy as its chairman.

So far, Mr. McLaurin said, industry has not made an alternative bid on the procurement of test models, nor has industry been awarded a study contract—procedures approved at the Thirteenth Meeting of CPRD. However, industry has been represented on the panels, with a beneficial effect.

With VA assistance, Mr. McLaurin said, prototype models can be obtained expeditiously.

Mr. McLaurin said that the workshop panels were well received, and their members look forward to the interplay of ideas. He believed that the panels should continue to meet. In concluding his report, Mr. McLaurin expressed the view that clinical representation at workshop panel meetings—for example, representation from the Subcommittee on Child Prosthetics Problems—would be beneficial. Closer ties with clinical needs should give the developing agencies a stronger sense of urgency.

Professor Herbert R. Lissner, Chairman of the Subcommittee on Evaluation, reported that since the Thirteenth Meeting of CPRD there had been two meetings of the Subcommittee.

Professor Lissner said that matters of special interest to the Subcommittee were the need for preparation of a manual for the production, prescription, and use of hand splints developed at Baylor University; a workshop meeting on feeders being planned by Dr. Sidney Fishman, Dr. Eugene F. Murphy, and Mr. Bert Titus; and the report of an evaluation of the Henschke-Mauch "Hydraulik" system. He advised CPRD members that the numerical rating scale being developed by the Subcommittee for use in the evaluation of prosthetic and orthotic devices was not yet ready for trial in a clinic or laboratory, since it required revision in the light of criticisms and comments made at the most recent meeting of the Subcommittee.

Dr. Frantz, Chairman of the Subcommittee on Child Prosthetics Problems, briefly reviewed the history of the Subcommittee since it was established in 1955. Some 20 clinics are now actively participating in the Child Prosthetics Research Program. Using a projection slide, Dr. Frantz showed the distribution of these clinics and said that efforts are being made to develop clinics in areas where children are not being treated. He stressed the importance of the meetings of the clinic chiefs and the valuable contribution made by the *Inter-Clinic Information Bulletin*, which has a steadily increasing circulation.

Dr. Frantz emphasized the need for further development of components and inquired whether the membership of the Subcommittee on Child Prosthetics Problems should be augmented by the assignment of such persons as engineers and prosthetists. In response, Dr. Aitken, the Chairman of CPRD, suggested the possibility of a workshop panel sponsored jointly by the Subcommittee on Child Prosthetics Problems and the Subcommittee on Design and Development, and it was agreed that this matter would be explored further.

Dr. Frantz advised CPRD members that administrative decisions in certain states prohibit the fitting of a prosthesis to a child within one year of amputation when the amputation resulted from a malignancy. Whereupon a motion was made, seconded, and unanimously carried that the Subcommittee on Child Prosthetics Problems develop a series of cases which would show whether or not there is a valid basis for such prohibition.

Professor Robert W. Mann, Chairman of the Subcommittee on Sensory Aids, gave an informational report on the Subcommittee which is in the process of being formed. He said that invitations had been sent to prospective members. Assuming there was a good response, the following categories would be represented: neurophysiologist, audition specialist, vision specialist, sensory psychologist, educational psychologist, scientist, engineer, and expert in data processing. When formed, the Subcommittee will be concerned with understanding the deprivation, invention of devices, bringing the devices into existence for evaluation, and also with a review of the existing VA program. Professor Mann said that both VA and VRA had volunteered to provide liaison personnel.

In the absence of Dr. John Lyman (who will be the Conference Chairman), Dr. Aitken reviewed the reports of the *ad hoc* committee charged with plans for the Conference on the Control of External Power in Upper-Extremity Rehabilitation. The Conference will be held at Airlie House, Warrenton, Va., during the period April 8-10, 1965. Some 100 persons from the United States, Canada, and overseas are expected to participate.

Dr. Aitken reviewed the history of CPRD interest in immediate postoperative fitting. He mentioned the presentations made by Drs. Thomas M. Hart, Frank L. Golbranson, and Eugene F. Murphy at the Thirteenth Meeting of CPRD in April 1964, the formation of an *ad hoc* committee under the chairmanship of Dr. Verne T. Inman, a VA grant to Dr. Ernest M. Burgess to examine the technique, and a trip made to Poland by Dr. Burgess and Mr. Joseph E. Traub during the latter part of 1964 for the purpose of observing the work of Dr. Marian Weiss, who originated the technique. After some discussion, it was decided that CPRD will sponsor a workshop meeting on immediate postoperative fitting, inviting the participation of surgeons and associates known to have employed the technique on more than one patient, and requesting the completion and submission of standard data-collection forms from all participants.

Dr. Eugene F. Murphy, Chief of the Research and Development Division of the VA Prosthetic and Sensory Aids Service, reminded all present that 1965 is the twentieth anniversary for CPRD and also for the VA Prosthetic and Sensory Aids Service. During the score of years of their existence, Dr. Murphy said, progress has been made, although there are times when the progress seems slow. Dr. Murphy said that VA is especially pleased that the Subcommittee on Sensory Aids is now taking shape. He also discussed progress on certain hydraulic lower-extremity units.

Dr. J. Warren Perry, Deputy Assistant Commissioner of VRA, said that the gauge whereby the VRA program is judged is the number of rehabilitations achieved—now more than 160,000, some 35 per cent of whom are orthopaedic rehabilitations. The budget of the VRA research and training program now amounts to some $40 million per year. Dr. Perry said that VRA was looking forward to the Conference on the Control of External Power in Upper-Extremity Rehabilitation, hopeful that the conference will provide principles and guidelines for the better evaluation of proposals. Under VRA sponsorship, some 9,000 trainees—physicians, prosthetists, orthotists, therapists, and others—are presently enrolled. There is a strong push, Dr. Perry said, toward greater professionalism in prosthetics and orthotics, with educational programs which provide Associate in Arts and Bachelor of Science degrees for successful participants. The educational programs are kept fluid, with the University Council on Orthotic-Prosthetic Education providing communication, coordination, and cooperation among the three universities principally concerned. In concluding his remarks, Dr. Perry expressed appreciation to CPRD for recommendations and reports and particularly for assistance in the processing of requests for grants.

Dr. Roy M. Hoover, Chairman of the Committee on Prosthetic-Orthotic Education, said that the area of activities of CPOE is not precisely defined. The work of the Committee is actually carried out by a number of subcommittees, and there is a variety of projects. The so-called Amputee Census (described in the Spring 1963 issue of *Artificial Limbs)* gathered some information. A clinical study is now in progress in a number of the larger clinics throughout the United States. In conjunction with the Conference of Prosthetists in AOPA, there has been developed a uniform facility record form which is now used in some 50 facilities. Another CPOE project is the preparation and distribution of projection slides on prosthetics for use in medical schools. In conclusion, Dr. Hoover said that he, as the new Chairman of CPOE, would welcome requests from CPRD for the performance of special activities.

There was some discussion as to whether the name of CPRD should be changed to Committee on Prosthetics-Orthotics Research. However, it was considered that the term "prosthetics" is sufficiently broad to encompass the increasing scope of CPRD activities, and that no change in name would be warranted for the time being.

First Meeting of CPRD Subcommittee on Sensory Aids

The first meeting of the recently formed Subcommittee on Sensory Aids of the Committee on Prosthetics Research and Development was held in the National Academy of Sciences Building, Washington, D. C, on March 31, 1965. The chairman of the subcommittee, Dr. Robert W. Mann, Professor of Mechanical Engineering at Massachusetts Institute of Technology, presided.

Members of the subcommittee present for the initial meeting were: Dr. Samuel Ashcroft, educational psychologist in the Department of Special Education at George Peabody College for Teachers; Dr. James C. Bliss, engineer and expert in data processing in the Control Systems Laboratory at Stanford Research Institute; Dr. Leo G. Doerfler, Director of the Department of Audiology at the Eye and Ear Hospital of Pittsburgh; Dr. Frank A. Geldard, Stuart Professor of Psychology at Princeton University; Dr. Donald R. Griffin, Professor of Zoology at Harvard University; Dr. Leon D. Harmon, engineer and expert in data processing at Bell Telephone Laboratories; Dr. Richard E. Hoover, vision specialist in Baltimore; Dr. Jerome Y. Lettvin, neurophysiologist associated with the Laboratory of Elec-

Professor Robert W. Mann, Chairman of the Subcommittee on Sensory Aids.

tronics at Massachusetts Institute of Technology; and Dr. Patrick W. Nye, sensory psychologist in the Computing Center at California Institute of Technology.

On behalf of the National Academy of Sciences and the Division of Engineering and Industrial Research, Mr. Louis Jordan, Executive Secretary of the Division, extended a welcome to all persons attending the meeting. He then briefly reviewed the history of the National Academy of Sciences since its founding by Act of Congress in 1863, pointing out that, although there are many close ties between the Academy and the Government, the Academy is not a governmental agency. The National Research Council, established by the Academy during World War I, is in effect the operating arm of the Academy and is organized into eight major Divisions. When the V'eterans Administration asked the Academy to extend its advisory services in prosthetics to include sensory aids, the request was passed for action to the Division of Engineering and Industrial Research and its Committee on Prosthetics Research and Development.

Dr. George T. Aitken, Chairman of the Committee on Prosthetics Research and Development, complimented Professor Mann upon gathering an illustrious group of members for the Subcommittee on Sensory Aids and then briefly described the Committee on Prosthetics Research and Development, pointing out that it has four permanent subcommittees: the Subcommittee on Child Prosthetics Problems, the Subcommittee on Design and Development, the Subcommittee on Evaluation, and the Subcommittee on Sensory Aids. Recommendations from the Subcommittee on Sensory Aids to sponsors regarding research and development projects would be transmitted through the Committee on Prosthetics Research and Development, the Division of Engineering and Industrial Research, and the National Academy of Sciences. Dr. Aitken described an evaluation procedure which has been evolved by the Committee on Prosthetics Research and Development and expressed the hope that CPRD, as the parent Committee for the Subcommittee on Sensory Aids, would develop into a body of men capable of making knowledgeable value judgments on the mating of man and machine; that is, that it would eventually become a bioengineering group. He stressed the importance of keeping man in any evaluation and particularly hoped that neither CPRD nor the Subcommittee on Sensory Aids would become simply a group of gadgeteers.

Under the leadership of Professor Mann, there was general discussion of the role of the Subcommittee on Sensory Aids, during which it was brought out:

That technology has done little for the blind.

That the problem of doing something for the blind is exceedingly complex, because of the variety of agencies and investigators involved (each with its or his special interest); the lack of integrated effort to produce results; the lack of a profit incentive for private capital; the lack of exact knowledge as to the size and nature of the handicapped population; and the lack of established, precise descriptive terminology for various degrees of handicap.

That many of the foregoing statements concerning the blind are equally applicable to the deaf.

That governmental agencies have a need for reports and recommendations from advisory groups so that efforts are not duplicated.

That panels and *ad hoc* groups may be appointed by the Subcommittee on Sensory Aids to focus on particular problems and report back.

That possibly the Subcommittee on Sensory Aids should have a short-range and a long-range goal.

Dr. Eugene F. Murphy, Chief of the Research and Development Division of the Veterans Administration's Prosthetic and Sensory Aids Service, made a brief presentation on the VA sensory aids development program. In opening his remarks, Dr. Murphy said that much more than "hardware"—the development of devices—is involved in the problem. But the immediate concerns of the VA program are with guidance devices and reading machines.

The problem has many dimensions, Dr. Murphy said. Losses in vision range from the relatively trivial up to bilateral enucleation. They result from a variety of causes; for example, disease, advancing age, and war explosions. In one individual, the losses may involve both sight and hearing. A young, otherwise-healthy, blind person's abilities and needs are different from those of an elderly, feeble, blind person. There is a need for a "blindamentarium," similar to the prosthetics armamentarium, from which the clinic team can prescribe. There is a need for piecemeal devices and multiple devices. There is a need for subsidies to stimulate the development and commercial manufacture of devices. There is a need for subsidies to educate the public concerning the use of new devices. Other dimensions of the problem are the attitudes of the blind persons themselves and the attitudes of prospective employers. The willingness or the lack of willingness of an afflicted person to wear a device which calls attention to his deprivation is still another dimension of the problem. A sensory aids program involves expenses which must be considered; balanced against the expenses are economic losses when handicapped persons must be cared for and economic gains when handicapped persons can be usefully employed.

Dr. Murphy said that VA expends each year approximately $1.25 million for its entire prosthetics and sensory aids program. About two-thirds of the program is contractual.

Traditional aids to mobility for the blind are the cane and the guide dog. In addition, the U.S. Army Signal Corps developed some years ago a ranging device employing a beam of light for the detection of obstacles in the path of a blind person. Evaluation of the Signal Corps device led to the following recommendations: improvement of its capability for object detection and its detection of the requirement to step down, lighter construction, and the use of rechargeable batteries.

Haverford College and Bionic Instruments, Inc., have worked on improvements of the basic Signal Corps device, Dr. Murphy said. The present device, known as the Bionic G-5 Object Detector, has been evaluated for VA by Tracor, Inc.

There is some difference of opinion, Dr. Murphy said, as to the proper goal in the development of such a device: Should the device simply enable the user to travel from one point to another, or should it also enable him to gain knowledge of his environment? Bionic Instruments, Inc., is now working on a long cane which, in addition to its capability simply for use as a cane, will possess a three-way object-detection capability: ahead, downward, and upward. Dr. Murphy explained that upward detection is necessary to enable the user to avoid collision with overhanging obstacles such as awnings.

In addition, Dr. Murphy said, VA has recently purchased for evaluation 10 copies of an object-detection device made in England by Ultra Electronics.

Dr. Murphy then discussed the development of personal reading machines for the blind, pointing out that such machines could be anything from a simple, one-photocell scanning device to an extremely complicated device involving speech synthesis and word reading. Output from the devices to their users might be either aural or tactile.

Dr. Murphy described work being carried on for VA by Mauch Laboratories, Metfessel Laboratories, Haskins Laboratories, and Battelle Memorial Institute. He mentioned a relatively small project in the VAPC office to develop a typesetter in Braille which has not yet achieved success.

Dr. Keith Graham, Executive Secretary of the Sensory Disabilities Research Study Section of the Vocational Rehabilitation Administration, said that the VRA constituency in-

cludes the blind. Until recently, grants were the mechanism used by VRA, but now contracts are also employed. For five or six years, Dr. Graham said, VRA has supported work being conducted at Massachusetts Institute of Technology on reading devices, mobility, and clues to environment. This is primarily a developmental effort—an attempt to bring devices up to a commercial level. VRA is also supporting work at Stanford and the Haskins Laboratories. It is supporting programs to train blind persons to become language teachers and translators, and efforts to develop new ways of preparing raised-line drawings for scientific texts so that blind persons can receive the text. Dr. Graham mentioned the possible application to aids for the blind of recent developments by the National Aeronautics and Space Administration.

In concluding his remarks, Dr. Graham said that VRA welcomed the formation of the Subcommittee on Sensory Aids because VRA is receiving many applications for support and needs guidance as to priorities.

Professor Mann advised the members of the subcommittee that both VA and VRA would provide him with questions upon which specific advice would be needed. *Ad hoc* groups would then consider these problems. This would probably constitute an important part of the immediate future activities of the Subcommittee on Sensory Aids.

Conference on the Control of External Power in Upper-Extremity Rehabilitation

Because of recent developments in bioengineering and widespread interest, the Committee on Prosthetics Research and Development sponsored a Conference on the Control of External Power in Upper-Extremity Rehabilitation at Airlie House, near Warrenton, Va., during the period April 8-10, 1965. The purpose of the conference was to develop an expert summary of the state of all aspects of the control problem and their possible solutions, as related to upper-extremity functional regain. The proceedings of the conference will be published by the National Academy of Sciences—National Research Council. Besides providing an interchange of up-to-date information among persons directly concerned with the development of externally powered prosthetic and orthotic devices and the application of such devices to patients, the hoped-for outcomes of the conference will be long-range goals and guiding principles useful to governmental agencies—chiefly the Vocational Rehabilitation Administration and the Veterans Administration—sponsoring work in the field through grants and contracts.

The conference was convened by Dr. John Lyman, Director of the Biotechnology Laboratory, Department of Engineering, University of California, Los Angeles, who served as conference chairman. Dr. James F. Garrett, Assistant Commissioner of the Vocational Rehabilitation Administration, speaking on behalf of the Commissioner, Miss Mary E. Switzer, extended greetings to the conferees. Dr. Eugene F. Murphy, Chief of the Research and Development Division, Prosthetic and Sensory Aids Service, Veterans Administration, greeted the conferees on behalf of VA; welcomed the international visitors from Canada, Great Britain, Sweden, Denmark, Germany, and Yugoslavia; and welcomed the representatives from Project ROSE (remotely

Some participants in the Conference on the Control of External Power in Upper-Extremity Rehabilitation, left to right: Dr. Eugene F. Murphy, Chief of the Research and Development Division, Prosthetic and Sensory Aids Service, VA; Hector W. Kay, Assistant Executive Director, CPRD; Professor Herbert R. Lissner, Coordinator, Biomechanics Research Center, Wayne State University; Rivington Stone, Applied Physics Laboratory, Johns Hopkins University.

Some participants in the Conference on the Control of External Power in Upper-Extremity Rehabilitation, left to right: Gunnar Holmgren, Chief Engineer and Prosthetist, University Hospital, Uppsala, Sweden; J. Raymond Pearson, Professor of Mechanical Engineering, University of Michigan; Karl Axel Olsson, Civil Engineer, Royal Institute of Technology, Stockholm, Sweden; Charles W. Rosenquist, Orthotist, Columbus, Ohio; Tor Hiertonn, M.D., Chairman of the Department of Orthopaedic Surgery, University of Uppsala, Sweden; Edward A. Kiessling, Project Manager, American Institute for Prosthetic Research, New York City; Ernst Marquardt, M.D., Orthopaedic Clinic, University of Heidelberg, Germany.

operated special equipment) of the National Aeronautics and Space Administration and the Atomic Energy Commission. Dr. George T. Aitken, an orthopaedic surgeon of Grand Rapids, Mich., and Chairman of the Committee on Prosthetics Research and Development, in a lecture entitled *The Man-Machine,* gave an overview of all the interrelationships concerned with the problem. In his presentation, Dr. Aitken pointed out that at present the severely handicapped person equipped with an upper-extremity prosthetic or orthotic device cannot operate the device and perform some other task, such as mental arithmetic, at the same time. Dr. Aitken expressed the hope that, with the application of modern knowledge and technology, it will soon be possible to have prosthetic and orthotic devices which will not require the full attention of their users.

Panels covered the six major subject areas of the conference: sources of control signals, transducers, actuators, signal processing, sensory feedback, and the selection and training of patients.

Under the chairmanship of Dr. Herbert Elftman, Professor of Anatomy at the College of Physicians and Surgeons of Columbia University and Vice-Chairman of the Committee on Prosthetics Research and Development, the panel on the sources of control signals covered both biomechanical and bioelectric signals. Colin A. McLaurin, Project Director of the Prosthetic Research and Training Unit at the Ontario Crippled Children's Centre in Toronto, discussed the control of externally powered prosthetic and orthotic devices by musculo-skeletal movement, pointing out that such controls are reliable and offer advantages in visual and proprioceptive cues, as compared with the use of more exotic controls such as myoelectric signals. Dr. Ernst Marquardt, of the Orthopaedic Clinic of the University of Heidelberg in West Germany, discussed the biomechanical control of pneumatically powered prostheses, giving special consideration to sequential controls. Dr. Jacquelin Perry, an orthopaedic surgeon at Rancho Los Amigos Hospital in California, discussed the possibilities of control through surgical conversion, specifically through the creation of muscle bulges by making hernias through the muscle fascia. Dr. Irving Wagman, a research physiologist at the Biomechanics Laboratory of the University of California, San Francisco, and Dr. Donald S. Pierce, of the Massachusetts General Hospital in Boston, Mass., discussed electromyographic signals as control sources. Dr. A. B. Kinnier Wilson, Director of Research at the Centre for Muscle Substitutes of the West Hendon Hospital in England, discussed control methods with mechanical and electromyographic inputs. Finally, Dr. F. Ray Finley, of the Bio-Cybernetics Department of the Philco Corporation, discussed electromyographic patterns of multiple muscle sources.

Dr. Eugene F. Murphy served as chairman of the panel on transducers. In his introductory remarks, Dr. Murphy said that the term "transducers" was being used broadly to cover harnessing of body motion (great or small) and of electrical signals associated with muscles or nerves. Dr. Edward Peizer, Chief of the Bioengineering Laboratory of the Veterans Administration Prosthetics Center in New York City, discussed transducers for use with gross body motions, pointing out that

such transducers are, in general, applicable to a fairly active group of patients, those who are gainfully employed. Dr. Worden Waring, of the Rancho Los Amigos Hospital, discussed transducers for use with refined body motions, saying that the target is VPV control; that is, volitional, proportional, vectorial control. Wilson Greatbatch, Vice President and Technical Director of Mennen-Greatbatch, Inc., discussed implanted electrodes as transducers, emphasizing that electrical engineers have recently arrived at a point where they can make significant contributions. Professor Wen-Hsiung Ko, of the Engineering Design Center of Case Institute of Technology, discussed implanted transducers, specifically, buried radio transmitters capable of broadcasting signals through the skin.

Mr. McLaurin served as chairman of the panel on actuators. Andrew Karchak, a research engineer at Rancho Los Amigos Hospital, discussed the functional needs of the paralyzed patient, briefly describing functional hand splints and feeding devices. Power sources currently in use are carbon dioxide gas and electricity. At present, he said, there are two basic control systems; preprogrammed, and volitional (on-off and proportional). He pointed out that velocity control and feedback would be desirable. Edward A. Kiessling, Project Manager of the American Institute for Prosthetic Research, discussed the functional needs of the upper-extremity amputee. Edward C. Grahn, Project Director of the Prosthetics Research Center at Northwestern University, discussed electrical actuators in prosthetics and orthotics, describing small, rechargeable batteries that have recently been developed and a number of miniature electric motors. Professor J. Raymond Pearson, of the Department of Mechanical Engineering at the University of Michigan, discussed actuators for compressed gas, describing in some detail various types of bellows, "muscles," linear actuators, diaphragm actuators, and rotators.

Dr. James B. Reswick, Director of the Engineering Design Center at Case Institute of Technology, served as chairman of the panel on signal processing. He briefly discussed the possibilities of using computer techniques in signal processing. Dr. Avery R. Johnson, President of ARJ, Inc., discussed the processing of electromyographic signals. R. N. Scott, President of the Technical Assistance and Research Group for Physical Rehabilitation in Fredericton, New Brunswick, also discussed the processing of electromyographic signals, stressing the importance of continuous voluntary control, even at the expense of performance. He described extensive experiments with semipermanent electrodes inserted shallowly into the skin. Professor Rajko Tomovic, of the Mihajlo Pupin Institute in Belgrade, Yugoslavia, discussed control theory and signal processing in prosthetic systems.

Dr. Hilde Groth, of the Biotechnology Laboratory at the University of California, Los Angeles, served as chairman of the panel on sensory feedback. Hewitt Crane, a staff scientist at the Computer Techniques Laboratory of Stanford Research Institute, discussed communication through the human integument. He reported studies made in the tactile transmission of English letters and words. Dr. A. H. Bottomley, of the Department of Medicine at St. Thomas's Hospital in London, discussed signal processing in a practical electromyographically controlled prosthesis. Professor Thomas B. Sheridan, of the Department of Mechanical Engineering at Massachusetts Institute of Technology, discussed mathematical models involving discrete perceptual sampling and preprogrammed muscle responses.

Dr. Robert G. Thompson, an Associate Professor of Orthopaedic Surgery at Northwestern University Medical School, served as chairman of the panel on the selection and training of patients. Dr. D. S. McKenzie, Senior Medical Officer at Queen Mary's Hospital, Roehampton, England, showed motion pictures depicting the application of externally powered devices to severely handicapped child-amputee patients. Dr. Jacquelin Perry discussed the problem of functional bracing for severely disabled patients. Dr. Marquardt discussed the training of amputee patients in the use of their powered prostheses. Dr. Roy M. Hoover, Medical Director of the Woodrow Wilson Rehabilitation Center in Fishersville, Va., discussed the rehabilitation and vocational training of severely handicapped patients. Miss Harriet Schmid, Director of Occupational

Therapy at the Mary Free Bed Guild Hospital in Grand Rapids, Mich., discussed the training of severely handicapped child-amputee patients and showed motion-picture films depicting the use by child patients of externally powered upper-extremity prostheses.

Dr. Lyman, as conference chairman, concluded the conference with a session on systems integration.

This conference was made possible by funds supplied by the Vocational Rehabilitation Administration and the Veterans Administration.

Hector W. Kay Joins CPRD Staff

Hector W. Kay, who is well known for his extensive participation in the fields of prosthetics and orthotics, has recently accepted an appointment as Assistant Executive Director of the Committee on Prosthetics Research and Development, National Academy of Sciences —National Research Council, Washington, D.C. A. Bennett Wilson, Jr., whose title has been changed from Technical Director to Executive Director, will continue to serve CPRD as its principal staff member.

Mr. Kay, who holds the degree of Bachelor of Arts from Sir George Williams College, Montreal, Canada, and the degrees of Bachelor of Science and Master of Education from Springfield College, Springfield, Mass., was formerly Associate Project Director, Prosthetic and Orthotic Studies, New York University.

Hector W. Kay, Assistant Executive Director, Committee on Prosthetics Research and Development.

Since 1961, Mr. Kay has been Editor of the *Inter-Clinic Information Bulletin,* published under the auspices of the Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development, which currently has a circulation of 1,600 in the United States, Canada, and overseas.

In addition, Mr. Kay has made numerous contributions to the literature of the Artificial Limb Program. Dr. Sidney Fishman and Mr. Kay were the authors of *Acceptability of a Functional-Cosmetic Hand for Young Children,* published by Child Prosthetic Studies, Research Division, College of Engineering, New York University, January 1964, which provided the basis for articles in the Spring and Autumn 1964 issues of *Artificial Limbs.* The most recent publication of which Mr. Kay is a co-author is *A Fabrication Manual for the Muenster-Type Below-Elbow Prosthesis,* published by Prosthetic and Orthotic Studies, Research Division, School of Engineering and Science, New York University, in April 1965.

Activities of CPOE Subcommittee on Prosthetics in Paramedical Education

The Subcommittee on Prosthetics in Paramedical Education of the Committee on Prosthetic-Orthotic Education met at New York University on April 26 and 27, 1965. Colonel Ruth Robinson, chairman of the subcommittee, presided. Participating in the meeting were: Miss Jeannine Dennis and Mrs. Janet Vandiveer, representing the Educational Council of the American Association of Occupational Therapists; Miss Beth Phillips, representing the Council of Physical Therapy School Directors; Miss Dorothy Hewitt, physical therapist; Miss Dorothy Baethke, physical therapist; Mrs. Barbara Madden, rehabilitation nurse; and Mrs. Barbara Friz, of the CPOE staff. Special guests included: Miss Lucy Blair, Executive Director of the American Physical Therapy Association; Miss Barbara Neuhaus, Educational Consultant in Recruitment of the American Occupational Therapy Association; and Miss Katherine A.

Keppel, Associate Executive Director of the American Nursing Association.

Dr. Sidney Fishman, Project Director of Prosthetic and Orthotic Studies at XYU, addressed the group on *Training Programs for Orthotists and Prosthetists.*

The subcommittee is making plans to study the working relationships of the various paramedical groups as they pertain to the practice of prosthetics and orthotics. At the request of CPOE, the subcommittee is also exploring the potential use of programmed instruction in prosthetics and orthotics education.

It was announced that the following instructional aids are now available:

1. An annotated list, *Review of Prosthetic-Orthotic Visual Aids,* which was developed by an *ad hoc* committee during the past year. (Distributor: Committee on Prosthetic-Orthotic Education, National Academy of Sciences, 2101 Constitution Ave., N.W., Washington, D. C. 20418.)

2. A set of loop films, each of which depicts a gait deviation portrayed in the film *Gait Analysis,* previously produced at Northwestern University. (Distributor: Ideal Picture Company, 417 North State St., Chicago, Ill. 60610. A check for $25.00 should be made payable to the distributor at the time of the order.)

3. Two films produced at UCLA Child Amputee Prosthetics Project: *Infant to School-Age Child— Unilateral Below-Elbow Amputee* and *Early Development of Ambulation —Unilateral Below-Knee Amputee.* (Distributor: Child Amputee Prosthetics Project, University of California Medical Center, 10975 Wilshire Blvd., Los Angeles, Calif. 90024.)

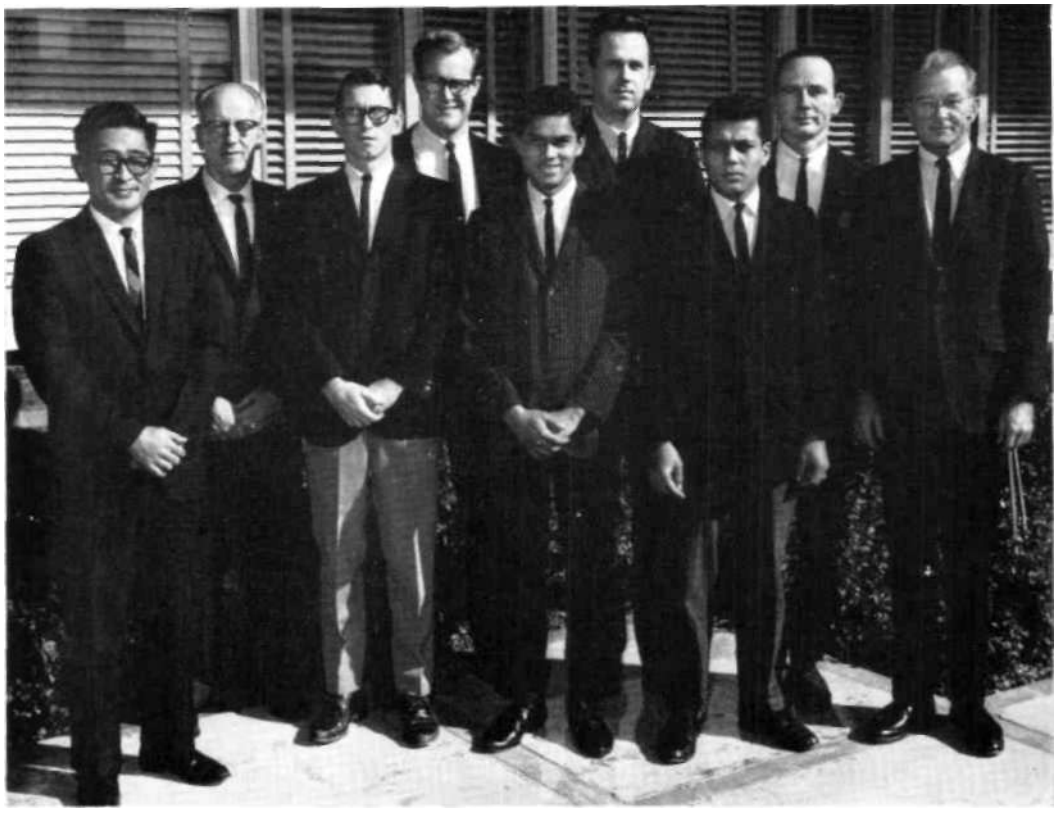
Prosthetics-Orthotics Education

Prosthetics-Orthotics Education at UCLA

Highlights of the 1964-1965 academic year for the UCLA Prosthetics-Orthotics Education Program included the establishment of a new two-semester certificate program for prosthetists-orthotists, record enrollments in courses for physicians and therapists, and the move to new and larger quarters in the UCLA Rehabilitation Center.

Five students were enrolled in the two-semester course: David L. Porter, John L. Stonecipher, Carman Tablada, and Jerry D. Vogt of the Southern California area, and Nelson Martinez from Hato Rey, Puerto Rico. During their two semesters in residence at UCLA, these students participated in the regularly scheduled courses in prosthetics and orthotics, attended eight hours of gross anatomy laboratory instruction, made field

New UCLA Rehabilitation Center nears completion. The UCLA Prosthetics-Orthotics Education Program moves into its spacious new quarters during the 1965 summer recess.



Participants in 1964-1965 two-semester program at UCLA. Left to right: Wallace Sumida, UCLA staff; Fred J. Sanders, UCLA staff; David L. Porter, student; John L. Stonecipher, student; Carman Tablada, student; Jerry D. Vogt, student; Nelson Martinez, student; John J. Bray, Associate Director, UCLA Prosthetics-Orthotics Education Program; Miles H. Anderson, Director, UCLA Prosthetics-Orthotics Education Program.

trips to numerous manufacturers' facilities in the Southern California area, took part in various research studies, and handled problem cases in all areas of prosthetics and orthotics. In addition, each student prepared and presented one unit of instruction in prosthetics-orthotics.

The UCLA Certificate Program for Prosthetists and Orthotists includes two full semesters of college-level instruction carried on under the rigorous discipline of a functioning medical center and school. The program provides eight hours per day of lectures and recitations, laboratory work, and clinical practice.

This same two-semester certificate program is being offered again by the UCLA Prosthetics-Orthotics Education Program during the 1965-1966 academic year. Six qualified students will be accepted with traineeship grants available from the Vocational Rehabilitation Administration to assist them. Selection of students is based on educational background and work experience. Preference is given to applicants with a baccalaureate degree and one year or more of shop and laboratory experience in prosthetics or orthotics. Applicants with only a baccalaureate degree are considered next, followed by those with an Associate in Arts degree and one year or more of shop and laboratory experience.

Applications for enrollment in the new two-week course at UCLA for physicians and therapists were filled early in the 1964-1965 academic year, and a number of applicants had to be turned away. The course for physicians and therapists includes complete coverage of upper- and lower-extremity prosthetics,

upper- and lower-extremity orthotics, spinal orthotics, and special material on reconstructive surgery of the upper extremities.

Information concerning UCLA instructional offerings in prosthetics and orthotics, together with application forms, can be obtained from Dr. Miles H. Anderson, Director, Prosthetics-Orthotics Education Program, Medical Center B4-229, University of California, Los Angeles, Calif. 90024.

Listed below is a tentative schedule of the courses offered during the 1965-1966 academic year:

Prosthetists and Orthotisls

Above-Knee Prosthetics—Sept. 20-Oct. 15.
Special Problems in Above-Knee Prosthetics—Oct. 18-29.
Below-Knee Prosthetics—Nov. 1-26.
Special Problems in Below-Knee Prosthetics—Nov. 29-Dec. 17.
Functional Long Leg Brace—Jan. 3-28.
Special Problems in Functional Long Leg Brace—Jan. 31-Feb. 11.
Hip-Disarticulation and Syme Prostheses—Feb. 14-Mar. 11.
Special Problems in Hip-Disarticulation and Syme Prostheses—Mar. 14-Apr. 1.
Upper-Extremity Prosthetics—Apr. 11-May 13.
Special Problems in Upper-Extremity Prosthetics—May 16-June 3.
Functional Bracing of Upper Extremities—June 6-24.
Child-Amputee Prosthetics—Nov. 1-5; Mar. 28-Apr. 1.

Physicians and Therapists

Prosthetics-Orthotics—Oct. 18-29; Nov. 29-Dec. 10; Jan. 31-Feb. 11; Mar. 14-25.
Child-Amputee Prosthetics—Nov. 1-5; Mar. 28-Apr. 1.

Rehabilitation Personnel

Prosthetic and Orthotic Rehabilitation—Sept. 13-17; Apr. 18-22; May 16-20.

In addition to their regular teaching duties, members of the UCLA Prosthetics-Orthotics Education faculty have been engaged in a number of related activities.

Miles H. Anderson, Ph.D., Director of the UCLA Prosthetics-Orthotics Program, was moderator for a panel on *Research Opportunities for Occupational Therapists in Prosthetics and Orthotics* at the annual convention of the American Occupational Therapy Association in Denver, Colo., October 28, 1964. He also spoke on *Upper-Extremities Research* at the annual assembly of Region XIII of AOPA in Shreveport, La., on March 26, 1965. At the request of Rancho Los Amigos Hospital, Dr. Anderson presented ten two-hour sessions of teacher training during April and May 1965.

John J. Bray, C.P.O., and Cameron B. Hall, M.D., attended a meeting of the U. S. Subcommittee of the Committee on Prostheses, Braces, and Technical Aids, International Society for Rehabilitation of the Disabled, in Florida on November 6, 1964. Mr. Bray also presented a paper entitled *The UCLA Functional Long Leg Brace* at the annual assembly of Region XI of AOPA in Portland, Oregon, June 18-19, 1965.

At the request of the Committee on Prosthetic-Orthotic Education, Dr. Hall's lecture entitled *Normal Human Locomotion* was made into a three-hour, 16-mm, black-and-white motion picture with sound. The film, specifically made for instructional purposes, is divided into logical teaching segments. Full details on its availability for loan have not yet been determined, although numerous requests have been received from hospitals and teaching institutions.

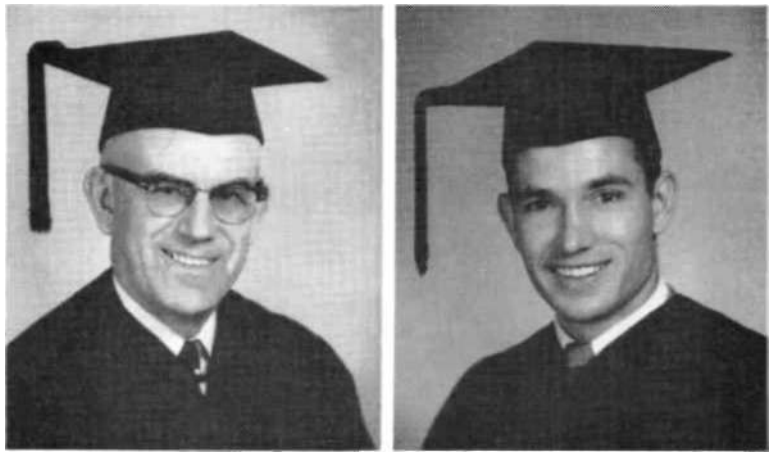
A new textbook, *Upper Extremities Orthotics,* was prepared by the UCLA Prosthetics-Orthotics Education Program staff and has been released by the publisher, Charles C Thomas. The new text replaces *Functional Bracing of the Upper Extremities.*

A symposium on Amputations and Prostheses was compiled by Leonard Marmor, M.D., of the UCLA faculty and appeared in Number 37 of *Clinical Orthopaedics and Related Research,* sponsored by the Association of Bone and Joint Surgeons.

Prosthetics-Orthotics Education at NYU

In June 1965 the first students will be graduated from New York University with the degree of Bachelor of Science in Prosthetics and Orthotics. These new graduates will be the first so accredited in this country or abroad. At present 25 baccalaureate candidates are pursuing this program of study.

To complete the curriculum for the senior year in the undergraduate program, two new courses in the area of specialization were intro



First two recipients of the degree of Bachelor of Science in Prosthetics and Orthotics at New York University. Ivan A. Dillee, at left, has been associated with NYU since 19S7 and is well known for his personal contributions to prosthetics. Hugh Panton, at right, developed interest in prosthetics when he became a below-knee amputee at eleven Upon graduation, he will be associated with J. E. Hanger, Inc., St. Louis, Mo.

Hans R. Lehneis, instructor at NYU, explains features of a long leg brace to an undergraduate.

Carlton E. Fillauer supervises a student laying out a brace at NYU.

duced in the fall semester of the 1964-1965 academic year. One was *Lower-Extremity Prosthetics: Foot and Below-Knee,* developed by Ivan A. Dillee, C. P.; the other was *Lower-Extremity Orthotics,* taught by Hans R. Lehneis, C.P.O. Three additional courses were inaugurated during the spring semester of the 1964-1965 academic year: *Lower-Extremity Prosthetics: Above-Knee and Hip,* taught by Mr. Dillee; *Upper-Extremity Orthotics,* taught by Mr. Lehneis; and *Spinal Orthotics,* taught by John Glancy, CO.

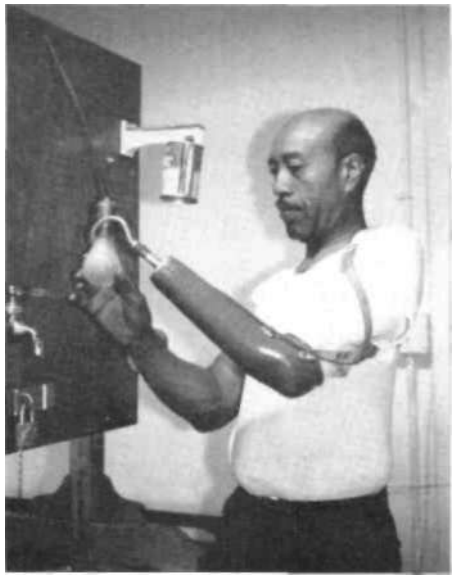
In the course in above-knee prosthetics, emphasis is placed on the fabrication of the newly developed plastic prostheses, along with instruction in the design of wooden sockets. The course in upper-extremity orthotics includes a review of anatomy and neurophysiology, types of upper-extremity disabilities, and the fabrication and fitting of protective and functional orthoses, including externally powered devices. The course in spinal orthotics covers spinal anatomy; neurological, muscular, and skeletal disabilities of the neck and trunk; and the fabrication and fitting of a variety of spinal and neck braces.

Clinically affiliated courses in prosthetics and orthotics are being offered to provide students with expanded opportunities for field work. With the cooperation of the American Orthotics and Prosthetics Association and the Metropolitan Orthopedic Appliance and Limb Manufacturers Association, students are placed not only in institutional settings but also in privately owned commercial facilities for on-the-job training experiences. The postgraduate prosthetics-orthotics educational program, now in its ninth year, continues to offer short-term courses in prosthetics and orthotics for physicians and surgeons, therapists, rehabilitation counselors, prosthetists, and orthotists.

In addition to the regular offerings, two courses in *Total-Contact Above-Knee Prosthetics* are being offered during the 1964-1965 academic year. Currently accepted methods of fabricating total-contact above-knee sockets are covered in these courses, with emphasis on the NYU Flexible Brim casting technique. Pertinent material on the total-contact above-knee socket has also been incorporated in the courses on lower-extremity prosthetics for physicians and surgeons, therapists, and rehabilitation counselors.

Two sessions of *Advanced Lower-Extremity Prosthetics* were included in the 1964-1965 schedule to acquaint graduates of earlier courses in lower-extremity prosthetics with new developments in the field. This course will be introduced from lime to time as the needs of graduates require it.

Mrs. Joan Edelstein, NYU faculty member, supervises physical therapists using prosthetic models to gain experience in amputee training problems.



Upper-extremity amputee practices bimanual activities of daily living at NYU.

The regular schedule of courses for physicians and surgeons during the spring session of the 1964-1965 academic year was supplemented with an evening session in *Lower-Extremity Prosthetics.* This session, meeting on Tuesday and Thursday evenings and on Saturdays for a three-week period, was designed to accommodate physicians unable to participate in the full-time one-week course. Registration for this course has been extensive, and similar sessions, in both prosthetics and orthotics, are planned for the 1965-1966 academic year.

During April 1965 a special invitational course for prosthetists was held. The course dealt with the fabrication and fitting of below-elbow prostheses, using the Munster fabrication technique as modified at NYU. Future courses in upper-extremity prosthetics will incorporate instruction in the design and use of the Miinster-type prosthesis, including its application to children.

During the fall of 1964 a course entitled *Physical Therapy Applied to Lower-Extremity Prosthetics and Orthotics* was inaugurated and

taught by Mrs. Joan Edelstein. It is a six-credit, two-semester, graduate-level course for students majoring in the physical therapy curriculum. Similar courses for graduate credit are being planned for students specializing in occupational therapy and rehabilitation counseling.

Listed below is the preliminary schedule of courses to be offered during the 1965-1966 academic year. Additional information and application forms can be obtained by writing to Dr. Sidney Fishman, Coordinator, Prosthetics and Orthotics, New York University, 342 East 26th St., New York, N. Y. 10010.

Prosthetists

Fluid-Controlled Above-Knee Prostheses—Sept. 13-17.
Wood Above-Knee Sockets—Sept. 7-17.
Upper-Extremity Prosthetics—Jan. 17-28.
Total-Contact Above-Knee Plastic Sockets—Mar. 21-26.
Below-Knee Prosthetics—May 16-June 3.
Above-Knee Prosthetics—June 13-July 1.

Orthotists

Lower-Extremity Orthotics—Jan. 17-28.

Physicians and Surgeons

Lower-Extremity Prosthetics—Oct. 4-9; Nov. 15-20; Feb. 14-19; Apr. 5-23; Apr. 25-30.
Upper-Extremity Prosthetics—Dec. 13-17; Mar. 28-Apr. 1.
Lower-Extremity Orthotics—Oct. 18-22; Mar. 1-17; Mar. 7-11; Apr. 11-15.

Therapists

Lower-Extremity Prosthetics—Sept. 20-Oct. 1; Nov. 1-12; Jan. 31-Feb. 11; May 2-13.
Upper-Extremity Prosthetics—Dec. 6-17; Mar. 21-Apr. 1.
Lower-Extremity Orthotics—Oct. 18-22; Mar. 1-17; Mar. 7-11; Apr. 11-15.

Rehabilitation Counselors

Prosthetics and Orthotics—Feb. 7-11; May 9-13.

A number of activities were undertaken by NYU staff and faculty members to provide young people with information concerning opportunities available in the fields of prosthetics and orthotics. At the invitation of high school guidance counselors, Messrs. Dillee, Gramza, and Springer participated in "Career Night" meetings, during which they led discussions on career opportunities in prosthetics and orthotics, exhibited and distributed materials, and answered students' questions.

Questions of visitors are answered at NYU booth at the Essex County Health Fair, June 1964.

During June 1964, NYU Prosthetics and Orthotics placed an exhibition booth at the Essex County Health Fair, sponsored by the New Jersey Inter-Professional Health Council, with attendance of more than 25,000 persons. The exhibit of mock-up arms, charts, literature, prostheses, braces, and similar materials attracted considerable attention. During and after the Health Fair, there were many inquiries concerning the educational program. NYU was also represented at a conference held during the spring of 1964 in New Brunswick, N. J., to discuss methods for recruiting students and staff in the health fields.

In addition to providing prospective students with information on career opportunities, these various activities also called attention to the traineeship assistance offered by the Vocational Rehabilitation Administration. The traineeship grants provide $3,600 for the junior year and $4,000 for the senior year for qualified full-time students matriculated in the Bachelor of Science curriculum. Inquiries concerning speakers for career information meetings or traineeship assistance may be addressed to Dr. Fishman.

Besides their teaching and administrative duties, faculty members have been active on various committees. Dr. Fishman has con-

tinued his work with a number of professional groups, including the University Council on Orthotic and Prosthetic Education, the Subcommittee on Child Prosthetics Problems of the Committee on Prosthetics Research and Development, and the Advisory Committee on Amputee Rehabilitation Centers of the New York City Interdepartmental Health Council.

Mr. Norman Berger and Mr. Dillee have represented NYU on the Subcommittee on Examinations of the University Council on Orthotic and Prosthetic Education and report considerable progress toward coordinating the content of university teaching programs with certification requirements. Mr. Warren P. Springer has worked with the Committee on Prosthetic-Orthotic Education on the preparation of teaching slides. Mrs. Edelstein presented a lecture program on lower-extremity prosthetics and orthotics at the State Education Meeting of the New Jersey Chapter of the American Physical Therapy Association. Mrs. Edelstein also serves as an abstractor of current literature for the *Journal of the American Physical Therapy Association.*

Prosthetics-Orthotics Education at NU

Scheduled to start in September 1965 is the Northwestern University—Chicago City Junior College program leading to the degree of Associate in Arts in Prosthetics.

In discussing the program, Mr. Robert Gruman, Past President of the American Orthotics and Prosthetics Association, said, "Our industry-profession is in need of more technicians and professional people each year. Currently, there are more than 250 facilities in the United States that need an additional man. The Associate in Arts degree program allows the profession the opportunity to recruit the new, the young blood that has been needed for some time. For years it has been everyone's responsibility to upgrade the professional standards of the industry. Now we have the added opportunity to recruit and teach newmen and continue the upgrading of the industry at the same time."

The program was developed in close liaison with representatives of the Vocational Rehabilitation Administration, the American Orthotics and Prosthetics Association, and Chicago City Junior College. The first year of

Representatives of the American Orthotics and Prosthetics Association's Advisory Committee to NU Prosthetic-Orthotic Education participate in a recent meeting to discuss the NU Associate in Arts degree program Seated, left to right: William Scheck, advisor; Richard Bidwell, advisor; Jack D. Armold, Director, NU Prosthetic-Orthotic Education; and Ralph Storrs, advisor. Standing are Chester Pachucki, Chicago City Junior College; and Don Irish, Administrative Assistant, NU Prosthetic-Orthotic Education.

Jack D. Armold, Director, NU Prosthetic-Orthotic Education, presents Certificates of Appreciation to. William Scheck, Richard Bidwell, and Ralph Storrs for their contributions to NU teaching programs.

training will be accomplished at the Southeast Campus of Chicago City Junior College and the remaining year will be on the Northwestern University campus. Qualifications for the program will be based upon high school graduation, completion of intelligence and mechanical comprehension tests, and admission by Chicago City Junior College. Those interested in the program should communicate with Mr. Chester Pachucki, Southeast Campus, Chicago City Junior College, 8600 South Anthony Ave., Chicago, Ill. 60617.

More than 700 students have enrolled for courses in prosthetics and orthotics at Northwestern University during the 1964-1965 academic year. Enrollment the previous year was 591. The substantial increase is attributable chiefly to the increase in attendance of residents in orthopaedic surgery and physical medicine. There have been slight increases in the enrollment of prosthetists and rehabilitation counselors, while the enrollment of therapists and orthotists has remained constant.

Enrolled in the Semester Program for Prosthetists, February 1-June 15, 1965, were: Harold K. Haines, Ankeny, Iowa; Harold Kramer, Barrington, Ill.; Ernest Munoz, Mar del Plata, Argentina; Alvin Pike, Chicago, Ill.; and Walter Wika, Cary, Ill.

Inquiries concerning instructional offerings by Northwestern University in prosthetics and orthotics should be addressed to Dr. Jack D. Armold, Director, Prosthetic-Orthotic Education, Northwestern University Medical School, 401 East Ohio St., Chicago, Ill. 60611.

Listed below is a tentative schedule of the courses offered during the 1965-1966 academic year:

Prosthetists

Below-Knee Prosthetics—Sept. 13-Oct. 1; Mar. 14-Apr. 1.

Above-Knee Prosthetics—Oct. 11-Nov. 5; Apr. 11-May 6.

Upper-Extremity Prosthetics—Feb. 7-Mar. 4.
Fitting and Fabrication of Special Prostheses—• May 16-June 3.
Management of the Juvenile Amputee—Nov. 29-Dec. 2; June 13-16.

Orthotists

Spinal Orthotics—Sept. 4-8; **June 20-24.**

Therapists

Lower-Extremity Prosthetics—Aug. 23-27; Sept. 27-Oct. 1; Nov. 1-5; Dec. 6-10; Mar. 28-Apr. 1; May 2-6; May 31-June 3.
Upper-Extremity Prosthetics—Nov. 8-12; Dec. 13-17; Feb. 28-Mar. 4; June 6-10.
Management of the Juvenile Amputee—-Nov. 29-Dec. 2; June 13-16.

Physicians and Surgeons

Lower-Extremity Prosthetics—Aug. 23-27; Sept. 27-Oct. 1; Nov. 1-5; Dec. 6-10; Mar. 28-Apr. 1; May 2-6; May 31-June 3.
Upper-Extremity Prosthetics—Nov. 8-12; Dec. 13-17; Feb. 28-Mar. 4; June 6-10.
Orthotics—Sept. 4-8; June 20-24.
Management of the Juvenile Amputee—Nov. 29-Dec. 2; June 13-16.

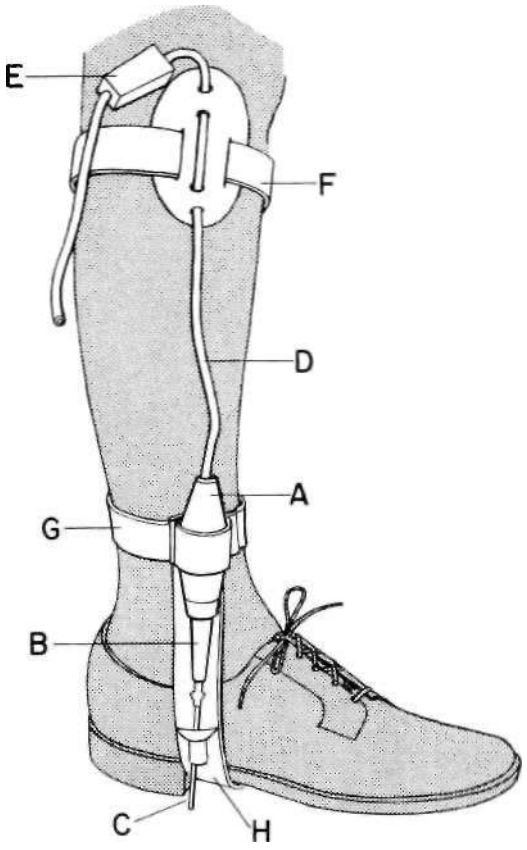
Rehabilitation Personnel

Orientation in Prosthetics and Orthotics—Nov. 15-19; Jan. 17-21; Jan. 31-Feb. 4.

New Swedish Technique for Gait Analysis

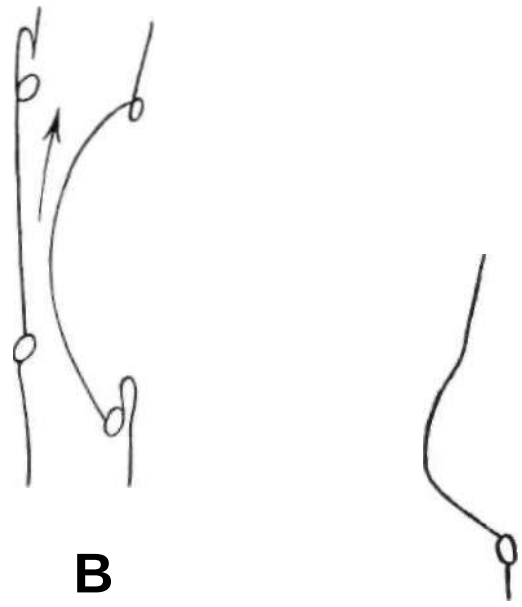
In an article entitled *A Simple Aid to Gait Analysis,* which appeared in *Svenska Lakartidningen,* 61: 2916 (No. 40), 1964, the author, Dr. Lars-Goran Ottosson of the Orthopaedic Clinic in Uppsala, Sweden, describes a simple, inexpensive technique for recording and analyzing the gait of a lower-extremity amputee as he walks on his prosthesis or prostheses.

A small container of liquid is attached to the lateral malleolus of each of the patient's legs. The container has an outlet through a short hose and a thin tube which discharges at the front edge of the heel. By means of a pinchcock, the flow of liquid is adjusted so that, as the patient walks over a long strip of newsprint, he makes a track in the form of a line of small drops during the swing phase and in the form of larger spots during the stance phase. The newsprint absorbs the dripping liquid and provides visible tracks, even with uncolored water in the container. A gait diagram can be preserved by filling in a representative part with grease pencil.



Swedish apparatus for gait analysis devised from a disposable unit for intravenous injection and three elastic bands. The liquid container *A* has an outlet through a short hose *B* and a thin tube *C* which discharges approximately at the front edge of the heel. A hose *D* with a pinchcock *E* (which controls the intake of air thereby regulating the discharge of drops of liquid) extends from the upper end of the container upward approximately to knee height. The apparatus is held in place by an elastic band *F* immediately distal to the knee joint, a second *G* immediately proximal to the malleoli, and a third *H* which passes under the shoe in front of the heel.

For records and filing over an extended period, Dr. Ottosson suggests photographing the gait diagrams, pointing out that if the photographs are made on the same scale, comparisons between different diagrams can easily be made. Since meaningful comparisons require a knowledge of the patient's walking speeds when the diagrams were obtained, the



Three gait patterns obtained by use of the Swedish apparatus: *A,* distribution of the drops during normal walking at a speed of 80 steps per minute; *B,* an example of medial circumduction; C, medial circumduction limited to the beginning of the swing phase.

author suggests that the walking speed be determined with the aid of a metronome. Speeds of 80 or 100 steps per minute are convenient speeds for many persons. In the case of pronounced walking difficulties, it may be necessary to reduce the rate to 60 steps per minute or less.

The gait diagram gives an impression of how the foot moves in the horizontal plane while walking. Frequently, the various motion phases in gait disturbances are quick and difficult to interpret or even to describe verbally. By providing the patient with a picture of his gait faults, the diagram can

sometimes assist him in overcoming the faults. To a trained appraiser, the diagram sometimes gives information about a faulty prosthesis which can then be remedied.

CPOE and Northwestern University Publish Pamphlet on Quadrilateral Socket for Above-Knee Amputees

A pamphlet entitled *Above-Knee Socket Shape and Clinical Considerations,* by Herbert Blair Hanger, C.P., Associate Director and Chief Prosthetist, Prosthetic-Orthotic Education Program, Northwestern University Medical School, has been published under the auspices of the Committee on Prosthetic-Orthotic Education. Funds for the publication were made available by the Training Division of the Vocational Rehabilitation Administration.

In a foreword to the pamphlet, the author acknowledges that the publication represents the thoughts, investigations, and clinical observations of many persons over a period of years, and indicates that the content is consistent with the instruction in prosthetics given at Northwestern University, the University of California at Los Angeles, and New York University.

Requests for the pamphlet should be addressed to the Executive Secretary, Committee on Prosthetic-Orthotic Education, National Academy of Sciences—National Research Council, 2101 Constitution Ave., N.W., Washington, D. C. 20418.

Trip to Orient by Dr. Eugene F. Murphy

Dr. Eugene F. Murphy, Chief of VA's Research and Development Division, Prosthetic and Sensory Aids Service, recently participated in the Pan-Pacific Conference on Rehabilitation held in Tokyo. He also served as lecturer there at a Prosthetics Seminar. Both activities were arranged by the International Society for Rehabilitation of the Disabled.

Part of Dr. Murphy's trip included visits to prosthetics activities at VA facilities in Manila and Hawaii and to nine VA prosthetic and sensory aids research projects in the United States.

IN MEMORIAM

Herbert Richard Lissner
1908-1965

An authority on analytical mechanics in general and biomechanics in particular, Herbert R. Lissner was Professor and Chairman of the Department of Engineering Mechanics and Coordinator of the Biomechanics Research Center, both at Wayne State University in Detroit. I first knew him as he collaborated with Dr. E. S. Gurdjian, in Neurosurgery, and Dr. Gaynor Evans, in Anatomy, in a classic series of studies of concussions, skull fractures, spinal column injuries, and fractures of the long bones. These experiments with models, monkeys, and cadavers, using electric strain gauges, "Stresscoat" brittle lacquer, and numerous other engineering techniques, illuminated causes of injuries from automobile and airplane accidents. Unquestionably this greater understanding has helped to prevent future deaths and disabilities.

Perhaps this work on concussions and fractures is his best known contribution. Fortunately, a number of workers are familiar with the techniques and philosophies that Professor Lissner and his colleagues reported effectively and enthusiastically before both medical and engineering audiences. The American Academy of Orthopaedic Surgeons and the American Society for Experimental Stress Analysis typify this diversity and interdisciplinary approach. He and the late Dr. Marian Williams, an anatomist and a therapist, were the coauthors of *Biomechanics of Human Motion,* a textbook intended for physical therapists.

Professor Lissner was a major organizer and Chairman during its formative years of Committee F-4 (Surgical Implant Materials) of the American Society for Testing and Materials. The Committee is devoted to improvement of the materials used within the human body to repair fractures, replace vessels or organs, and so on. In its brief history, the Committee has already made important progress in bringing together an interdisciplinary group, in drafting specifications for certain materials used in the body, and in conducting a symposium *(Artificial Limbs,* Autumn 1964).

Professor Lissner represented the American Society for Engineering Education on the Committee on Engineering Interactions with Biology and Medicine of the Engineers Joint Council (composed of the major engineering societies). By a peculiar transfer of roles, I happened to represent the American Society for Testing and Materials on this Committee, which is concerned with all aspects of bioengineering.

I also had an opportunity to observe him contribute to the Human Factors Division of the American Society of Mechanical Engineers.

He participated vigorously in the week-long summer Conferences on Engineering in Medicine at Andover, New Hampshire. These were sponsored by the Engineering Foundation.

My wife and I recall vividly both his energy and his enthusiastic references to his family. With characteristic, unassuming generosity he provided a home for a widow and her three small sons after his three boys were partially grown. He lived in an area far beyond normal commuting distance (35 miles) from Detroit, and had a summer home in Colorado.

With his broad backgrounds in biomechanics and in administration, Professor Lissner was an effective member for the past three years of the Committee on Prosthetics Research and Development. His particular responsibility was the chairmanship of the Subcommittee on Evaluation. This key function, involving testing plus a critical analysis of results, had been recognized as a special problem from the very early days of the Artificial Limb Program. With humor, perspective, devotion, and ability, Professor Lissner attempted to define successive steps, encourage better planning and more meaningful testing, and especially to stimulate attempts at assigning numbers to as many aspects as feasible—a most difficult task. Some elements of prosthetic or orthotic devices are easily—even deceptively—quantifiable. Many aspects, perhaps including the most crucial, are extremely difficult to measure or even to assign in order of rank. Professor Lissner's persistent efforts, including an editorial in this journal *(Artificial Limbs,* Spring 1964), focused attention on some of these unsolved problems.

At the Conference on the Control of External Power in Upper-Extremity Rehabilitation at Warrenton, Virginia, in April 1965, Professor Lissner appeared to be recovering safely from a mild heart attack. He dutifully rested after lunch and otherwise restrained his usual energetic style, yet his modest and thoughtful presence was felt by all.

Just before Professor Lissner's untimely death of a heart attack on May 28, 1965, he was helping to plan a workshop or small conference on "feeders"—assistive devices for upper-extremity paralysis—under the auspices of the Committee on Prosthetics Research and Development and his Subcommittee on Evaluation. The loss of his guidance and stimulation will be a severe handicap.

Professor Lissner's talents and contributions have earned deserved recognition. In May 1965 he received the Alumni Honor Award for Distinguished

Service in Engineering from his alma mater, the University of Illinois. At the Annual Meeting of the American Society for Testing and Materials to be held at Purdue University on June 16, 1965, he was scheduled to receive the Award of Merit for Distinguished Service to the Society.

In addition to the American Society of Mechanical Engineers and the American Society for Testing and Materials, Professor Lissner was a member of the Society of Automotive Engineers, the American Society for Engineering Education, the Society for Experimental Stress Analysis, the American Institute of Aeronautics and Astronautics, the American Association of Anatomists, Sigma Xi, and Tau Beta Pi.

Numerous articles by him as author or as coauthor have appeared in such diverse publications as the *Journal of Neurosurgery,* the *Proceedings of the Society for Experimental Stress Analysis, The American Journal of Surgery,* the *American Journal of Physical Anthropology, The Anatomical Record, Radiology, Medical Physics, The Journal of Bone and Joint Surgery,* the *Journal of Engineering Education,* the *Journal of the American Medical Association, Mechanical Engineering,* and the *Journal of the American Physical Therapy Association.*

EUGENE F. MURPHY, PH.D.[1]

[1] Chief, Research and Development Division, Prosthetic and Sensory Aids Service, Veterans Administration, 252 Seventh Ave., New York, N.Y. 10001.

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

THE NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL is a private, nonprofit organization of distinguished scientists and engineers dedicated to the furtherance of science and its use for the general welfare. The Academy itself was established by a Congressional Act of Incorporation, signed by Abraham Lincoln on March 3, 1863. Each year, the Academy elects up to 35 U. S. scientists and engineers to its membership, selected for their outstanding contributions to knowledge. Its members now number almost 700.

Under the terms of its Congressional charter, the Academy is called upon to act as an official—yet independent—adviser to the Federal Government in any matter of science or technology. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency.

The National Research Council was organized by the Academy in 1916, at the request of President Wilson, to enable the broad community of U. S. scientists and engineers to associate their efforts with the limited membership of the Academy in service to science and the nation. Its members, who receive their appointments from the President of the Academy, are drawn from academic, industrial, and government organizations throughout the country.

Supported by private and public contributions, grants, and contracts, and voluntary contributions of time and effort by more than 3,000 of the nation's leading scientists and engineers, the Academy and its Research Council thus work to serve the national interest, to foster the sound development of science and its applications, and to promote their effective utilization for the benefit of society.

COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT
COMMITTEE ON PROSTHETIC-ORTHOTIC EDUCATION

The *Commillee on Prosthetics Research and Development* and the *Committee on Proslhetic-Orlholic Education,* units of the Division of Engineering and Industrial Research and the Division of Medical Sciences, respectively, undertake activities serving research and education in the fields of prosthetics and orthotics, when such activities are accepted by the Academy as a part of its functions. Activities of the Committees are presently supported by the Department of Health, Education, and Welfare and the Veterans Administration. Information or reports developed by activities of the Committees are officially transmitted and published through the National Academy of Sciences.