Autumn 1968

Artificial Limbs

A Review of Current Developments

COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT

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The Problem of the Geriatric Amputee

HERBERT E. PEDERSEN, M.D.[1]

IT HAS been demonstrated that 70 to 90 per cent of all peacetime amputations result from gangrene in the lower extremities of elderly patients. Hansson[2] reported that in Sweden the amputation rate in males over 60 years of age rose from 34 per 100,000 population in 1947 to 129 per 100,000 in 1962. He predicted that those rates would continue to rise. Our experience in the United States seems to parallel that in Sweden, and therefore interest in the specific problems of the "geriatric" amputee is now high.

During the period of increasing incidence, the mortality rate following amputation for gangrene has declined sharply, from 45 per cent to approximately 5 per cent for all amputations. Furthermore, studies show that, following amputation, patients live long enough to justify every effort at their rehabilitation, and that when they effectively use a prosthesis they live longer and the remaining extremity survives longer.

For some time it has been recognized that the lower the level of a successful amputation the greater the chance that the patient will effectively use a suitable prosthesis. The most important factor in the ability of the geriatric amputee to use effectively a satisfactory prosthesis is the presence of the knee joint. In the absence of other complications, the patient who was able to walk before the onset of his disease should be able to walk with any type of satisfactory prosthesis after amputation below the knee once the stump is well healed.

It is apparent that the current problem of the geriatric amputee is not primarily one of prosthetic components, prosthesis design, fitting and alignment, or gait training. The current problem of the geriatric amputee is preservation of the knee joint.

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[2] Hansson, Jan, *The leg amputee,* Acta Orthop. Scand. (Suppl.), 69:1-104, 1964.

For at least 20 years literature has been available which discusses the specific indications for amputation levels of the lower extremity and details the surgical techniques necessary to ensure successful amputations at low levels in the ischemic extremity. The principles set forth in that literature became very important to surgeons who were particularly interested in amputations. Recently, as the result of the work of Burgess *et al.* on immediate postsurgical fitting and the concomitant upsurge of interest in amputations, many more surgeons have come to recognize the importance of these principles. The research project headed by Burgess and sponsored by the Prosthetic and Sensory Aids Service of the Veterans Administration, aside from its other important contributions, has done more to stimulate interest in amputations than any other single peacetime venture.

Despite the renewed interest in amputations, it is still true, unfortunately, that most amputations for gangrene are performed by surgeons who are much more interested in other problems. Far too many feel that the nature of the disease makes amputation above the knee inevitable, or that the mortality and morbidity associated with unsuccessful attempts at amputation at low levels preclude such efforts. The techniques for successful management of delayed healing are poorly understood. In many areas it is still not recognized that the problem in diabetes, leading to progressive lower-extremity tissue necrosis, is frequently uncontrolled infection, rather than ischemia.

This all suggests that in terms of man-hours, dollars, and total available facilities, great improvement in the rehabilitation of the geriatric amputee can come from a more efficient educational program which will lead to a higher incidence of successful amputations at low levels.

It has been suggested that to reach the surgeons who perform most of the amputations for gangrene there is need for a document which is generally accepted and widely distributed, and which will be read by those surgeons. In 1961 the Committee on Prosthetics Research and Development, recognizing the need for improvement in the rehabilitation of the geriatric amputee, sponsored a conference for the purpose of stimulating research in that area. The report of the conference, *The Geriatric Amputee* (NAS Publication 919), was well received, and, in addition to serving its original purpose as a reference for research personnel, has been used extensively in education and training of medical and paramedical personnel. New knowledge has made obsolete much that is contained in *The Geriatric*

Amputee, and CPRD has recommended to the Committee on Prosthetic-Orthotic Education that the necessary steps be taken to provide an authoritative document that will be useful to all who are engaged or expect to be engaged in the rehabilitation of the geriatric amputee. To this end, CPOE is calling upon a number of individuals from various disciplines with vast experience to assist in the preparation of such a document.

Surgeons need not wait, however, until publication of this volume to begin to take positive action to improve the lot of future geriatric amputees. They should review the literature and take every action possible to retain the knee joint in the geriatric case when amputation is indicated.

Recent Advances in Above-Knee Prosthetics

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During the past few years, many innovations have been introduced into the practice of above-knee prosthetics. Most of the literature on the new practices has been provided by the innovators, and therefore the reports and articles on the subject generally are limited to a single approach. It is the purpose of this article to survey past and present practices and to set forth, as accurately as possible, a perspective of procedures and devices available today for the management of the above-knee amputee.

Amputation through the thigh results in distinct functional losses. The obvious ones are loss of support by the long bones and loss of joints, resulting in inability to stand and move extensively from place to place. In addition, the appearance of the patient becomes altered from the "normal" in both static and dynamic conditions.

Lost support and mobility can be replaced to some extent by the use of a wheelchair or crutches or both, but it has been shown that use of an articulated prosthesis is the most effective means of compensating for these losses. An amputee with a functional prosthesis can negotiate stairs, ramps, and other obstacles and, therefore, can move through areas that would be impracticable if not impossible for a wheelchair. Crutches, properly used, offer a great deal of facility of movement but require the use of considerably more energy than a well-fitted and -aligned above-knee prosthesis, or even a peg leg *(2,19).* Also, when crutches are used the hands are not free during ambulation. Another argument for the use of a functional prosthesis is that a fairly normal appearance can be achieved.

The basic functional prosthesis for the above-knee amputee consists of a socket, a knee unit, a shank, and a foot-ankle unit. In cases where it is not deemed advisable to keep the socket in place by air pressure (suction socket), suspension must be provided by a belt about the pelvic area or by a shoulder harness.

Not so many years ago it was common practice for the prosthetist to make in his shop nearly every part for a prosthesis from basic materials such as wood, steel, and leather. This practice was time-consuming and wasteful. To eliminate as much manual work as possible, the prosthetist today designs and fabricates the socket from basic materials to fit each patient individually, but uses prefabricated components, which he purchases from manufacturers, for the rest of the prosthesis (2, *16).*

SOCKETS

Until the introduction of the suction socket in the late 1940's *(9),* it was common practice to provide the above-knee amputee with a so-called plug-fit socket suspended by a pelvic band connected to the socket by a metal "hip" joint (Fig. 1) *(23).* The plug fit did not provide for a very adequate distribution of forces between stump and socket. There was a tendency for the formation of an adductor roll, and the stability provided between stump and socket left much to be desired. The pelvic belt was heavy. The "hip" joint restricted motion essentially to flexion and extension, and was subject to frequent breakage. Most of the sockets were

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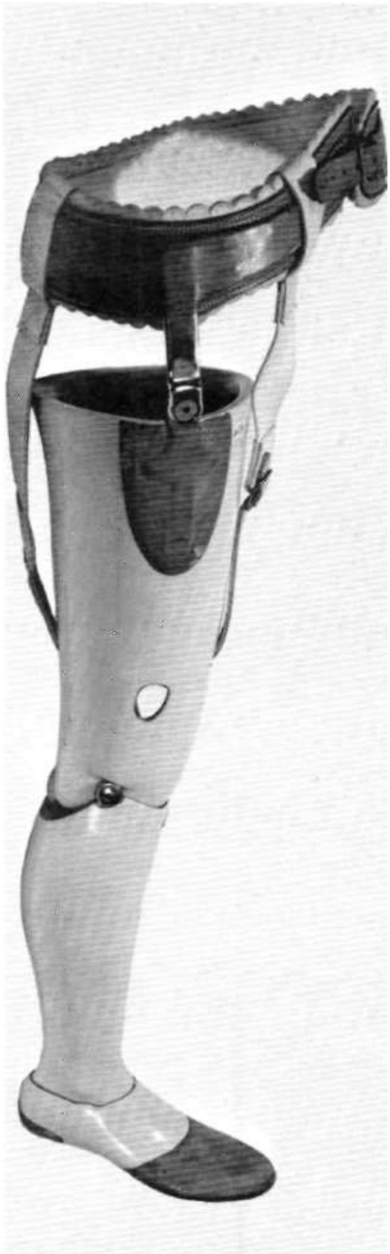


Fig. 1. Typical prosthesis for above-knee amputees during the 1940's. Note pelvic band, mechanical "hip joint," carved wooden socket with a "plug fit," and pelvic-control knee joint.

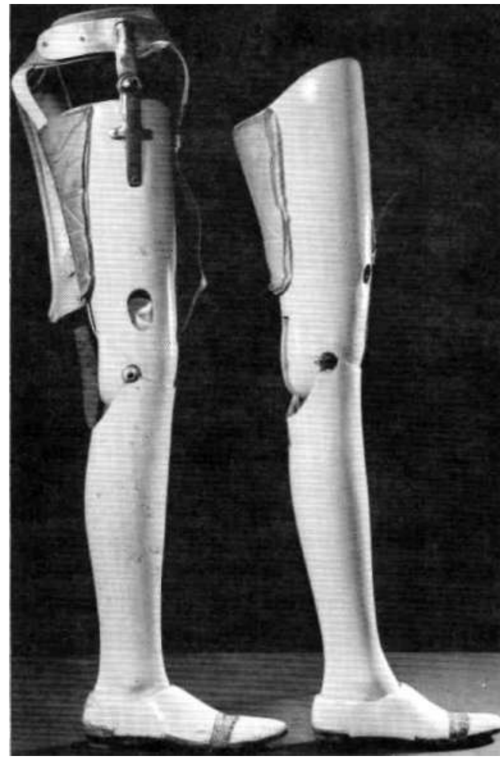


Fig. 2. An early version of the suction-socket prosthesis *(right)*, shown in comparison to the so-called conventional above-knee prosthesis.

carved from willow wood and reinforced with rawhide, although sockets formed from aluminum sheet were not uncommon.

The primary purpose of the suction socket (Fig. 2) was to provide increased function and comfort by eliminating the mechanical hip joint and pelvic belt. Pressures between the stump and socket were distributed over wider areas; stability and, therefore, control were improved materially. A socket of the quadrilateral shape *(11,17)* became standard whether or not suction was used for suspension. The waist belt and Silesian bandage were introduced as more comfortable suspension methods to supplant the pelvic belt and hip joint in some cases. Willow wood remained the material of choice, but plastic laminate

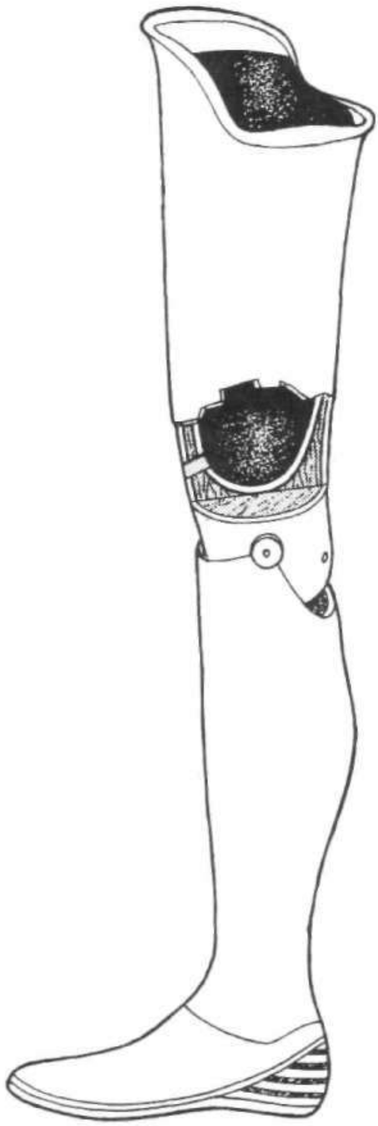


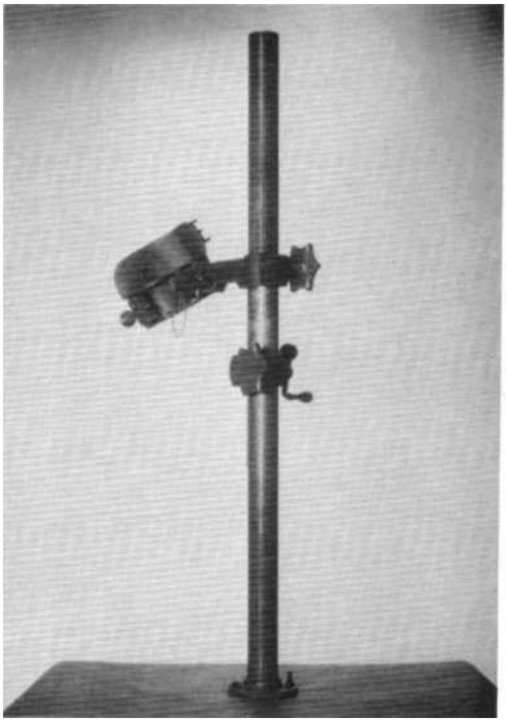
Fig. 3. An above-knee prosthesis with a quadrilateral, total-contact socket.

(usually nylon stockinet impregnated with a polyester resin) replaced rawhide as a reinforcement material.

Experience with problem cases, with the early versions of the suction socket in which a certain amount of air space is left below the distal end of the stump, led the University of California, Berkeley, to develop the modification now known as the total-contact above-knee socket (Fig. 3)(5,6). In a certain number of cases, edema developed in spite of most careful fitting with the "open-end" socket. It was found that the edema could be eliminated by providing a small amount of counterpressure over the distal end. It was also found that the entire stump must be in contact with the socket in order to keep the circulatory system in balance. The introduction of counterpressure also reduced the unit pressures at the proximal region of the stump, and the contact over the end of the stump seemed to enhance proprioception.

To provide a well-fitting total-contact socket of wood requires a great deal of skill and is quite time-consuming compared with the use of plastic laminates. Plastic laminates, which had proven so useful in the fabrication and fitting of upper-extremity and below-knee prostheses, had not been used for above-knee sockets because of the difficulty encountered in obtaining an adequate cast for preparation of the positive model needed for molding the laminate. A few highly skilled prosthetists had been known to produce adequately formed casts using only their hands, but this achievement was exceptional. To solve this problem, several devices were developed so that casts of above-knee stumps that required a minimum amount of modification could be achieved.

The UC-Berkeley device (Fig. 4)*(5,12)* uses a series of adjustable brims with which the cast is taken under weight-bearing conditions; the Veterans Administration Prosthetics Center device uses a three-part universal jig for holding the stump in position, also under weight-bearing conditions (Fig. 5)*(12);* the New York University casting fixture is a portable device that holds the cast in position but does not require the patient to be in a weight-bearing position (Fig. 6)*(12)*; and Northwestern University has developed



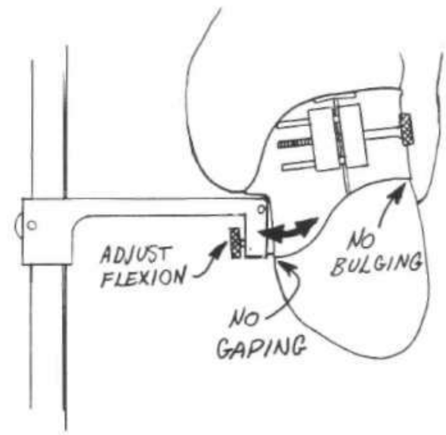


Fig. 4. The fixture for the "brim-fitting" technique developed at the University of California Biomechanics Laboratory (San Francisco and Berkeley). Adjustable, easily interchangeable brims are available in a complete range of sizes. The view on the right shows attitude of patient in fixture; right leg is not shown for clarity. See Figure 7 for still another view.

a modification of the UC-Berkeley technique in which a cast sock is used to suspend the stump and thus assist in forming the desired contours (Fig. 1)*(10)*.

The object of each of these tools is exactly the same: to provide a cast of the above-knee stump that requires the least modification for the fabrication of a well-fitting, quadrilateral, total-contact socket. Each has its advantages and disadvantages. None is superior to the others in all aspects, and selection is based on the personal preferences of the prosthetist. Many facilities have two or even all three devices available for use as circumstances dictate.

FITTING AND ALIGNMENT

The basic rationale of alignment as set forth by Radcliffe *(17)* in the early 1950's is essentially unchanged, although proper use of some of the hydraulic knee units demands some variations.

In order to make it easier for the prosthetist to achieve optimum alignment, the University of California, Berkeley, developed the adjustable leg (Fig. 8) and alignment duplication jig (Fig. 9)*(20)*. Dynamic alignment is obtained during amputee ambulation with the adjustable pylon, and the alignment obtained is transferred to the finished prosthesis during fabrication by use of the alignment duplication jig. This procedure proved to be highly satisfactory for use with single-axis, constant-mechanical-friction knee joints, since the adjustable leg also contained this type of joint. Because the functions of the Hydra-Cadence leg demanded that it be aligned somewhat differently, the STAROS-GARDNER coupling (Fig. 10) was designed *(20)*. When

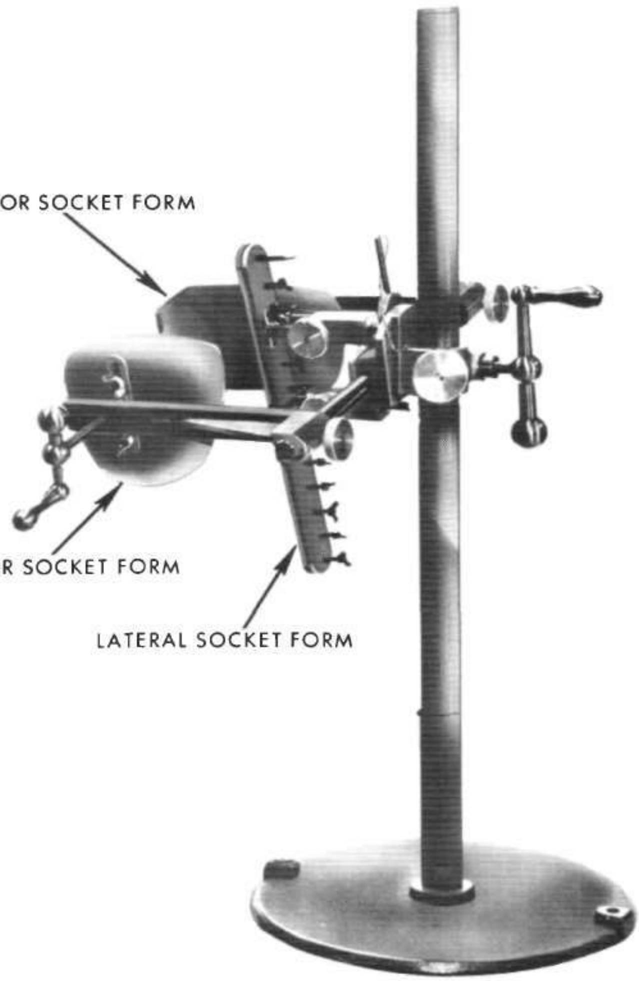


Fig. 5. The fixture for casting the impression of an above-knee stump developed at the Veterans Administration Prosthetics Center.

placed between the top of the knee block and the thigh piece or socket, the Staros-Gardner coupling provides all the adjustments permitted by the adjustable leg except mediolateral placement of the foot with respect to the knee axis, an adjustment not often used and, then, only to provide better cosmetic appearance. A technique was developed so that when final alignment was achieved a wooden block could be substituted for the coupling, thereby eliminating the need for the alignment duplication jig.

COMPONENTS

Components for above-knee prostheses can be obtained from central manufacturers in a number of ways. The most common approach is to purchase "knee-shin set-ups" and foot-ankle units, and to connect these to each other and to the socket in the alignment best suited for the individual patient. The knee-shin set-up usually consists of a wooden knee block, the proximal portion of a hollow wooden shank, and a knee control mechanism (Fig. 11). Excess wood is provided so that the

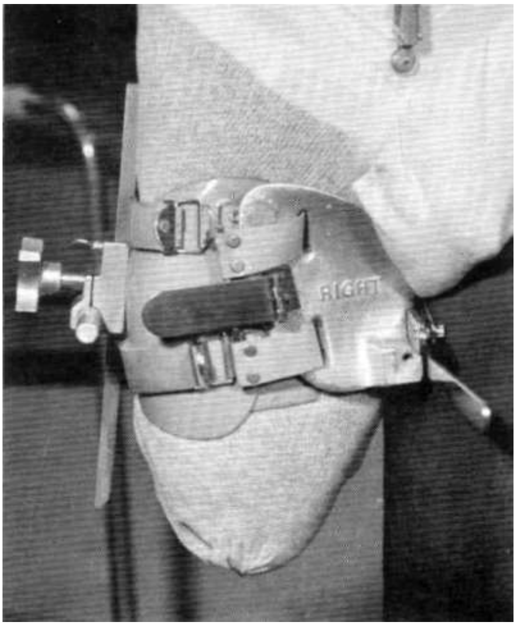


Fig. 6. Anterior view of the New York University casting brim in use.

knee and shin can be individually contoured, and in the finished prosthesis the entire unit is reinforced structurally by the application of a plastic laminate over the exterior. Complete wooden set-ups are available, but are seldom used. However, when coordinated motion between knee and ankle is incorporated in the prosthesis, as in the Hydra-Cadence unit, a complete set-up is used.

A number of temporary, or preparatory (see *inset* on p. 18) prostheses, popularly known as "pylons," are available (Fig. 12). Usually these devices are used with an ordinary foot-ankle unit which can be incorporated into the final or definitive prosthesis.

KNEE UNITS

Probably no other component of artificial limbs has received as much attention from designers and "gadgeteers" as the knee joint. Several hundred patents have been issued for knee designs, and many types have been produced and offered to the public, but relatively few designs have been used widely.

The primary functions of a knee unit for above-knee prostheses are control of the leg during standing and the stance phase of walking, and control of the shank during the swing phase of walking.

Swing-Phase Control

The articulated above-knee prosthesis functions as a compound pendulum. As the thigh stump is brought forward during the latter stages of stance phase, the knee begins to flex and the foot is lifted from the ground because of the effects of inertia. The force propelling the shank acts more or less horizontally through the knee joint, while the center of gravity of the

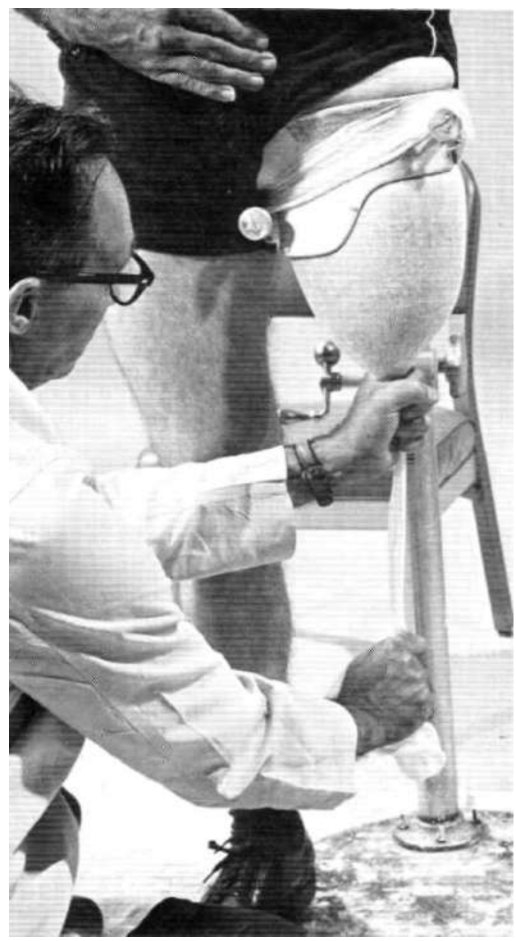


Fig. 7. A method, developed at Northwestern University, which uses the University of California casting fixture.

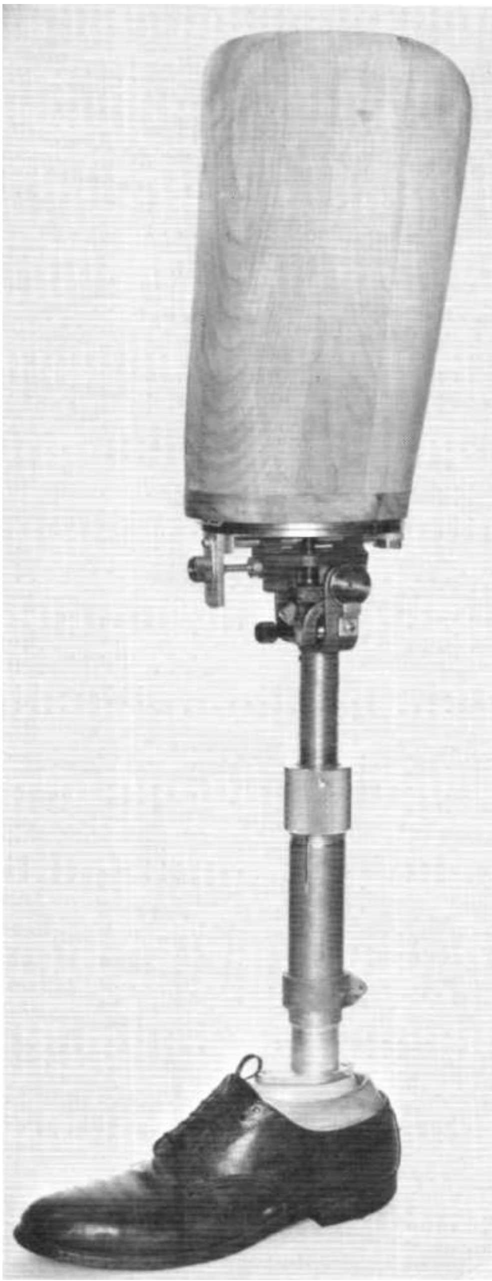


Fig. 8. The adjustable above-knee leg developed by the University of California Biomechanics Laboratory (San Francisco and Berkeley).

shank is well below this level; thus a moment is created, resulting in rotation of the shank about the knee joint in a backward direction (Fig. 13)*(15,16).*

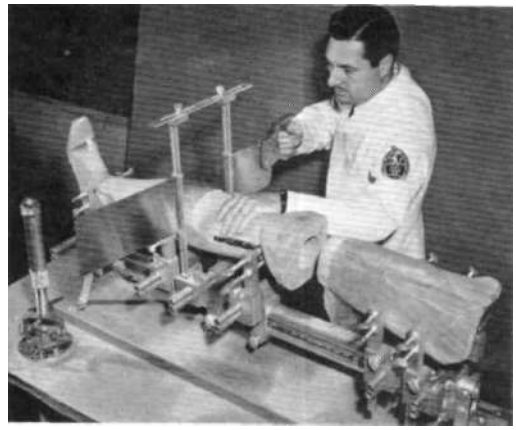


Fig. 9. The alignment duplication jig developed by the University of California Biomechanics Laboratory (San Francisco and Berkeley) to be used in conjunction with the adjustable leg shown in Figure 8.

The less friction there is in the joint, the higher will be the rise of the heel for any given acceleration. Therefore, when a nearly frictionless joint is used, the amputee must use very short steps at a low cadence, so that the shank and foot will return to the proper fully extended position to support him as stance phase is begun. If friction, or some other form of resistance, is introduced, rise of the heel is restrained and shank motion toward full extension is retarded, so that longer steps at higher cadences are possible. When the amount of friction is constant, only one best speed is available to the patient. To overcome this limitation, designers have turned to hydraulic and pneumatic devices to obtain desirable resistance.

To guide the design of swing-phase control units, the University of California has plotted knee moments against time for the ideal prosthesis during swing phase (Fig. 14)*(28).* This diagram is based on data accumulated from four normal young males, allowances being made for weight and weight distribution between normal and artificial limbs. The values, of course, will change as cadence is varied and as the height and weight distribution are changed. However, the general pattern should not change.

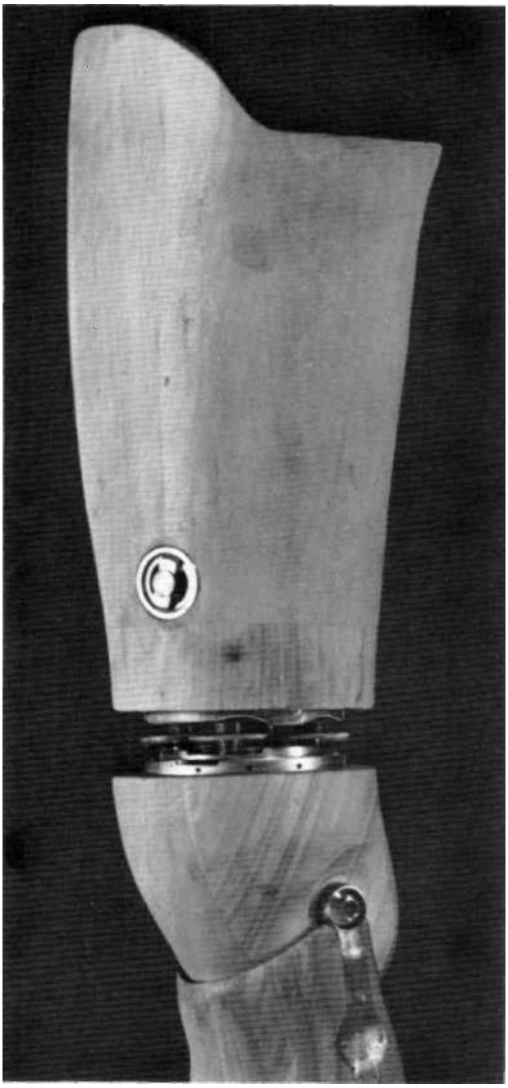


Fig. 10. Staros-Gardner coupling being used to achieve alignment in an above-knee prosthesis. When the desired alignment has been achieved the coupling is replaced with a section of wood. A technique has been developed so that alignment can be maintained without need for the alignment duplication jig.

Constant Friction (Mechanical)

Constant friction in a way is a misnomer, because the amount of friction or restraint can be controlled or set, but does not vary in accordance with the needs of the amputee during a given cycle. The amount of friction can be controlled in a number of ways, the most common being the application of a braking surface to the peripheral area of the knee bolt (Fig. 15). The typical knee-moment diagram for a constant-friction knee unit is shown in Figure 16.

Intermittent Friction

To more closely approximate the ideal knee-moment diagram, several designs have been made to vary the amount of

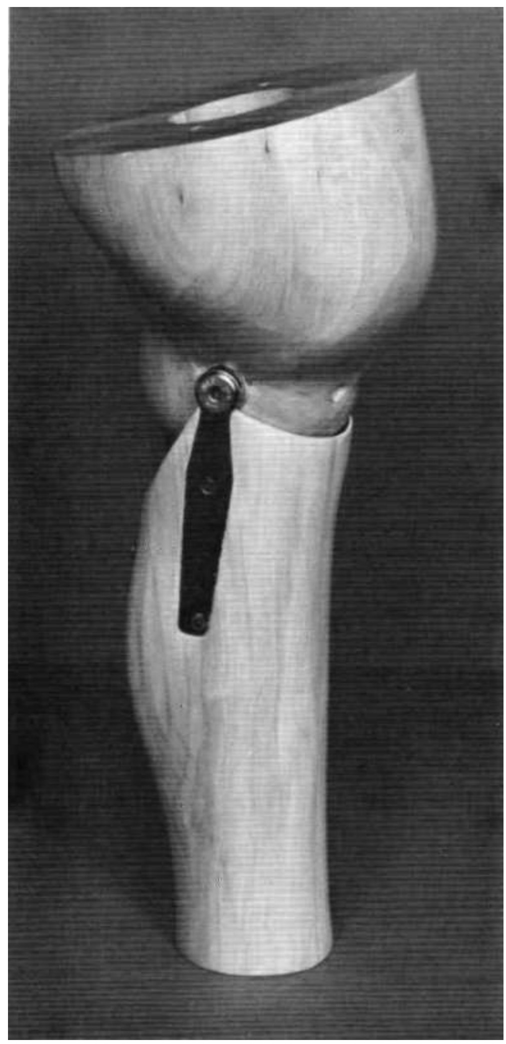


Fig. 11. Typical knee-shin wood set-up. *Courtesy U.S. Manufacturing Co.*

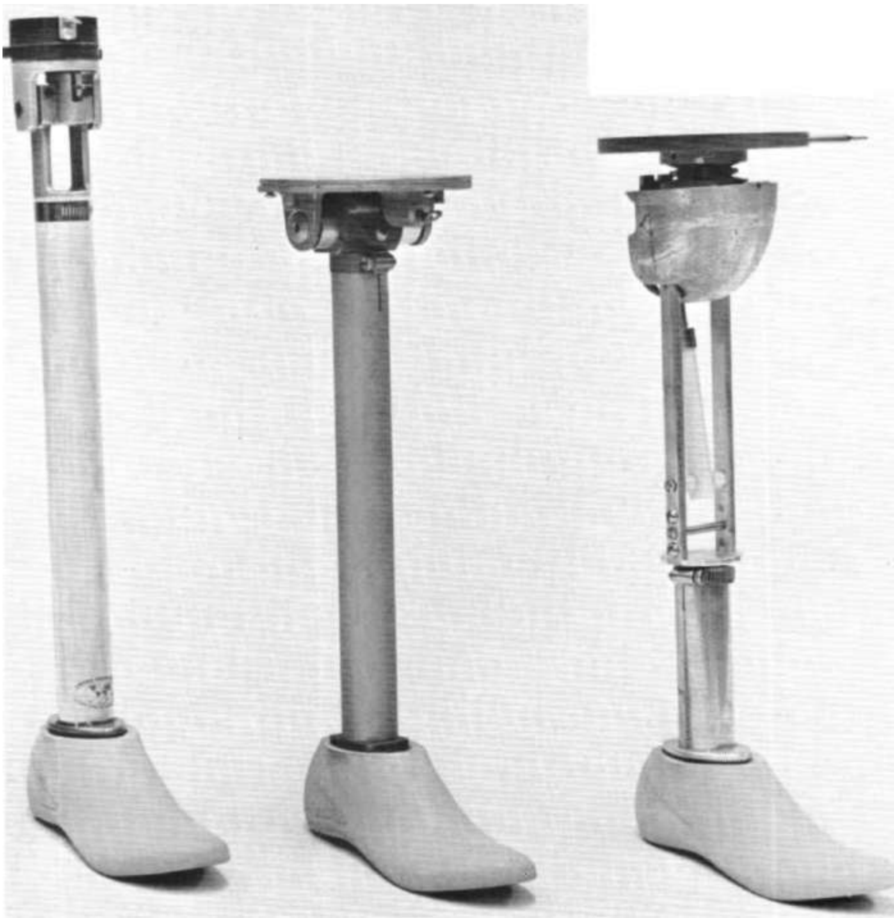


Fig. 12. "Pylons" for above-knee amputations. *Left,* U.S. Manufacturing Co.; *Center,* A. J. Hosmer Corp. unit based on the UCB adjustable leg; *Right,* VAPC unit designed to accommodate a variety of knee-control devices.

mechanical friction applied at predetermined points during the swing phase. The Northwestern University Intermittent-Friction Knee Unit (Fig. 17) is one such device that is available commercially. Mechanical friction is provided by pressure between three disks mounted concentrically with the long axis of the knee bolt. The resistance offered by each individual disk is brought into play at varying intervals during the swing phase. The knee-moment diagram of the Northwestern University unit is shown in Figure 16. The unit is available in a wood set-up, and is delivered with three disks installed. Two additional disks of different configurations are provided for interchange with the regular disks, so that the pattern of resistance about the knee can be changed to suit the amputee on an individualized basis *(22).*

Hydraulic Swing-Phase Control Units

Because the resistance offered by an orifice to the flow of a fluid increases at a greater rate than the increase in velocity of the fluid, hydraulic systems are ideally suited for control of the shank during

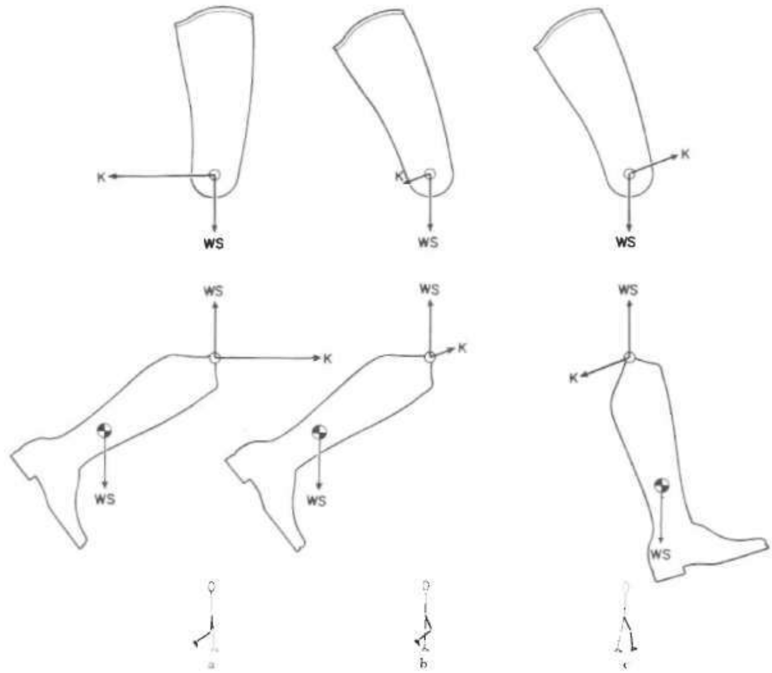


Fig. 13. Forces developed during rotation of the shank about the knee joint during forward swing of the thigh.

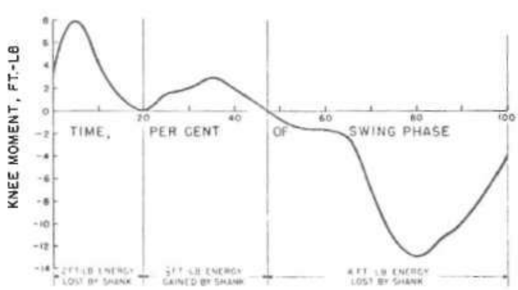


Fig. 14. Knee-moment pattern required for natural swing of an artificial leg. This curve was developed by the University of California Biomechanics Laboratory based on data collected during the study of human locomotion *(18).*

swing phase. Thus, heel rise and terminal deceleration can be controlled automatically over a wide range of cadences, giving the amputee much more flexibility in speed of ambulation *(19).* The value to be obtained by applying these principles has been recognized for many years, but a good deal of engineering was required to develop units that met the exacting demands of limb prosthetics *(13,21).*

The Henschke-Mauch Model "B" unit (Fig. 18) is a very sophisticated device available in a wood set-up to make its use compatible with standard components and practices. A number of orifices are so incorporated into the cylinder wall that the moving piston successively blocks off escape of the fluid and thus varies the resistance throughout the swing phase in order to approximate the ideal moment curve (Fig. 16). Resistance to flexion and to extension may be adjusted independently of each other by the wearer.

In a clinical evaluation program conducted by the Veterans Administration, involving more than 30 test subjects, the results were overwhelmingly in favor of the Henschke-Mauch unit in comparison with mechanical friction devices previously worn by the amputees in the study *(25).*

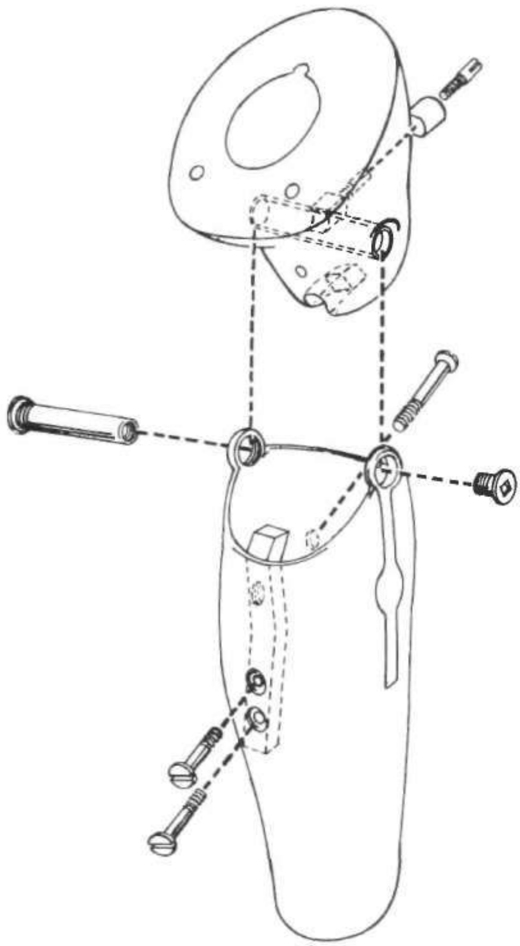


Fig. 15. One type of constant-friction single-axis knee joint.

The ability to vary gait easily and a reduction in effort required and fatigue produced were the advantages most frequently cited. The last two advantages are particularly noteworthy, since the experimental prostheses were heavier than the prostheses worn previously.

The DuPaCo "Hermes" Knee (Fig. 19) is quite similar in design and function to the Henschke-Mauch Model "B" unit and is also available in a wood set-up. Resistance to flexion and to extension may be adjusted independently of each other by the amputee. A clinical study of the DuPaCo knee by the Veterans Administration resulted in very positive reactions, strikingly similar to those obtained in the study with the Henschke-Mauch Model "B" unit *(26).*

Unlike the Henschke-Mauch and DuPaCo units, the "Hydra-Cadence" hydraulic leg (Fig. 20) is an integrated system incorporating some ankle control as well as swing-phase control. This system is available only in a metal frame, with a specially designed foot-ankle assembly. For appearance, the metal frame that constitutes the shank is covered with a cosmetic cover of a relatively thin, semirigid plastic cast to resemble an average normal shank. The swing-phase unit is a relatively simple piston type and does not offer quite as precise control of function as the more sophisticated units. In addition to control of the shank during swing phase, resistance to plantar flexion is controlled hydraulically, and motion between the ankle and knee are coordinated so that dorsiflexion of the ankle takes place after the knee has been flexed 20 deg. The object of the coordinated motion feature was to provide additional toe clearance during the swing phase, but unfortunately the motion does not take place at the time when it is needed most. Nevertheless, as in many other instances, the side effects are highly useful. One advantage of coordinated motion appreciated by amputees is that during sitting dorsiflexion of the foot allows the wearer to draw his artificial foot comfortably under his knee, thus keeping it out of the way when he is seated in a theater or bus. In clinical tests conducted by the Veterans Administration, the overwhelming majority of test subjects preferred the "Hydra-Cadence" unit to their conventional limbs *(24).*

The swing-phase control system of the "Hydra-Cadence" unit is offered in a wood set-up or separately for use in a pylon as the "Hydra-Knee" (Fig. 21).

Although the problems of leakage and high maintenance costs have been overcome to a point where hydraulic devices

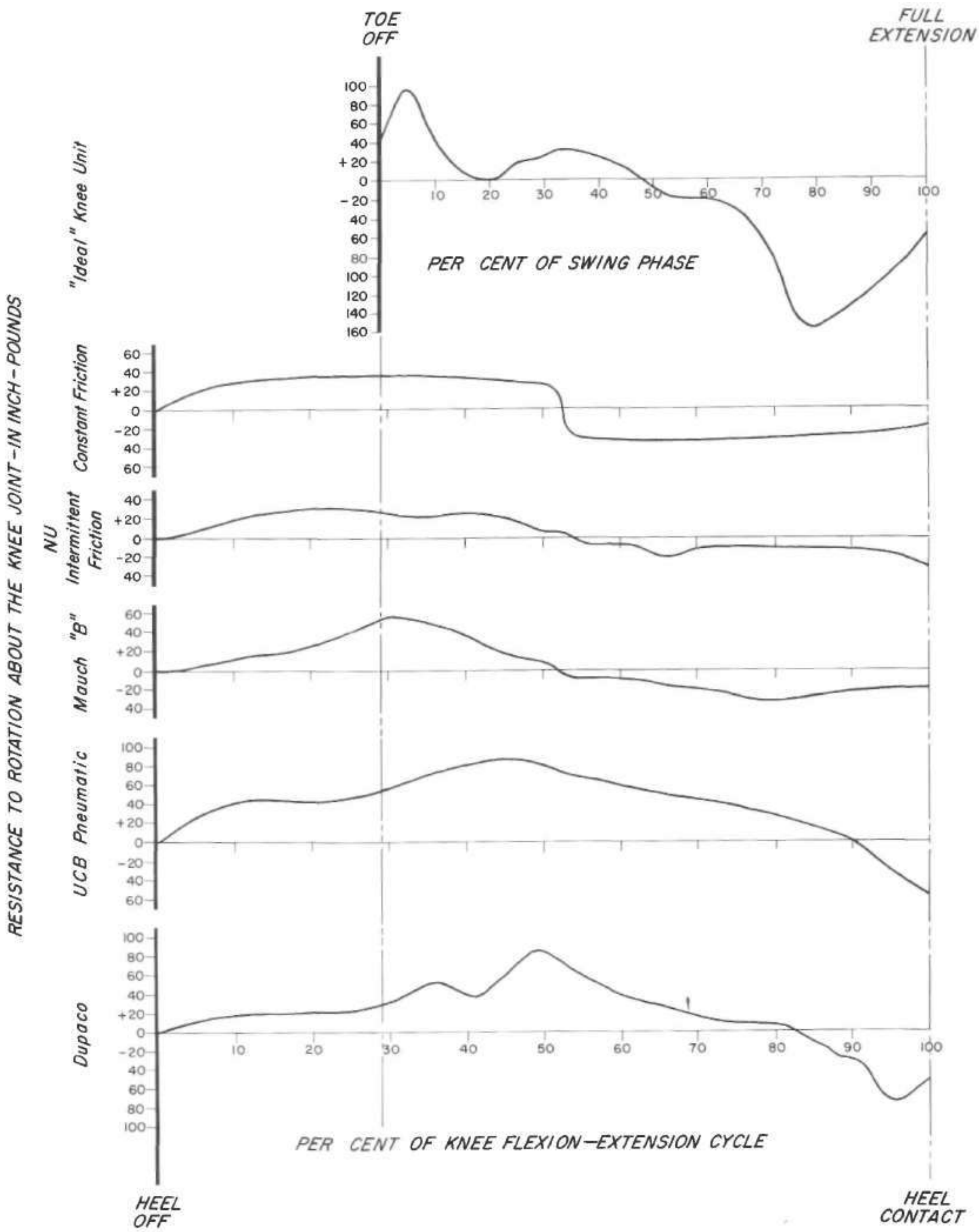


Fig. 16. Knee-moment patterns of various swing-phase units in comparison with the ideal curve of Figure 14. Data were taken at the Veterans Administration Prosthetics Center. The knee units were adjusted for intermediate resistance, and were subjected to 43 cycles per min.

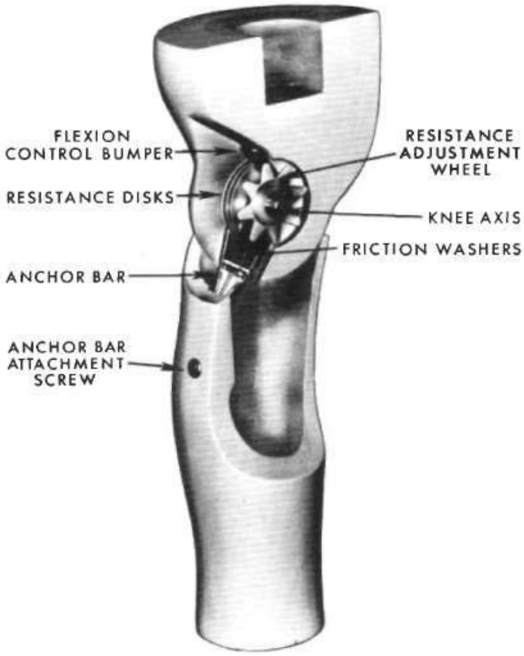


Fig. 17. Intermittent-Friction Knee Unit developed at Northwestern University, installed in a wood set-up.

are practical, pneumatic systems also have appeal since manufacturing costs should be materially lower. Pneumatic systems are not apt to produce a knee-moment curve as smooth as those obtained with hydraulic units, but many feel that they offer an excellent compromise suitable for many amputees.

One such device nearly ready for commercial distribution is the University of California Pneumatic Swing-Phase Unit *(15,21).* Like the Henschke-Mauch and DuPaCo units, the UCB device consists essentially of a moving piston in a cylinder (Fig. 22). It will be available initially in a pylon-type shank and wooden knee block.

STANCE-PHASE UNITS

Increased understanding of fitting and alignment has alleviated many of the former problems of stability control of the leg during stance phase, especially for those patients with relatively strong stumps. Nevertheless, there appears to

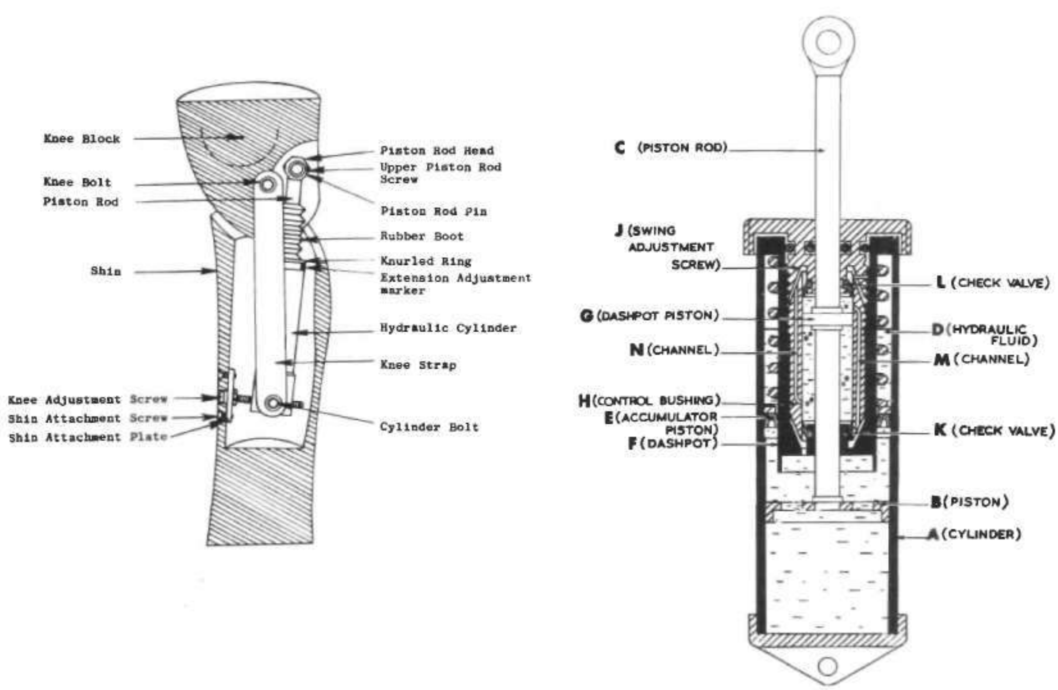


Fig. 18. The Henschke-Mauch "Hydraulik" Knee Unit. *Left,* Unit installed in a wood set-up; *Right,* cross-section of the Model "B" (Swing-Phase) Unit.

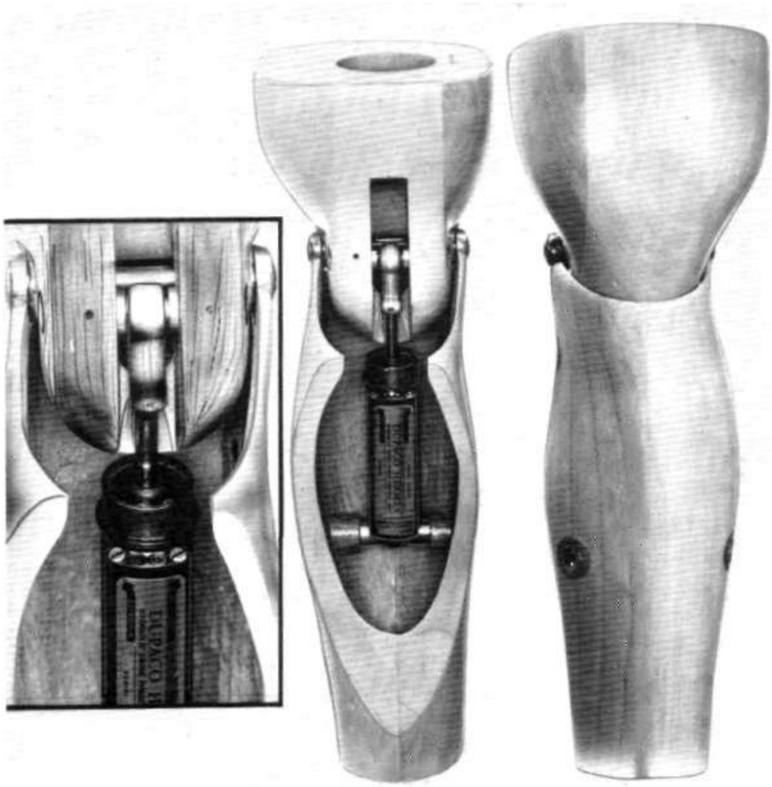


Fig. 19. DuPaCo "Hermes" Hydraulic Swing-Phase Control Unit mounted in a wood set-up.

be a real need for knee units that provide assurance against buckling yet do not interfere with other functions of the leg. The increase in the number of "geriatric" patients in recent years has tended to highlight this need. Patents have been granted for many ways of stabilizing the knee, but few have been found practical.

Doubtless the most widespread stance-phase control device in use today is the Otto Bock knee (Fig. 23). Purely mechanical in action, the Bock knee provides resistance to flexion by a friction braking action effected by weight-bearing. When weight is placed on the prosthesis, the knee block moves slightly toward the shank to engage a "V"-type brake. Swing-phase control consists of constant friction and a spring-biased extensor mechanism.

The Henschke-Mauch Model "A" unit (Fig. 24), currently in an advanced experimental stage, consists essentially of the Model "B" unit (Fig. 18) with provisions for stance-phase control added. Braking of the knee joint is controlled by the complex interaction of a pendulum and a counterweight suspended in hydraulic fluid *(16).* The braking action is brought into play whenever required to arrest buckling action, and is removed only by the prolonged hyperextension moment typical of late stance phase, so theoretically there should be a smoother transition between stance phase and swing phase than that provided by other units. Moreover, for special tasks, the amputee can set the knee either in "freewheeling" or almost fully locked position.

Fig. 20. "Hydra-Cadence" Artificial Leg with cosmetic cover removed.

A clinical evaluation by the Veterans Administration involving 50 units has nearly been completed. It is expected that the Henschke-Mauch Model "A" unit will be available for general use in the near future.

FOOT-ANKLE UNITS

Many attempts have been made to develop foot-ankle units that offer more than the minimum function required, which is controlled plantar flexion. Through the years several designs have been manufactured and made available, but none has found widespread use, usually because the maintenance requirements of the units have outweighed any functional gain they offered. Thus, today, nearly every artificial leg (except the "Hydra-Cadence") incorporates either a SACH (solid-ankle cushion-heel) foot (Fig. 25) or a so-called conventional foot (Fig. 26). Both designs provide controlled resistance to plantar flexion, firm resistance to dorsiflexion, and limited toe motion, but little else. Resistance to plantar flexion can be adjusted more easily in the conventional foot by introducing rubber bumpers of different densities. The absence of parts in the SACH foot which rotate or rub and its resistance to moisture make its use attractive. Since its introduction in 1958, the design of the SACH foot has been refined

Fig. 21. "Hydra-Knee" installed in a wood set-up.

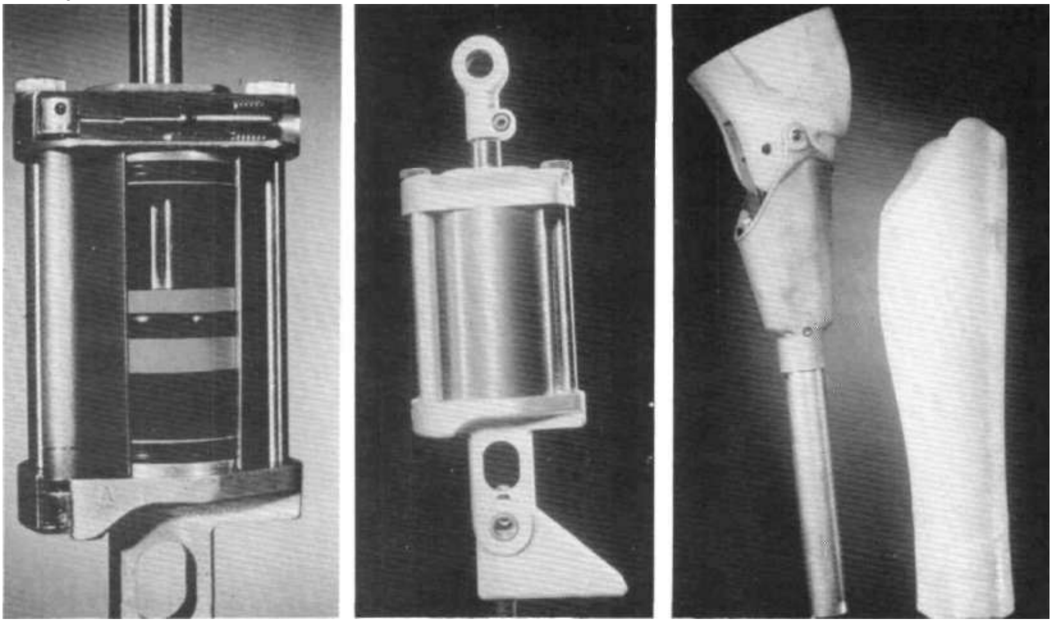


Fig. 22. Pneumatic Swing-Control Unit developed at the Biomechanics Laboratory, University of California (San Francisco and Berkeley). *Left,* Cutaway view; *Center,* complete unit; *Right,* pylon and cosmetic cover designed especially for the pneumatic unit.

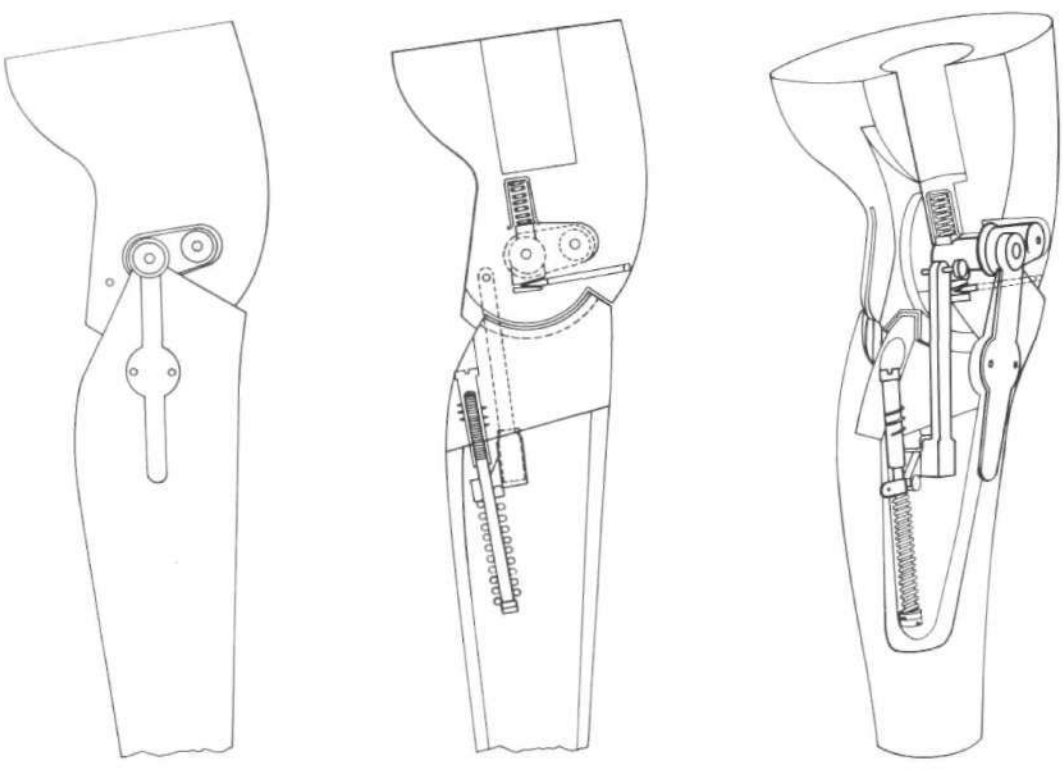


Fig. 23. The Otto Bock Safety Knee Unit.

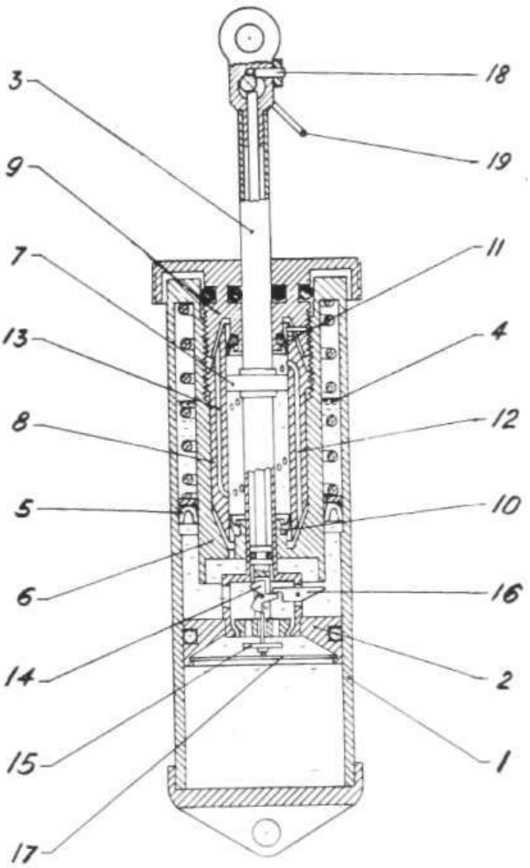


Fig. 24. Henschke-Mauch "Hydraulik" Model "A" (Swing and Stance Control) Unit. *1*, Cylinder; *2*. piston; *3*, piston rod; *4*, hydraulic fluid; 5, accumulator piston; *6*, dashpot; 7, dashpot piston; *8*, control bushing; *9*, swing adjustment screw; *10* and *11*. check valves; *12* and *13*. channels: *14*, pendulum; *15*, valve; *16*, counterweight; *17*, spring; *18*, stance adjustment screw; *19*, selector switch.

in a number of ways. Initially the SACH foot was made by laminating layers of foam rubber around a wooden keel. Later, techniques for molding the rubber were developed and most units are manufactured in this manner. However, the laminated type is available for special applications where shaping to unusual sizes and configurations is required.

Very recently, a special SACH foot has been made available by Kingsley Manufacturing Co. for use in immediate postsurgical fitting procedures (Fig. 27). This version has a flat, wide sole designed for

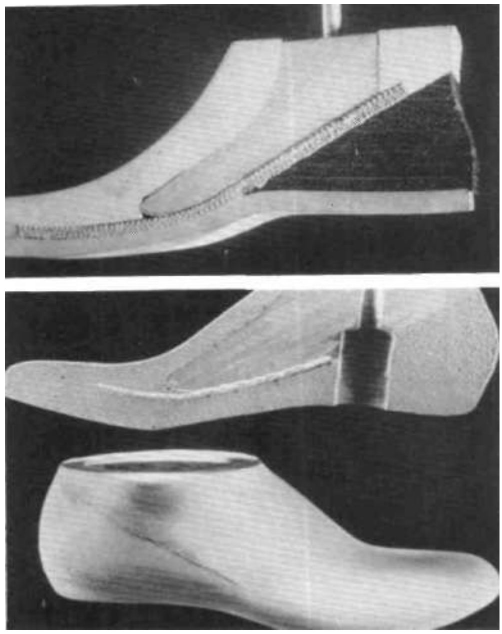


FIG. 25. The SACH (solid-ankle, cushion-heel) Foot. *Upper*, Laminated type; *Lower*, molded type.

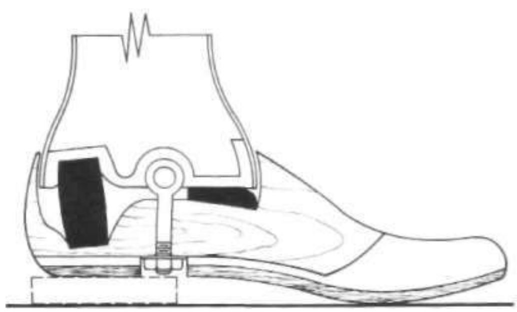


Fig. 26. Cross-section of a typical "conventional" foot-ankle unit.

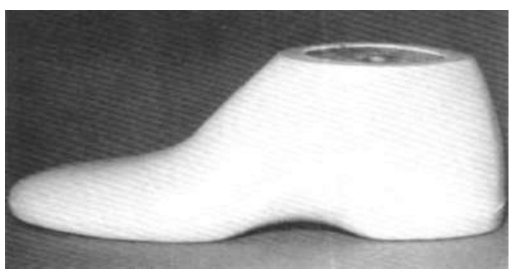


Fig. 27. Special SACH foot for use in immediate postsurgical fitting procedures. *Courtesy Kingsley Manufacturing Co.*

DEFINITIONS

Preparatory Prosthesis

A cosmetically unfinished functional replacement for an amputated extremity, fitted and aligned in accordance with sound biomechanical principles, which is worn for a limited period of time to expedite prosthetic wear and use and to aid in the evaluation of amputee adjustment.

Pylon

A rigid supporting member, usually tubular, that is attached to the socket or knee unit of a prosthesis. The lower end of the pylon should be connected to a foot-ankle assembly.

Rigid Dressing

A plaster stump wrap, usually applied in the operating or recovery room immediately following operation, for the purpose of controlling edema and pain. It is preferably shaped in accordance with the basic patellar-tendon-bearing (PTB) or quadrilateral designs, but is not necessarily so.

Immediate Postsurgical Prosthetic Fitting

A procedure wherein a functional socket, designed for weight bearing and walking, is fitted to the patient immediately after operation in the operating or recovery room, or at some time prior to removal of sutures. As distinct from the rigid dressing, referred to above, this socket should be shaped in accordance with the basic PTB or quadrilateral design; it incorporates provision for easy attachment and detachment of a pylon and foot-ankle assembly.

Early Prosthetic Fitting

A procedure wherein a preparatory prosthesis, as defined above, is provided for the amputee immediately following removal of sutures.

Permanent Prosthesis

A replacement for a missing limb, which meets accepted checkout standards for comfort, fit, alignment, function, appearance, and durability.

use without a shoe while the patient is in the hospital. This permits equal leg length when the natural foot of the patient is bare or is covered simply with a sock or slipper. It is also about 20 per cent lighter than the conventional SACH foot, and resistance to toe break is less.

The Veterans Administration Prosthetics Center is responsible for updating the specifications for the SACH foot, and makes periodic checks of mass-produced units on a random basis.

At the present time, development of a more functional foot-ankle unit using hydraulic principles is under way.

PYLONS

Recently a number of devices known as pylons (see "Definitions") have been developed to meet the requirements imposed by immediate and early postsurgical fitting, namely, functional devices that contain built-in alignment features but are light enough for use throughout the day. Also, devices used in fitting immediately postoperatively should be easily removable from the socket so that the device may be disconnected when the patient is sleeping. Provision for locking the knee joint manually is desirable for use with infirm patients.

The Hosmer Above-Knee Temporary Leg (Fig. 28) is a modification of the adjustable leg originally designed by the University of California Biomechanics Laboratory for alignment adjustment during walking trials.

The U.S. Manufacturing Co. above-knee constant-friction pylon (Fig. 29) is simple, is light in weight, and provides all adjustments necessary in aligning a leg. However, the wedge disks used to change the adduction-abduction and flexion-extension attitudes of the socket require compensatory adjustments to maintain position in one while the other is

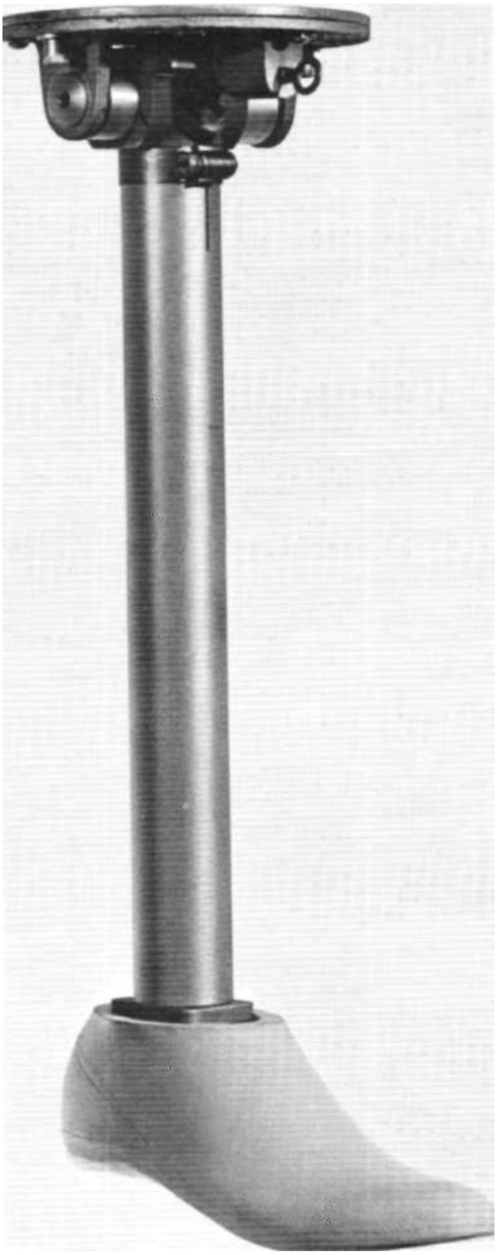


Fig. 28. The Hosmer Above-Knee Temporary Leg.

Fig. 29. The U.S. Manufacturing Co. Above-Knee Constant-Friction Pylon. The expanded metal straps at the top are provided for use with plaster-of-Paris sockets. *Courtesy U.S. Manufacturing Co.*

changed. Hence some degree of skill in using this unit is required.

The U.S. Manufacturing Co. also provides an above-knee temporary prosthesis with the "Hydra-Knee" unit installed (Fig. 30). Alignment adjustment is provided in the same manner as in the above-knee unit shown in Figure 29. Cosmetic covers similar to those used with "Hydra-Cadence" units are available.

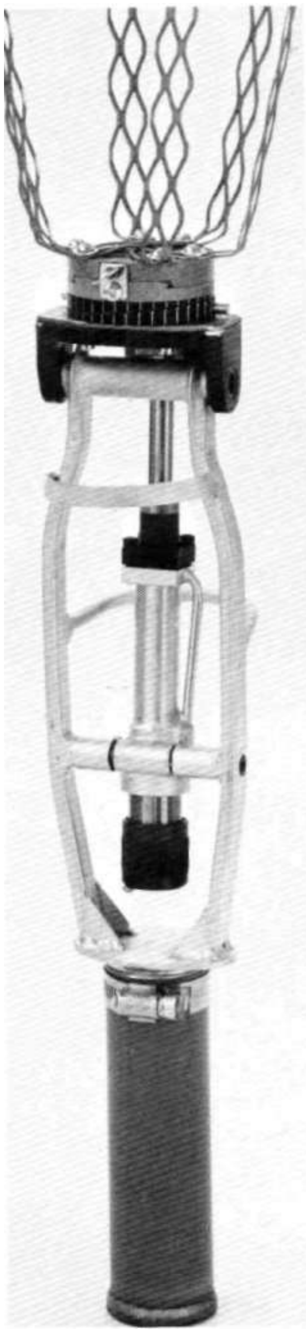


Fig. 30. The Hydra-Knee Pylon. *Courtesy U.S. Manufacturing Co.*

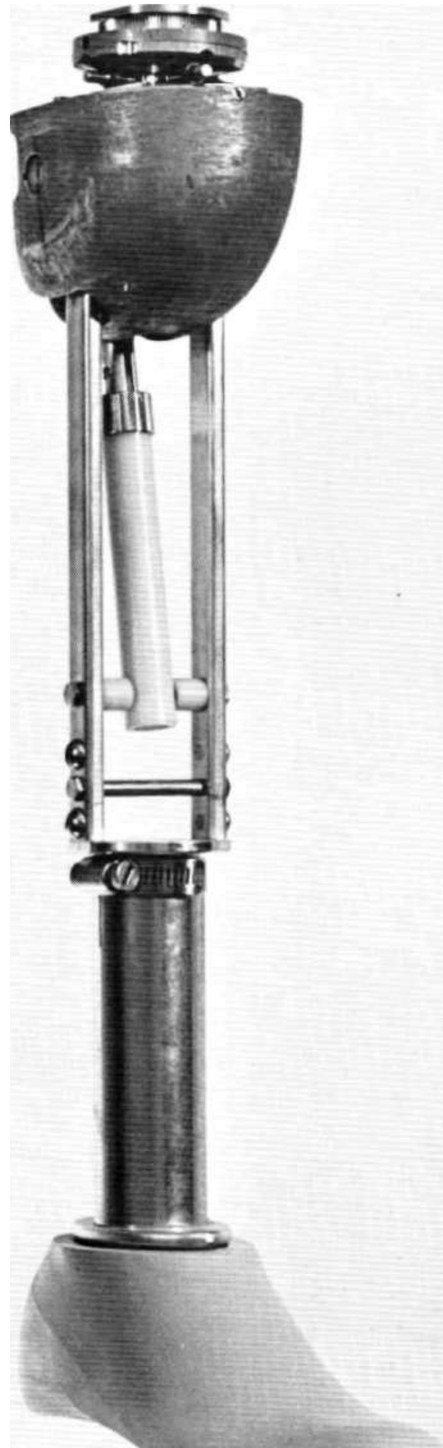


Fig. 31. Pylon developed at the Veterans Administration Prosthetics Center. This unit will accommodate a number of different standard mechanisms for control of the knee.

To provide for independent adjustment in the adduction-abduction and flexion-extension planes, the Veterans Administration Prosthetics Center designed a unit (Fig. 31) in which threaded "disks" are used to provide a wedging action between two conical surfaces placed apex to apex. This device is incorporated in the VAPC "Standard" above-knee pylon which permits the interchange of several knee mechanisms including various constant friction knees, the DuPaCo swing-control unit, both of the Henschke-Mauch knee units, and the UCB pneumatic device. This very desirable interchangeability feature permits the patient to try out a number of swing-control devices at a minimum cost.

It is feasible and practical to use any of these prostheses for indefinite periods. Thus, changes in alignment can be made if they are needed. A comparison of the major features and characteristics of the various pylons is given in Table 1.

TIME OF FITTING

From time to time through the years, a few clinicians have argued for fitting new amputees with temporary or "training" limbs, either for acceleration of the rehabilitation process or to evaluate the patient's potential for use of a prosthesis if there is doubt about his ability to use one. No one argued against this approach provided the temporary limb was properly fitted and aligned. However, when fitting was done before the stump had stabilized the frequent socket changes that were necessary resulted in high costs. If poorly fitted and aligned prostheses were used, more harm than good could result.

The introduction of improved casting methods, improved fabrication techniques, and adjustable pylons led the Orthopaedic Department at Duke University to conduct a series of experiments, beginning about 1960, in which it was demonstrated that it is feasible and, indeed, desirable to

TABLE 1. CHARACTERISTICS OF ADJUSTABLE ABOVE-KNEE PROSTHETIC UNITS

	U.S. Mfg. Co. Standard Adjustable AK Prosthetic Unit	U.S. Mfg. Co. Adjustable Hydraulic Prosthetic Unit	Hosmer Temporary Walking Leg	VAPC Standard AK Prosthetic Unit
Weight with straps and 12-in.-long tube	2.5 lb.	3.9 lb.	3.5 lb.	3.75 lb.[a]
Outside diameter of tube	1.625 in.	1.625 in.	1.625 in.	1.625 in.
Wall thickness of tube	.0625 in.	.0625 in.	.0625 in.	.0625 in.
M-L adjustment range	.875 in.	.875 in.	1.75 in.	.75 in.
A-P adjustment range	.875 in.	.875 in.	.5 in.	.75 in.
Socket flexion-extension adjustment range	10 deg.	10 deg.	None	8 deg.
Socket adduction-abduction adjustment range	10 deg.	10 deg.	None	8 deg.
Quick disconnect for socket removal?	Yes	Yes	No	Yes
Length of assembly above axis of knee	2.75 in.	2.75 in.	1.4 in.	2.4 in.
Independent adjustability?	No	No	Yes	Yes
Manual knee lock?	Yes	Yes	Yes	Yes
Type of swing-phase control	Constant friction	Hydraulic	Constant friction	Variable friction[a]

[a] Will also accept Henschke-Mauch, DuPaCo, and UCB pneumatic knee-control units. Weight is increased accordingly.

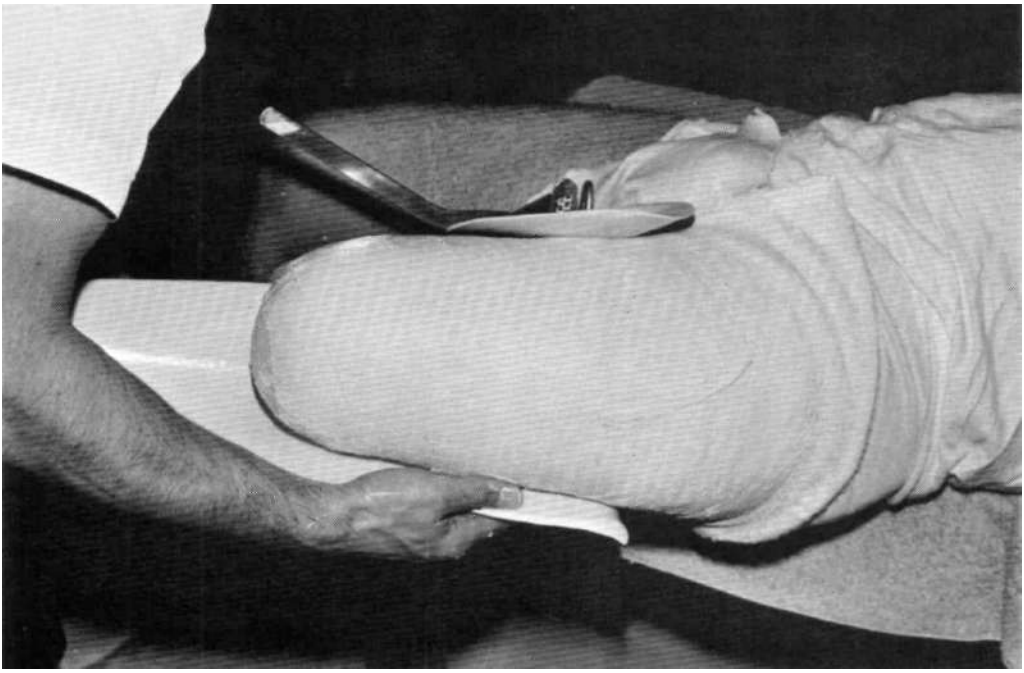


Fig. 32. Use of the Prosthetics Research Study (Seattle) casting fixture to form socket in fitting above-knee case with prosthesis immediately after operation. *Courtesy Prosthetics Research Study, Seattle, Wash.*

fit amputees as soon as the wound has healed *(8).* In 1963, several groups in the United States began experimenting with the concept of fitting the patient immediately after operation and allowing some degree of ambulation very soon thereafter, a technique that had achieved some success in a rather crude way in France and Poland *(4,7,27).*

By 1967 the technique had been developed in sufficient detail at the Prosthetics Research Study, Seattle, Washington, and experience with experimental cases was such that it seemed warranted to offer special courses in the Prosthetics Education Program in immediate postsurgical fitting of prostheses. The technique applies to all levels of lower-extremity amputation. Experience has shown that the formation of edema is materially reduced, postoperative pain is reduced, development of contractures is avoided, stump bandaging is unnecessary, and the general well-being of the patient is better than when he is treated in the conventional manner. The procedure obviously reduces both time of hospitalization and time required for rehabilitation, and it is appropriate for use in virtually all types of cases except where an open amputation is indicated. More time is required by the surgeon and prosthetist in the management of the patient during the first two weeks, but substantial savings are effected in the over-all treatment program.

For the above-knee case, immediate postsurgical fitting consists essentially of providing the patient with a quadrilateral total-contact socket of plaster-of-Paris bandage (Fig. 32) and an easily detachable functional pylon, allowing him to begin weight-bearing about 24 hours after amputation (Fig. 33). No special surgical techniques are needed. Myoplasty, consisting of some method to ensure reattachment of the cut muscles about the thigh, is recommended in any case *(4).* The cast-socket is left in place for 8 to 12 days, at which time the sutures can usually be removed. A new cast socket is applied immediately and is kept in place until measurements and a cast can be made for the definitive prosthesis, usually 10 to 12 days later. If some other condition precludes

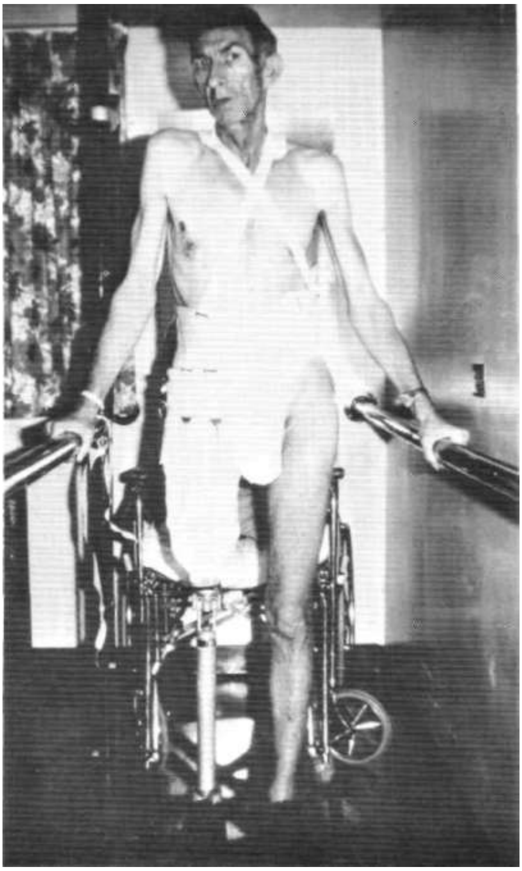


Fig. 33. Above-knee amputation patient fitted with a prosthesis immediately after amputation. *Courtesy Prosthetics Research Study, Seattle, Wash.*

the patient from walking, a rigid dressing of plaster of Paris should be used, rather than conventional dressings, to keep formation of edema to a minimum and thus provide a stump that will cause the prosthetist less trouble.

Immediate postsurgical fitting and early fitting have been very successful in the hands of competent surgeon-prosthetist teams, and are routine procedures in many centers today. Research in this area is continuing in order to refine the methods still further.

ABOVE-KNEE PROSTHETICS FOR CHILDREN

Amputation in children can be classified as either acquired or congenital. The acquired amputation is the result of trauma or of disease, usually a malignant tumor. The congenital type is the result of a malformation occurring during embryonic development.

Management of the acquired amputation in children is essentially the same as that for the adult. Because wounds in children tend to heal faster than they do in adults, immediate postsurgical fitting and early fitting techniques are most appropriate. Usually care must be taken to keep the child patient from being too active. The quadrilateral, total-contact, plastic, suction socket is nearly always indicated. A Silesian bandage may be used, but is usually not needed. For patients below the age of puberty, the only knee unit available is the constant-friction type. SACH and conventional feet are available in sizes suitable for children of all ages.

Children with congenital malformations of the lower extremities usually offer a greater challenge. Many times the stump and proximal anatomy are abnormal in structure, and these features must be taken into account in design of the socket and suspension. For guidelines and suggestions for treatment of unusual and bizarre cases, the reader is referred to *The Limb-Deficient Child (3).*

For the high, bilateral above-knee case where conventional above-knee or knee-disarticulation prostheses are not suitable, *i.e.,* the patient is unable to use crutches, the use of the swivel walker is recommended (Figs. 34 and 35)*(14).* Designed at the Ontario Crippled Children's Centre for use by patients with severe involvement of all four limbs, the swivel walker has met with success wherever it has been used. Motion is effected by displacement of the center of gravity of the body. Although movement is restricted to smooth, level surfaces, the swivel walker offers an effective means of mobility, and the psychological benefits to be gained from it are quite rewarding.

ABOVE-KNEE PROSTHETICS FOR GERIATRIC CASES

At one time it was an almost universal rule to amputate through the thigh in

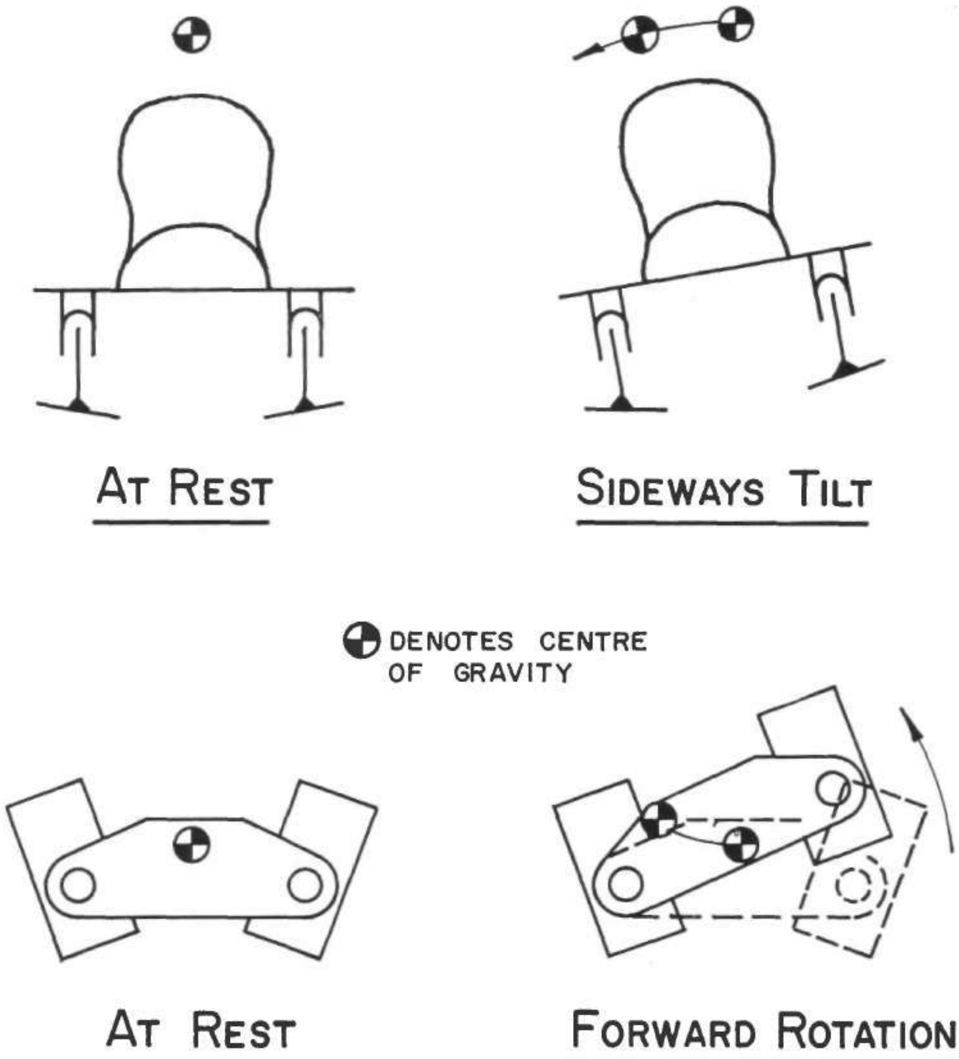


Fig. 34. Principle of the "Swivel Walker" developed at the Ontario Crippled Children's Centre, Toronto, Canada, for very high, bilateral, lower-extremity cases.

cases of peripheral vascular disease when limb ablation was indicated. However, since it has been shown that many knee joints can be saved in spite of what appear to be overwhelming odds, the ratio of above-knee to below-knee amputations is decreasing. Unfortunately, however, there will always be a certain number of above-knee cases.

Immediate postsurgical and early fitting practices should be used whenever possible. Proper use of these procedures reduces the mortality rate drastically and permits the fitting of definitive prostheses considered impossible, or at least impractical, only a few years ago. The use of provisional prostheses permits the clinic team to determine, without question, whether or not a definitive prosthesis is indicated. The VAPC "Standard" AK Pylon permits experimentation with several hydraulic units as well as with mechanical friction knee control.

In spite of the many useful innovations that have been introduced into the practice of above-knee prosthetics through the years, there is still room for further improvement. Among the developments needed are more foolproof methods of obtaining optimum fit and alignment. Sockets that can be adjusted to meet the constantly changing cyclical demands of the amputee are certainly desirable and possible. Indeed, it might be feasible to provide a socket that is adjusted automatically to meet the needs of the patient constantly throughout the day. In any event, studies of the effect of pressure on human tissues must lead eventually to a better application of limb prostheses.

Needed also are methods for fitting and fabrication of limbs in even less time than is presently required. Materials that can be formed at temperatures safe to human tissues are now becoming available, and it is hoped that a useful socket can be molded over the stump, eliminating the need for plaster of Paris in taking impressions and making models of the stump. Such a technique, when used with adjustable pylons that are cheap enough and light enough to leave as the "permanent" prosthesis, should permit fast, economical service.

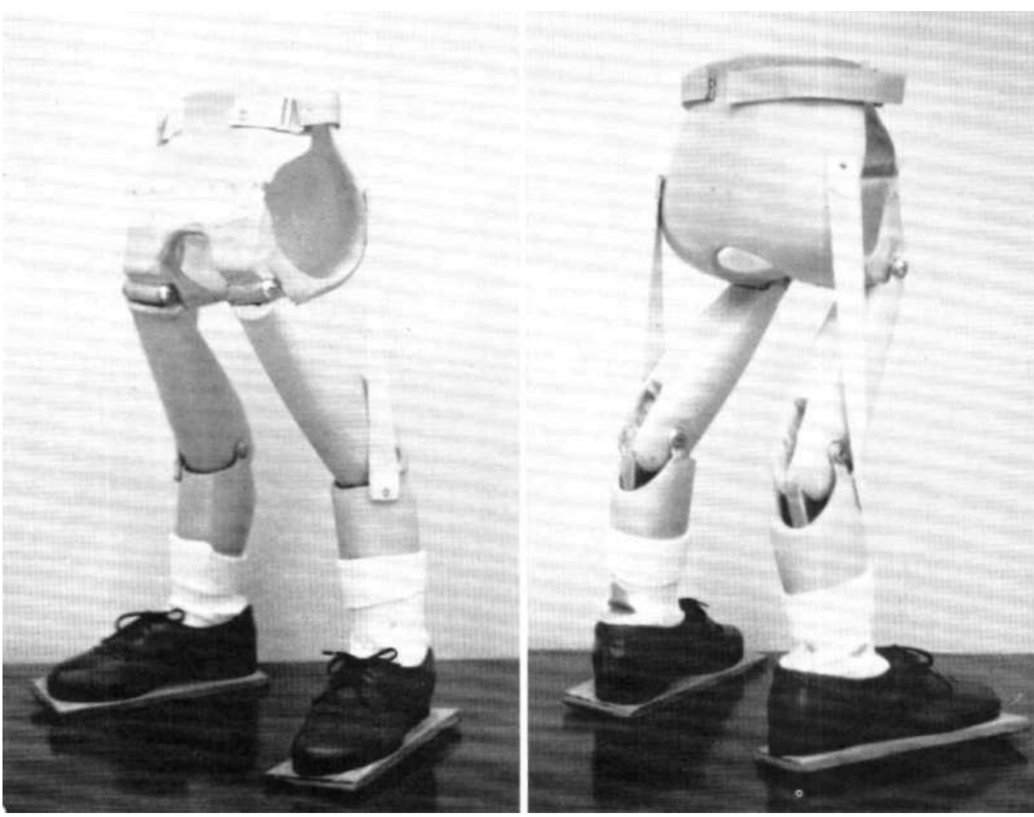


Fig. 35. The OCCC swivel walker with articulated joints that permit a sitting position.

Concurrently with studies designed to point the way to more functional prostheses and more efficient service, a number of surgeons are studying and trying to devise methods for providing more functional stumps. In recent years the techniques of amputation have taken on more significance in the minds of surgeons and, consequently, prosthetists have been seeing stumps that are more functional than has been the case in the past. Further research and a continuation of educational programs should result in even more improvement.

ACKNOWLEDGMENT

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Some Considerations in Management of the Above-Knee Geriatric Amputee

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The gradual increase in the life span of people in the developed countries of the world has resulted in a tremendous increase in the number of amputees in the older age, or "geriatric," group. A survey by Glattly in 1962 *(4)* showed that approximately 52 per cent of all amputees fitted with prostheses for the first time were over 50 years of age. Of these patients, 82 per cent had had amputations as a result of disease, 2 per cent because of tumor, and 16 per cent because of trauma. Most of these, of course, were lower-extremity cases.

As short a time as 10 years ago, only a relatively few geriatric amputees were provided with limbs, and not much attention was given to the special problems of older patients. However, it has now been demonstrated that, with expert care, older amputees can be fitted with functional prostheses and that the results obtained are well worth the extra efforts required. The below-knee case obviously presents fewer problems as a rule than does the above-knee case, but though surgeons are now saving more and more knee joints there will always be a certain number of above-knee cases that require attention.

Just as in the case of younger amputees, geriatric patients should be fitted as soon as possible. The longer the patient goes without a prosthesis, the greater the possibility for the development of contractures, edema, and other undesirable conditions. If the patient is not provided with a prosthesis immediately after the amputation, he should be fitted with a preparatory prosthesis as soon as he is seen by the clinic team.

When treating the geriatric amputee, the clinic team must keep in mind constantly that the patient's potential is far from that of an otherwise healthy person, and certain compromises must be made if optimum results are to be achieved. The primary factors to be considered are condition of the skin, muscle tone and strength, coordination and balance, and energy potential.

ANATOMICAL AND PHYSIOLOGICAL FACTORS

Skin loses its turgor and becomes more fragile as age increases, and although it does not necessarily become more sensitive to the touch it does become more subject to abrasion and breakdown. This is true especially for the below-knee amputee but also demands special consideration when fitting and training the above-knee patient, and every effort is made to limit relative motion and pressure between the socket and stump.

The older a person becomes the more likely he is to collect a fair number of scars, some of which may become supersensitive. The patient who has had an amputation secondary to vascular occlusion may well have scars present in the femoral triangle or abdominal scars from previous sympathectomies (Fig. 1). Particular care must be given to socket fit and suspension in order to avoid undue

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pressure and abrasion of these scarred areas. The presence of abdominal or inguinal hernias must likewise be taken into consideration and appropriate relief given if necessary.

Subcutaneous atrophy occurs in the elderly patient and may present difficulties with socket fitting. The loss of fatty tissue padding often gives rise to complaints of extreme discomfort in areas subjected to high pressure, such as the ischial tuberosity and the laterodistal end of the femur. It may also complicate socket fitting, because flabby tissues tend to roll and therefore provide less stability. Muscles also tend to atrophy with age and, in addition to becoming weaker, have correspondingly less tone and less bulk, as any surgeon knows who has operated through the muscles of an elderly patient. Loss of muscle tone and bulk further decreases the soft tissue padding over bony prominences and may contribute to socket discomfort. Loss of definition of muscle groups leads to loss of stump contour and hence less stability between socket and stump. The decrease in muscular strength which accompanies atrophy results in less strength for actuating the prosthesis; hence, the weight of the artificial limb becomes an extremely important factor.

Fig. 1. Sensitive scars in the inguinal area secondary to vascular reconstruction may require modifications in the quadrilateral socket.

Coordination and balance definitely are affected by the process of aging and rapidly become impaired when any degree of cerebral arteriosclerosis is present. Studies have shown that vestibular function decreases steadily after 50 years of age and, in addition, there is a general slowing of reflex motor action to proprioceptive stimuli which is irreversible *(3)*. The prosthesis, therefore, must be modified frequently to provide increased stability.

The energy expenditure in the elderly above-knee amputee has been studied only recently, and is highly significant in the management of this class of patient. Miiller and Hettinger showed that energy expenditure was 25 per cent greater in above-knee amputees than in normal people (6). Bard and Ralston gave a figure of 20 per cent greater energy expenditure in the above-knee amputee over the normal person (2). Later, Ralston studied 17 above-knee amputees, all over 50 years of age, and found that the average energy expenditure was 55 per cent greater than for a normal elderly person (9). He further demonstrated that a normal subject walking at a comfortable speed consumed 580 cc. of oxygen per min., whereas the same subject at maximum walking speed consumed 715 cc. of oxygen per min. This figure coincided almost exactly with the figure of 700 cc. of oxygen per min. consumed by above-knee amputees walking at a slow speed. The average pulse rate in these elderly amputees walking at slow speed was 110 per min. From these studies it is obvious that energy expenditure is greatly increased when an elderly person must use an artificial limb instead of his own.

The use of crutches without a prosthesis has been used in the past as a criterion for prescribing prostheses for the elderly. However, this not only demands more energy from the patient than the prosthesis itself, but also demands more balance and coordination, and therefore the use of this criterion has been discontinued. Many patients who are not able to use crutches without a prosthesis can achieve some functional activity with a prosthesis. Use of a temporary, or preparatory, prosthesis (Fig. 2) offers the best index to future function *(10).* This is to be distinguished from a pylon, which has no articulated knee joint and no prosthetic foot. The temporary, or preparatory, prosthesis has a completely formed, quadrilateral, total-contact socket on an adjustable knee with a positive knee lock, an aluminum shank, and an articulated SACH (solid-ankle, cushion-heel) foot.

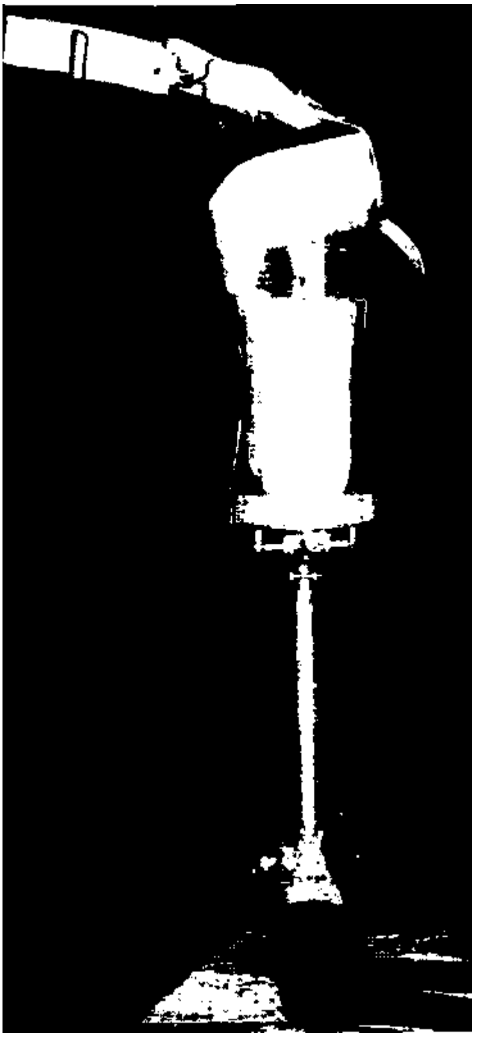

Fig. 2. A typical temporary above-knee prosthesis for determining the feasibility of a permanent prosthesis for the elderly amputee.

SOCKET DESIGN

Hall has reviewed the principles which led to the development of the quadrilateral socket as we know it today (5):

1. Actively functioning muscles should have relief.
2. Stabilization forces should be applied where no functioning muscles exist.
3. Functioning muscles should be placed at slightly greater than rest length for maximum power.
4. Properly applied pressure is well tolerated by neurovascular structures.
5. Force is best tolerated if it is distributed over the largest available area.

For these reasons, the quadrilateral socket is relieved anterolaterally for the functioning rectus muscles and posterolaterally for the functioning gluteus maximus muscle; it is flattened along the lateral wall to provide the greatest surface area for the forces of abduction and along the posterior wall to provide a similar large area for the forces of extension, and is molded snugly into Scarpa's triangle to keep the ischial tuberosity displaced posteriorly on the ischial seat.

Although it may seem like fitting a round peg into a square hole, the quadrilateral socket has provided the most satisfactory union between stump and prosthesis ever achieved for the above-knee amputee, because its shape permits proper function of the muscles which move the stump. At the same time, the forces generated by this muscular activity are distributed over relatively large areas.

This is in contradistinction to the "plug-fit" socket which was used formerly and which did not take properly into consideration muscle action and the forces generated. The plug-fit socket, seemingly more compatible because it provides a round hole for a round peg, allows the ischium to slide inside the socket brim and the weight to be borne chiefly on the gluteal muscle mass and adductor region. Because the weight is borne chiefly by the soft tissues and because the socket is of a conical shape, there is a wedging effect of the stump in the socket and the distal tissues are pulled tightly over the end of the femur, frequently causing pain or stump breakdown. Stability about the long axis is poor because of its round cross section. In addition, the forces of abduction are distributed over relatively small areas as the femur is pushed out against the lateral wall.

The use of the plug-fit socket has been largely abandoned today, but some of its features are useful at times for the geriatric amputee, particularly when pressure is to be avoided over Scarpa's triangle because of a femoral bypass graft or because of inadequate circulation. In some geriatric patients there is justification for modifying the quadrilateral shape in the direction of a rounded or plug-fit shape, retaining, however, certain characteristics of the quadrilateral socket.

The quadrilateral socket is not made to a rigid pattern but is modified from a typical pattern in various ways to accommodate individual stumps. If the rectus femoris is unusually large, it may be accommodated by further relief. The same is true for the hamstring and gluteal groups. If the gluteal muscles are underdeveloped or atrophied, less relief can be given. In the elderly, because of tissue atrophy, ischial weight bearing is often uncomfortable and the posterior wall may be modified to distribute the load over the gluteal group. If it is necessary to have the Scarpa's-triangle area free from pressure, this can be accomplished by relief in this area, allowing the ischium to slide into the socket over a properly contoured posterior brim.

We must also reconcile ourselves to the fact that, as much as we delight in rehabilitating the geriatric amputee to an ambulatory status, he will, nevertheless, spend much of his time sitting, and certain socket modifications must be made to provide comfort during prolonged periods of sitting. The thickness of the posterior wall may be decreased so that pressure neuropathy of the sciatic nerve does not develop, and the anterior brim may be lowered so that excessive pressure does not develop in the region of the femoral neurovascular bundle or the anterior superior iliac spine.

There appear to be no contraindications to the fitting of total-contact sockets to the elderly above-knee amputee. With total contact, not only are the tissues supported evenly and edema and skin breakdown prevented, but a greater proprioceptive and kinesthetic sense is developed, a condition of even more importance to the geriatric amputee than it is to his younger counterpart. Total contact, however, is not as important with pelvic suspension as it is with suction suspension, and it is difficult to maintain, particularly when stump socks are used.

SUSPENSION

There is uniform agreement that suction provides the best suspension available. Suction suspension, however, has a limited use in the geriatric amputee because of the exertion required in donning the prosthesis and the fact that many elderly patients have a limited ability to bend forward.

The pelvic band is in wide use, but it has disadvantages. It is apt to create excessive pressure about the lower abdomen when the patient is sitting. It must be well padded to prevent the development of excessive pressure over the iliac crest and over any scarred areas on the abdomen. The location at the hip joint is critical.

The preferred method of suspension in the elderly above-knee amputee is the Silesian bandage or one of its modifications. When used with the quadrilateral total-contact socket, it provides comfortable suspension and gives good stability. It may be modified to include a shoulder strap, or may be modified further to incorporate an elastic webbing band from the posterior portion of the belt to the posterior wall of the socket to act as a hip-extensor aid *(8).*

The inability of most elderly above-knee amputees to don a suction socket properly has led to the development of a split-socket type of appliance at the University of Miami Prosthetic Laboratory (Fig. 3). In this type of prosthesis the intimate fit of the suction-type socket is obtained, yet it is donned easily by the geriatric amputee. [A complete description of the split-socket type of appliance will be published in the Spring 1969 issue of *Artificial Limbs.*—Ed.]

Fig. 3. The double-wall above-knee suction socket with anterior opening developed by the University of Miami Prosthetic Laboratory for easy application in the older amputee. The flexible inner socket is jointed to the outer by a lateral Velcro strap.

ALIGNMENT

The above-knee socket, in general, is adducted at least 5-10 deg. to restore the normal position of the femur and place the abductor muscles at their optimum functional length. Adduction of the socket also has the effect of narrowing the base of gait, an important factor in energy conservation (2). If the abductor muscles are not placed in their optimum position of function, if the socket is abducted too far, or if the prosthetic foot is located too far laterally, the center of gravity of the body must shift over the supporting leg in order to gain sufficient stability during walking. Conversely, if the adduction of the socket is sufficient to hold the femur in a normal position of adduction and to keep the abductor muscles at their optimum length, these muscles will act to stabilize the pelvis with a minimum amount of contraction while dissipating the force of stabilization by femoral pressure against the lateral wall of the socket. This ideal cannot always be achieved in the elderly patient and the socket sometimes has to be aligned in the neutral or slightly abducted position in order to gain the required stability, at the expense of increased energy consumption.

Aligning the socket in some degree of flexion increases the power of hip extension and voluntary knee stability. In general, the above-knee socket should be aligned in some degree of flexion, usually by 5 deg. in excess of the maximum amount of hip extension that can be obtained by the amputee while standing on his good leg without producing excessive lordosis. The amount of flexion will vary from 5 to 35 deg., depending on the length of the stump and the amount of hip-flexion contracture present. Alignment of the socket in flexion is limited by the length of the stump, and in the longer stump is minimal. As socket flexion is increased, the knee bolt must be moved somewhat more posteriorly in order to retain the same alignment stability at the knee *(7).*

Although adduction of the socket is quite efficient because there is very little excursion of the femur outward toward the lateral wall of the socket in walking, flexion is not nearly so efficient because the large posterior muscle mass allows considerable backward shift of the femur in the soft tissues prior to its exerting significant pressure on the posterior wall. This has been documented by the senior author in a cineradiography movie of above-knee stumps in sockets (Fig. 4). Because of this backward excursion of the femur in the soft tissues as the thigh is extended, it is felt that the femur should be set in the maximum amount of flexion consistent with cosmesis to give greater voluntary control of extension to the knee.

In the elderly patient with less voluntary control and deficiencies of balance and coordination, even a long stump may require the alignment characteristics of the medium or short stump.

STABILITY OF THE KNEE JOINT

Knee stability is usually achieved by a combination of voluntary control by the hip extensors and alignment of the knee axis so that it is posterior to the weight-bearing line (so-called alignment

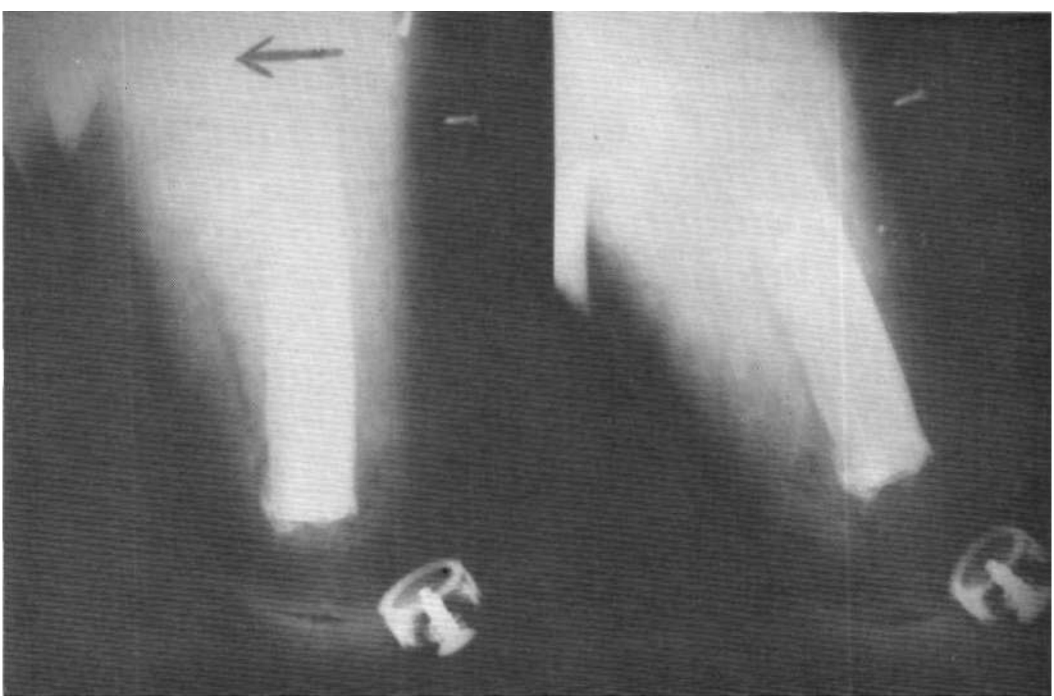

Fig. 4. Frames from a cineradiography film of an above-knee stump in the socket. *Left,* The femur displaces posteriorly in the soft tissues a considerable distance before effective force can be transmitted to the posterior socket wall to stabilize the knee. *Right,* The limb is at heel strike prior to hip-extensor thrust.

stability), or by a lock or brake. Voluntary control of knee extension is usually diminished in the geriatric amputee because of muscular weakness and poor coordination, and often an increased amount of alignment stability is necessary. This alignment stability, in combination with a single-axis constant-friction knee, the most standard type, is generally sufficient. However, there may be instances in which additional stability during weight bearing is necessary, and this can be provided by the use of a unit, such as the Bock Safety Knee, which gives a braking action during weight bearing. The chief disadvantage of this type of unit is the added weight of the mechanism.

For the elderly amputee with extreme instability and insecurity, such as a bilateral amputee, or one in whom there is a severe flexion contracture, some type of positive knee lock is usually necessary. The knee is locked in extension throughout all phases of gait, producing obvious gait deviation, but as someone once said, "an abnormal gait is better than no gait at all," which would otherwise be the case.

Hydraulic knee units can be used successfully by the elderly above-knee amputee, and offer many advantages when the amputee has sufficient muscle power to handle these necessarily heavier limbs. The chief advantage of the hydraulic unit in geriatric patients is that it allows more anterior placement of the knee joint without sacrificing stability, and less energy is consumed in hip flexion to initiate the swing phase of gait. The other primary advantage of the hydraulic knee unit, that of permitting rapid walking by faster and more reliable knee extension, is frequently lost on geriatric amputees as they usually walk with a slow, purposeful gait.

Until recently it has been a most difficult task to provide the knee-disarticulation and long above-knee stumps with adequate swing-phase control. DuPaCo recently introduced a set up so that the DuPaCo "Hermes" unit can be used with these long stumps.

Stability at heel strike is extremely important to prevent buckling of the knee or jack-knifing, which may occur in the elderly above-knee amputee with insufficient hip-extensor power. The less resistance to plantar flexion, the more stability there is at heel contact and shortly thereafter. Locating the foot anteriorly with respect to the knee also increases stability during the period just after heel contact.

The SACH foot is generally satisfactory for use by geriatric amputees, although in cases where weight is a real consideration a wooden foot with an aluminum ankle joint can be lighter than the SACH feet available commercially. For the elderly amputee the heel should be relatively soft in order to act as a shock absorber and enhance stability of the knee at heel contact. A single-axis wooden foot in which the softness of the plantar bumper can be varied can give greater stability than even the softest SACH heel available. However, excessive stability results in unnecessary expenditure of energy.

The foot must occasionally be outset more than usual to enhance lateral stability in the elderly. This again is another example of obtaining stability at the expense of increased energy consumption, for outset of the foot requires a greater lateral shift of the center of gravity in walking.

AMBULATION

While it is desirable to return all elderly above-knee amputees to an ambulatory status, it is often not practicable. Nearly all bilateral above-knee amputees over 50 years of age will find the wheelchair an easier and more practical means of locomotion than the use of prostheses. One must carefully evaluate the patient in terms of strength, endurance, balance, and coordination prior to prescribing a prosthesis. The patient and his family or, more likely, the government will be saved unnecessary expenditure by proper selection of patients for fitting. Often, one must accommodate the patient's own desire to find out for himself whether or not he should be relegated to the wheelchair permanently. In the true geriatric amputee, once ambulation has been achieved it is best to continue the use of some type of external support, depending upon the patient. Usually a cane or single crutch on the opposite side will be sufficient support for the elderly amputee. In some extreme cases a walker may be used, which admittedly makes for poor gait pattern, but this is preferable to no gait at all. The use of external support not only gives increased mechanical stability but also provides the amputee with additional proprioceptive feedback from the terrain on which he is walking, thus leading to better balance. In determining the functional capacity of the bilateral amputee in the older age group, the use of "stubbies" is strongly recommended and the patient should graduate to nonarticulated pylons with increasing height, to a preparatory prosthesis, and, finally, to a permanent prosthesis. Needless to say, the bilateral above-knee patient must always use external support when walking, and a wheelchair should be considered the primary mode of locomotion.

SUMMARY

In order to provide optimum function in the elderly above-knee amputee, one must consider thoroughly certain anatomical and physiological characteristics of the patient which may indicate the necessity for modifications of the standard prosthesis. The characteristics are individual and vary greatly from one elderly amputee to another, but include skin condition, condition of the subcutaneous tissue, muscle strength and tone, coordination, and general factors relating to energy consumption. Modifications based on these factors may then be made in the prosthesis to ensure optimum functional performance. These modifications may include changes in socket shape and alignment, changes in the suspensory apparatus, provisions for increased stability at the knee, and provisions in the ankle to ensure over-all stability. In every instance an attempt should be made to provide the amputee with a minimum prosthetic weight. The future level at which the amputee will function can best be anticipated by the initial use of a temporary, or preparatory, prosthesis.

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Toronto Orthosis for Legg-Perthes Disease

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The treatment of Legg-Perthes disease has been given considerable attention at the Hospital for Sick Children in Toronto during the last few years. It is now known that certain types of Legg-Perthes disease have a good prognosis regardless of the type of treatment used, whereas other types tend to have a poor prognosis. Proper prescription of treatment must, therefore, recognize this difference in prognosis.

Attempts have been made to assess the outcome of the disease on the basis of age at onset and the degree of involvement of the ossific nucleus of the femoral head.

In children who develop Legg-Perthes disease prior to the age of five years, the prognosis tends to be better than in a child who develops the condition at an older age. This difference is probably related to the total mass of bone that has to be reossified, since it has been noted that in a smaller femoral head the time for reossification is often shorter, being in the vicinity of 12 to 18 months compared to several years for an older child.

The degree of involvement also plays a most important part, and attempts have been made here to differentiate between cases where the entire femoral head is involved, with avascular necrosis of the entire ossific nucleus, and those where merely a portion is involved. The partial-head-type of Legg-Perthes disease carries a much better prognosis and is less liable to deformity, since a part of the femoral head remains uninvolved.

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If there is any tendency towards the formation of a metaphyseal cyst, the possibility of a poor long-term result is increased.

The stage at which the patient is first seen is of the utmost importance. If the child is seen early in the course of the disease, before joint deformity has occurred, proper management, if instituted quickly, can often result in a congruous joint. If, however, there is already considerable flattening and subluxation when the child is first seen, then the result, of course, cannot be as good. If the entire process of re-ossification has already occurred by the time the child is first seen, the golden opportunity has passed, and at this stage only secondary reconstructive procedures can be carried out, with even less satisfactory results.

Certain selected cases are suitable for innominate osteotomy, in which the femoral head is covered and seated just as if the hip were held in abduction and internal rotation. At present, innominate osteotomy is restricted to the child who carries an unusually bad prognosis; that is, a child over the age of six years with total involvement of the femoral head. In addition, an arthrogram must be made to be certain that a significant joint deformity is not already present. If a deformity is present, innominate osteotomy is contraindicated. In addition, prior to the use of an innominate osteotomy, full joint movement must be obtained, which sometimes will require traction or soft tissue release of contracted structures, such as the psoas tendon.

In the very young child with only a part of the head of the femur involved, often no treatment is indicated, provided that no soft tissue contractures have occurred. If soft tissue contractures are present, then soft tissue release may suffice, with or without a short period of traction.

This leaves a small group of children for whom bracing may be used to advantage. These children would typically be in the under-six age group, with partial or total head involvement and with free joint movement, before deformity has set in.

In the past, ischial weight-bearing braces have been used in the treatment of Legg-Perthes disease with little regard for the various forms and severity of the disease process. Cineradiography has revealed that as the patient walks with an ischial-bearing brace the involved hip tends to move medially and laterally, a condition which may contribute to subluxation and further flattening in the form of a coxa plana; therefore, use of such braces has been discontinued at the Hospital for Sick Children.

In 1957, Dr. William Craig[2] of Los Angeles first reported *(1)* the use of the abduction and internal rotation method of treatment of Legg-Perthes disease, a procedure which has been modified by Dr. Gordon Petrie[3] of Montreal (2). When a child was allowed to bear weight on the legs in the abducted cast, it was found that a remodeled femoral head would, in fact, develop in a spherical fashion in its round and uninvolved acetabulum. This method has proved satisfactory in many instances, but there are certain disadvantages. Because the child's legs must be kept in abduction for a period of several years, cast changes must be made at 8- to 12-week intervals. Considerable stiffness develops about the knees and ankles and, in some instances, there has been a suggestion of flattening of the femoral condyles because of the continuous pressure that is applied to the knee as it is held in one position over a prolonged period of time. In addition, prolonged plaster immobilization encourages the development of osteoporosis, atrophy of muscle, pressure sores, and other problems.

To eliminate some of the problems encountered with the use of abduction casts, a new type of articulated experimental brace has been designed. Known as the "Toronto Legg-Perthes Brace," it provides for 90-deg. abduction and slight internal rotation, yet allows hip and knee movements so that the child may ambulate and sit (Figs. 1 and 2). With the brace, the child is encouraged to walk as much as possible, for it is the weight-bearing movement with the hips centered in a safe position that encourages successful remodeling of the femoral head during growth. The brace is removed easily, but the child, of course, must not be allowed to walk without the brace. It is emphasized that at present (1968) this brace has been used on an experimental basis for the past 18 months, and we do not yet have any indications as to whether any problems will develop, such as those that were produced by ischial weight-bearing braces which, in fact, produced a coxa plana and probably did more harm than good. Cineradiography on one patient has indicated that the femoral head does stay within the acetabulum during loading and unloading of the joint.

Sixteen patients are presently using the Toronto brace and, in our present state of knowledge, this new type of brace appears to fulfill all the criteria set forth.

BIOMECHANICS

The Toronto brace holds the legs in 90-deg. abduction with respect to each other, with the feet rotated internally. The body weight, when the patient stands erect, is distributed axially through each leg to each foot. The shoes are fastened to blocks of wood with the plantar surface

[2] Dr. William Craig, 328 W. 23rd St., Los Angeles, Calif. 90007.

[3] Dr. James A. Petrie, Orthopaedic Surgeon, Royal Victoria Hospital, Montreal, P.Q., Canada.

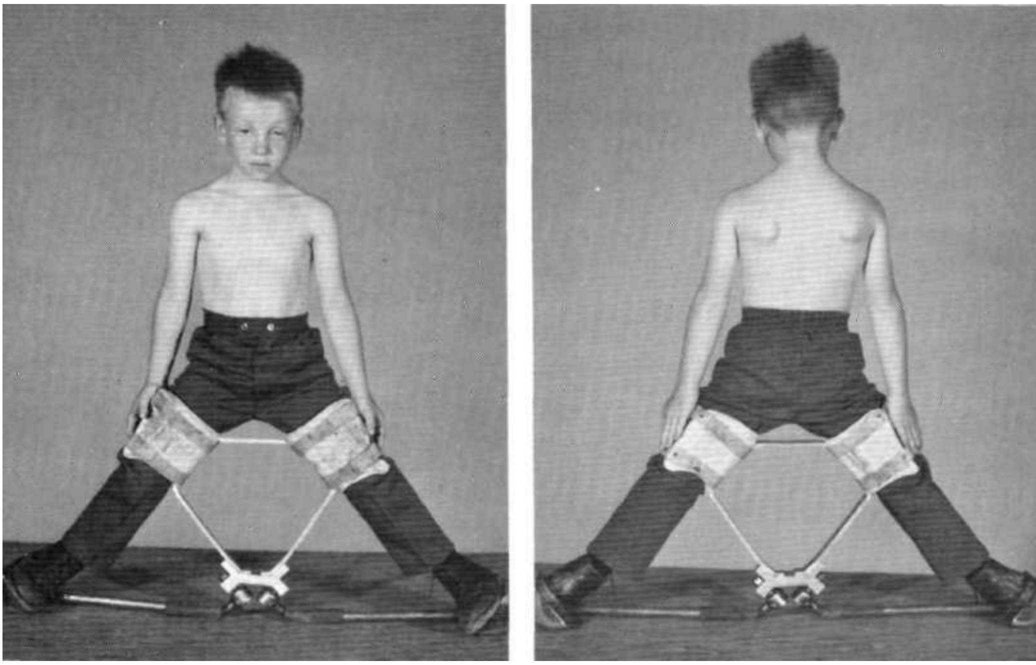

Fig. 1. Front and rear views of the Toronto brace for Legg-Perthes disease.

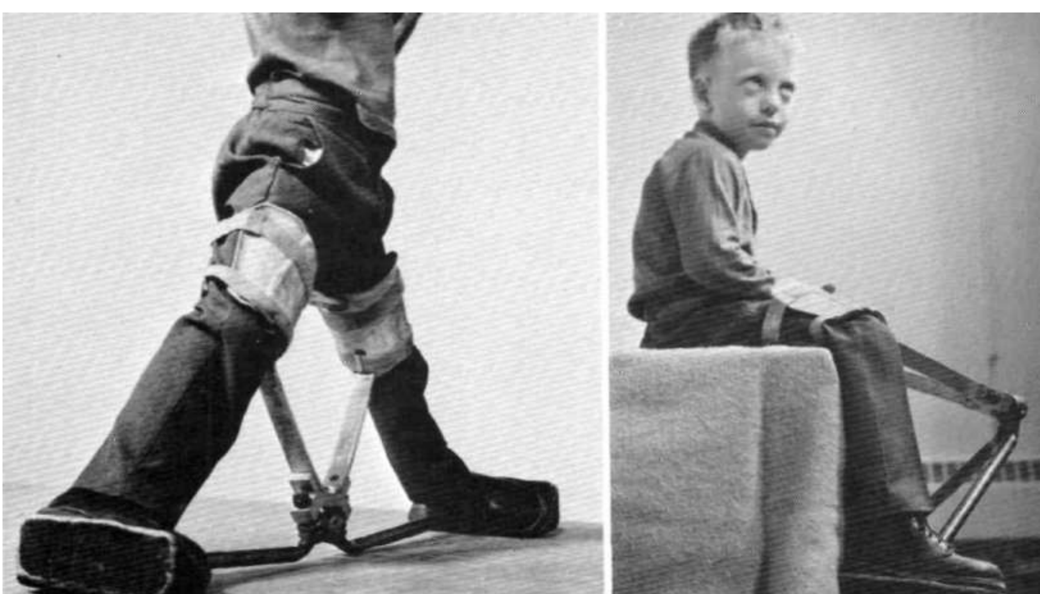

Fig. 2. The Toronto brace for Legg-Perthes disease in use. *Left,* Three-quarter view in the standing position; *Right,* side view in the sitting position. Note that the thighs are maintained in the abducted position at all times.

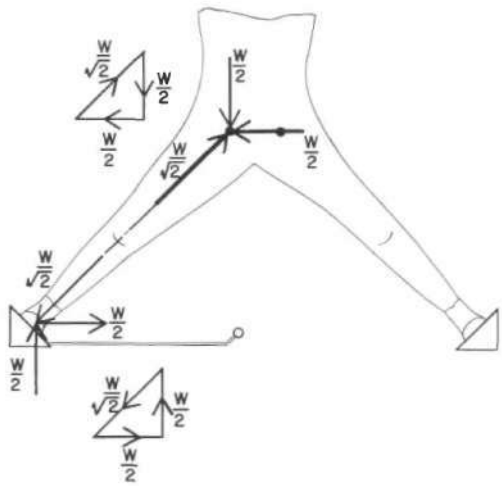

Fig. 3. Resolution of forces being applied to patient using the Toronto brace for Legg-Perthes disease.

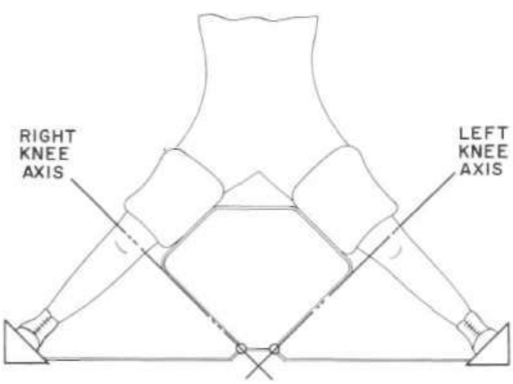

Fig. 4. Schematic view from the front of the Toronto brace for Legg-Perthes disease to show the geometry of the system.

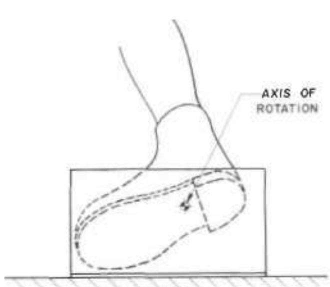

Fig. 5. Location of the shoe with respect to the foot block.

at an angle of 45 deg. to the floor. The foot blocks are tied together by rods which are rigidly attached to the blocks but articulated at the sagittal plane. The force diagram is shown in Figure 3.

Each tie rod is connected by a ball joint to a rigid frame that supports the two thigh cuffs. The thigh cuffs take no load when the patient stands with knees extended, yet the hips are held in abduction as the knees are flexed. The geometry permits each knee to flex independently of the other (Fig. 4) and, because ball joints are used, accurate alignment is not necessary. The ball joints also allow dorsiplantar flexion of the foot block (Fig. 5). Because the plantar surface of the shoe and foot is at 45 deg. to the floor, plantar flexion of the foot itself is accompanied by toe-in and dorsiflexion of the foot is accompanied by toe-out. Otherwise, toe-in and toe-out are securely held to the appropriate angle (Fig. 6).

FITTING AND FABRICATION

The first step in fitting and fabrication of the Toronto orthosis is to make a tracing of the patient's legs and pelvis when he is supine with each leg abducted 45 deg. from

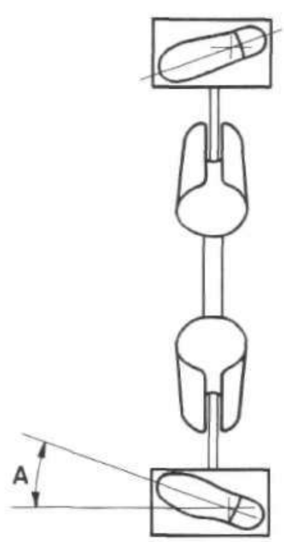

Fig. 6. Schematic view from the top of the Toronto brace, showing angular position of the sole of the shoe.

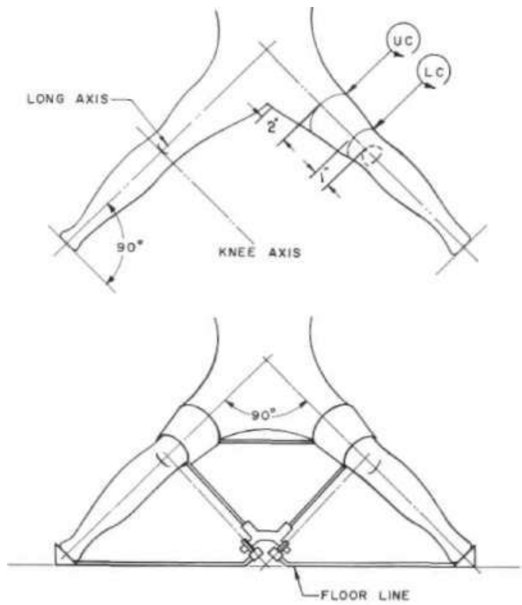

Fig. 7. Typical tracing needed for fabrication of the Toronto brace for Legg-Perthes disease.

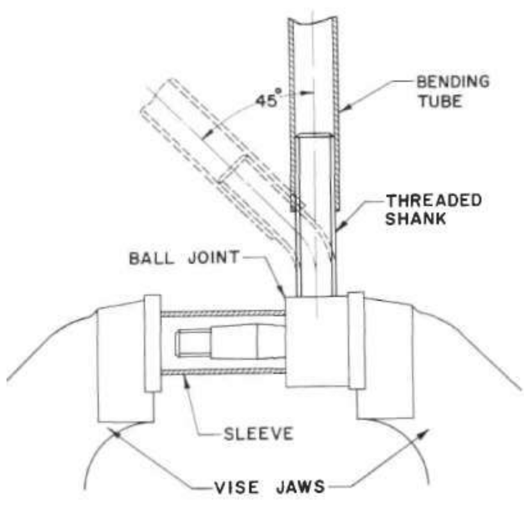

Fig. 8. Method of bending threaded shank of the ball joint.

the center line of the body. (If this cannot be accomplished, traction or soft tissue release is indicated before fitting can proceed.) The shoes are put on the patient's feet so that the edge of the sole is traced rather than the edge of the foot itself, because the shoes are a part of the total structure. The following information should be indicated on the tracing (Fig. 7):

1. The position of the thigh cuffs, which should be 1 in. above the patella and 2 in. below the groin.
2. The position of the shoe, when the sole of the shoe is placed at a 90-deg. angle to the long axis of the leg.
3. The position of the knee axis.
4. Measurements of the lower (LC) and upper (UC) circumferences of the thigh cuffs.

The frame, joint block, tie rods, foot blocks, and thigh cuffs are outlined on the tracing to facilitate fabrication.

FRAME

The frame, which supports the thigh cuffs and joint block, is made from 1 in. X 1/4 in. 24ST-4 aluminum bar, bent cold into a more or less diamond shape to conform to the tracing, and attached to the upper sides. The joint block is attached to the lower apex.

JOINT BLOCK

The purpose of the joint block is to provide a firm mounting for the ball joints to which the tie rods are attached. The block is assembled from five sections cut from 3 in. X 3 in. X 1/2 in. 65 ST (or equivalent) aluminum angle. Two automotive-type tie rods and joints are used for the ball joints,[4] which are located in the block so that they are in line with the knee axis. The threaded shank of the socket is bent to a 45-deg. angle before being brazed to the tie rod (Fig. 8). The tapered shank (Morse taper no. 1) on the ball of the joint is fitted to a hole in the joint block when the Chevy II part is used.

TIE RODS

The tie rods which connect the joint block with the foot blocks are made from chrome molybdenum tubing, 3/4 in. O.D. X .056 in. wall thickness. Tubing of this strength is required to resist damage that may be encountered with curbs, steps, etc. One end of the tie rod is brazed to

[4] Joints from a 1965 Chevy II have been used satisfactorily.

a foot-block plate and the other end to the threaded shank of the joint.

FOOT BLOCKS

The foot blocks are used to secure the shoes to the rods and support the shoes at the correct angle. Each foot block consists of a metal plate and a triangular block of wood. The metal plate is brazed to the distal end of the tie rod, and the wooden block is fastened to the plate with epoxy resin and wood screws. The shoes are fastened to the sloping surface of the wood block with rubber cement and wood screws. Note that the shoes are aligned on the block with approximately 15 deg. to 20 deg. internal rotation, as shown in Figure 6. The bottom surface of the blocks should be covered with a tough soling material. A section of automobile tire is very serviceable, but tends to mark floors. It can be fastened on with rubber cement and wood screws. Frequent replacement is usually necessary.

THIGH CUFFS

The thigh cuffs should fit from 2 in. below the groin to 1 in. above the proximal border of the patella. The distal posterior edge should be flared to minimize discomfort in the popliteal area when the knees are flexed. The cuffs should be made to fit (not too tightly) over the trousers. They should be made from a semi-flexible material with a lateral opening so that the brace can be put on and taken off readily. Velcro straps provide a convenient method of adjustment. Cuffs made at the Centre were formed from a thermoplastic material from Smith and Nephew called "San Splint." A similar material, "Orthoplast," is marketed by Johnson and Johnson. The thigh cuffs and Velcro straps have required frequent replacement in active patients.

GAIT TRAINING

Usually about three days of intensive training by a physiotherapist are required for the child to learn to walk in the brace. Two crutches are used. They are usually held in front of the body, although the occasional child keeps one crutch behind. Stairs and curbs can be negotiated with little difficulty, and some patients learn to walk without crutches for short distances.

The braces are removed for bathing, swimming, and sleeping, but the child must never be allowed to stand, kneel, crawl, or walk without the brace.

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Technical Notes from the Artificial Limb Program

This section of ARTIFICIAL LIMBS *is intended as an outlet for new developments in limb prosthetics and orthotics which, though not deserving of a long feature article, nevertheless ought to be brought to the attention of the readers of this journal. Notes may vary in length from a single paragraph to several pages of manuscript, as appropriate. Illustrations also are acceptable.*

Fabrication and Use of Plaster Sockets for Amputation Stumps

The use of elastic plaster-of-Paris bandage in application of a rigid dressing to an amputation stump immediately after operation is now a standard, well-accepted procedure. Its use in making serial stump-shrinker casts prior to fitting a permanent, or definitive, artificial limb is also practiced widely. However, little attention has been given to its application in making hard sockets that are removable and replaceable as is the case when permanent, or definitive, prostheses are used.

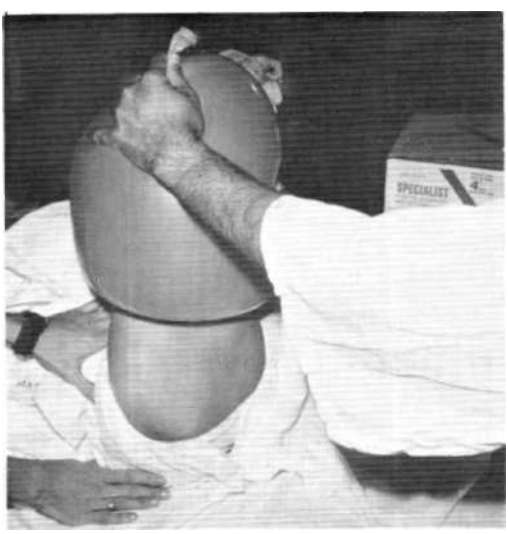

Fig. 1. Inflated balloon being inverted over the stump.

Fig. 2. Single layer of stretched rubber membrane covering the stump.

We first used a hard elastic plaster socket on a painful above-elbow stump as an expedient measure. The generalized pain, which had come on several months after the amputation, could not be attributed to any known cause. Because the use of a prosthesis with a total-contact socket alleviated the pain, we felt that use of a hard socket during the periods that the prosthesis was not being worn would probably be effective. The workload of our prosthetists was such that they could not meet the urgent needs of this patient at an early date and, therefore, the method of fabricating hard sockets described below was born.

The criteria for the socket were:

1. Close fit and conformity to the stump, to achieve total contact.
2. A perfectly smooth inner wall, to prevent irritation of the skin.
3. Resistance to sweat and water, to prevent its distintegration due to sweating and to allow necessary cleaning.

Elastic plaster suggested itself very logically to meet the first criterion. To meet the second, a smooth, thin, true-conforming elastic membrane, like latex rubber, covering the stump was needed. The rubber-balloon technique used by the University of California Biomechanics Laboratory in casting the feet for shoe

Fig. 3. Elastic plaster cast being applied over the rubber-membrane-covered stump.

Fig. 4. Finished patellar-tendon-bearing (PTB) socket.

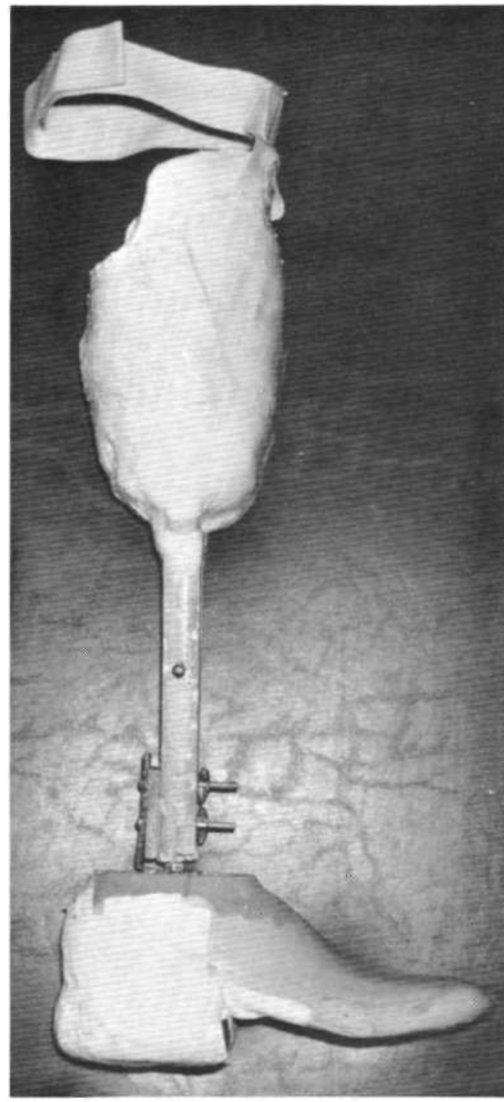

Fig. 5. Elastic plaster lacquered socket pylon, PTB type.

inserts appeared ideal for this situation (i). Finally, we felt that a nonallergic plastic coating would accomplish the third goal. Castex[1] finishing lacquer, a nonallergic plastic coating which has been in use at Children's Hospital Medical Center, Boston, was found to meet the need adequately.

[1] Castex Laboratories, Inc., 203 Arlington St., Watertown, Mass. 02172.

THE TECHNIQUE

An inflated rubber balloon of an appropriate size is invaginated over the stump (Fig. 1) to cover any desired length. As the balloon is being forced on the stump, air is allowed to escape gradually. When deflation is complete, the mouth of the balloon is cut off and the outer layer of rubber is removed, leaving a very smooth, thin, rubber membrane over the stump (Fig. 2). Mineral oil to provide a parting medium is applied generously to the membrane, and elastic plaster-of-Paris bandages are used to form a cast (Fig. 3). The usual precautions for application of elastic plaster-of-Paris bandages are exercised, and each layer of plaster is rubbed thoroughly as it is applied. For the external layers, ordinary plaster bandage is used to yield the needed strength. Molding of the socket is carried out in accordance with biomechanical principles used in the fitting and fabrication of permanent sockets. After the plaster hardens—a matter of 5 to 7 min.—the socket is slipped gently off the rubber-membrane-covered stump (Fig. 4). The inner wall of a socket formed in this

Fig. 6. Total-contact quadrilateral socket made by the technique described and mounted on an above-knee pylon being used by the patient as a temporary prosthesis while the permanent one was being fabricated.

Fig. 7. PTB-type socket mounted on a below-knee pylon being used as a trial limb to determine the suitability of the same for a permanent limb in a bilateral amputee.

manner is perfectly smooth—devoid of any ridges or defects except those intentionally created while molding. The cast is allowed to dry overnight, and then a layer of diluted Castex finishing lacquer (two parts lacquer plus one part acetone) is applied to all surfaces by rubbing it in quickly. Rubber gloves should be used. Use of a brush for this purpose does not yield as smooth a surface as the rubbing process does. The lacquer dries very quickly, and the socket can be used almost immediately.

INDICATIONS AND CONTRAINDICATIONS FOR USE

For the past two years, hard sockets fabricated according to the method described above have been used to alleviate pain in stumps where the etiology is not known, to shrink stumps, to prevent the formation of excessive edema, and as temporary, or preparatory, prostheses. The only contraindications to use are the presence of infection and an open stump.

The results have been quite gratifying. The method is easy to use, and can be carried out quickly and inexpensively.

We believe the technique has sufficient merit for consideration in other clinics.

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Data on Some Plastics Used in Prosthetics and Orthotics

[At the fifth meeting of the Workshop Panel on Lower-Extremity Orthotics (Atlanta, Ga., April 3-4, 1968; ARTIFICIAL LIMBS, *Spring 1968) William J. Mcllmurray, Chief, Prosthetics-Orthotics Service of the* 1 *eterans Administration Prosthetics Center, presented a compilation concerning plastic materials that have been found useful in the VAPC. Mr. Mcllmurray's list is presented here for use by others.—Ed]*

Type of Material	Trade Name	Source of Supply	Application	Standard Units	Approximate Costs	Remarks
Plastic adhesive	Super-Bond All Purpose Cement	K&K Prosthetics Supply Co., Bellmore, Long Island, N.Y.	Leather work, plastics, wood, etc.	Gallon	$4.60 per gal.	Provides better bonding than Barge Cement. However, to separate for repairs is difficult.
Neoprene polymer	Prenyl	Ortho Shoes, Inc., New Rochelle, N.Y.	Hand splints, plastic shields, etc.	1/16" or 1/8" thick; 1' wide; 3' long	$7.00-810.00 per sheet	Readily molded directly to area to be immobilized, splinted, or protected. Heat to 160-170 deg. F. with hot water or heat gun.
Synthetic balata	Polysar	U.S. Manufacturing Co., 623 S. Central Ave., Glendale, Calif.	Direct forming of various sockets and splints in prosthetics and orthotics	Tubular stock I.D. Wall thickness 2 1/2" 3/16" 3" 1/4" 3 1/2" 1/4" 4" 1/4" 4 1/2" 1/4" Sheet stock 12" X 36" X 1/8" 12" X 36" X 3 1/6" 12" X 36" X 1/4"	Tubular stock prices start at $9.75 per ft. Sheet prices start at $10.00 per sq.ft.	rectly to area to be splinted, or protected. Heat to 160-170 deg. F. with hot water or heat gun.

Data on Some Plastics Used in Prosthetics and Orthotics—*continued*

Type of Material	Trade Name	Source of Supply	Application	Standard Units	Approximate Costs	
Synthetic balata	Orthoplast	Johnson & Johnson, Hospital Division, New Brunswick, N.J.	Direct forming of various sockets and splints in prosthetics and orthotics	Sheet stock 1/8 X 12" X 20" 1/8 X 18" X 24" (perforated)	5.00 per sq. ft.	Readily molded directly to area to be immobilized, splinted, or protected. Heat to 160-170 deg. F. with hot water or heat gun.
Mono-filament , nylon cord	Perlon	K&K Prosthetics Supply Co., Bellmore, Long Island, N.Y.	Upper-extremity transmission systems	1.5 cm, 2.0 cm.	$0.20 per yd.	Material will elongate under excessive force but will return to original length. Manufactured in Germany.
Nylon pressure tube	Nylaflow	Polymer Corp. of Penn., 50 Church St., New York, N.Y.	Housing for upper-extremity transmission systems. Hosmer heavy-duty retainer and cross bar can be threaded onto tube.	I.D.—.110" O.D.—3/16"	$0.05 per ft.	Ends can be flared in the cold state. It can be lubricated with silicone spray.
Synthetic foam rubber with adhesiv backing	Tesamol tape	United Mineral & Chemical Corp., 129 Hudson St., New York, N.Y.	Padding for pelvic belts, arm sockets, etc.	1/8", 1/4", and 1/2" thick; 4" wide	$11.00 per roll (25 ft.)	Very good adhesive qualities.
Polypropylene	Polyhinge	| Stokes Molded Products, Trenton, N.J.	Any prosthetic or orthotic device requiring a non-weight-bearing hinge	.100" thick, *VA"* or 2" wide	$25.00 per 100 ft. coil	Riveting usually necessary as material has poor bonding qualities to polyester laminates or other plastics.
Pre-Preg Fiberglas with epoxy resin (fabric)		DePew Manufacturing Co., Hicksville, Long Island, N.Y.	Used where additional reinforcement is desired in prosthetic and orthotic devices	36" wide roll	$2.75 per sq. ft.	Exceptionally useful for reinforcing complex shapes
Braided nylon tubular cloth	Taslon	K&K Prosthetics Supply Co., Bellmore, Long Island, N.Y.	Heavy-duty reinforcement for laminates. 6" width for Hessing braces, Syme's or Chopart prostheses. 10" width can be used for AK external socket finish.	6" wide and 10" wide	6", 10 yd. roll, $50.00 10", 10 yd. roll, $60.00	Excellent for adding rigidity and strength to laminations.
Plastic vinyl	Scotchlite brand heat reactive tubing	3M Electrical Products Division, Minnesota Mining & Manufacturing Co.	Used for covering metal parts of braces	Supplied in black, brown, and white in many sizes. However, 5/16", 7/16", 1/2", 5/8", 3/4", and 1" inside diameters are the most useful.	$0.20 per ft.	Shrink with heat gun.
Anaerobic compound polyester-type resin	Loctite	Morris Abrams Inc., Plainview, Long Island, N.Y.	Used to lock, seal, or retain threads.	10 cc. bottles	$1.35 per 10 cc. bottle.	Excellent sealant, especially for bonding plastic to metal (bushings).
Closed-cell sponge rubber	Rubatex	Rubatex Rubber Corp., Bedford, Va.	Used for insert liners in BK sockets.	1/8 X 36" X 36"	$4.25 per sheet	
Laminated closed-cell sponge rubber and Neoprene	Rubatex	Rubatex Rubber Corp., Bedford, Va.	SACH foot-type heels for braces. Firm material used for heavier patients (180 lbs. or more); medium used for patients in the 150 lb. range; soft used for patients in 120 lb. range.	15/16" thick, laminated closed-cell sponge rubber laminated to 5M*e"* thick Neoprene	*W* thick, 3' X 3' sheet. Firm (#451-N) $28.90 per sheet. Medium (//431-N) $27.50 per sheet. Soft (//425-N) $26.90 per sheet.	Can be attached easily to heel of shoe by means of Super-Bond, even over a stirrup or caliper plate.
Dacron with pressure adhesive backing		Rhopac, Inc. Skokie, Ill.	Used in place of metal for laminated cock-up splints. Used for build-ups in AK or BK sockets.	25" X 26' 30" X 26'	$8.50 per linear yd.	Used to reinforce laminations in specific areas.

The Swedish Knee Cage

Adequate control of genu recurvatum with a knee cage has been a problem every practitioner is familiar with. Usually it is necessary either to provide some means for suspension of the knee cage or, more commonly, to extend the brace to the shoe in order to avoid relative motion of the knee cage on the patient's leg. Even then, the functional performance of such a brace is hardly more than marginal.

In 1966 a knee cage designed in Sweden was brought to the attention of the Committee on Prosthetics Research and Development; it was subsequently evaluated at the Institute of Rehabilitation Medicine.

Description

The Swedish knee cage consists of two plastic-coated aluminum uprights, connected posteriorly with a semicircular horizontal bar. The three-point pressure system controlling recurvatum (Fig. 1) is applied anteriorly through two webbing straps fitted above and below the knee, while counterpressure is applied posteriorly through a fluid-filled pad. This pad is attached to the uprights in such a manner that it creates a hammock effect inside the posterior metal band and is fitted in the popliteal area (Fig. 2).

The anterior straps have a fixed attachment on the medial uprights and are looped over the lateral uprights where they are held in place by a snap button to facilitate donning and removal of the brace. The depth of the posterior pad can be adjusted at its attachment to the uprights to accommodate the size of the patient's leg and to control recurvatum properly (Fig. 3).

Evaluation

A total of six patients were fitted with the Swedish knee cage (Table 1). All

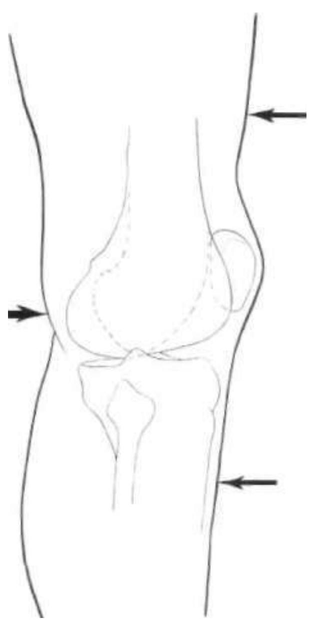

Fig. 1. Schematic diagram representing forces applied by the Swedish knee cage.

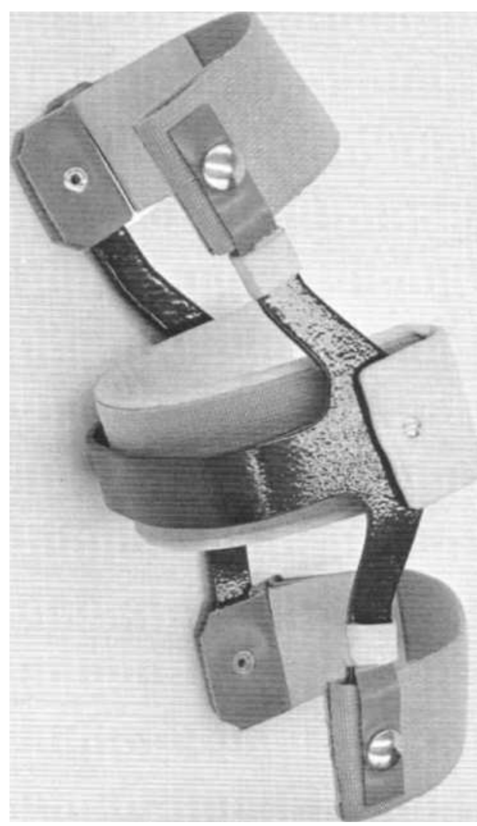

Fig. 2. The Swedish knee cage.

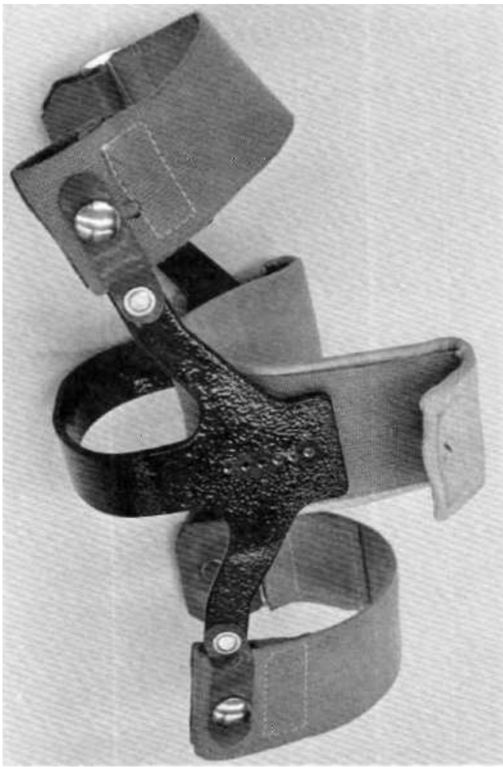

Fig. 3. **The posterior pressure pad is adjustable at its attachment to the uprights to control genu recurvatum.**

TABLE 1

Sub-ject	Diagnosis	Age yr-	Weight lb.	Height in.
GA	Multiple sclerosis	26	110	62
AV	Hemiplegia	19	160	69
WM	Traumatic hemiplegia	29	145	69
WG	Quadriparesis	21	130	75
WP	Fracture,left tibia and fibula	23	160	67
IR	Post-poliomyelitis	66	150	70

those fitted exhibited genu recurvatum (Fig. 4); in the case of WP, there was mediolateral instability as well. The application of the knee cage was successful in all six cases in preventing recurvatum and in providing some degree of mediolateral stability (Fig. 5). Because of the lightness of the device, no additional suspension was required. The following advantages were noted:

1. **Effective control of genu recurvatum.**
2. **Lightweight.**
3. **Absence of mechanical knee joint and lock.**
4. **No resistance to flexion of the knee (Fig. 6).**
5. **Ease of fitting.**

Problems noted were:

1. **Protrusion of proximal and distal ends of uprights when sitting (Fig. 7).**
2. **Development of leaks in the posterior fluid pad within a period of two to three weeks of patient wear.**
3. **Insufficient adjustment range.**

Fig. 4. Genu recurvatum secondary to post-poliomyelitis.

A report of this evaluation was given at the Fourth Workshop Panel on Lower-Extremity Orthotics sponsored by the Committee on Prosthetics Research and

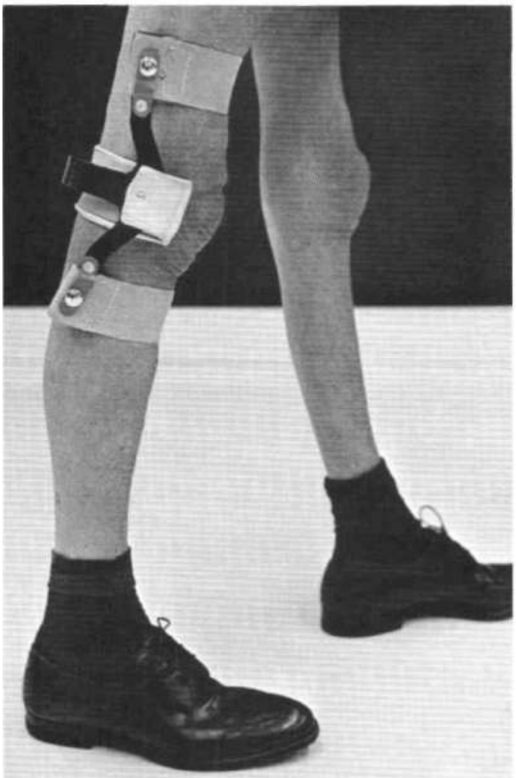

Fig. 5. Effective control of genu recurvatum with the Swedish knee cage.

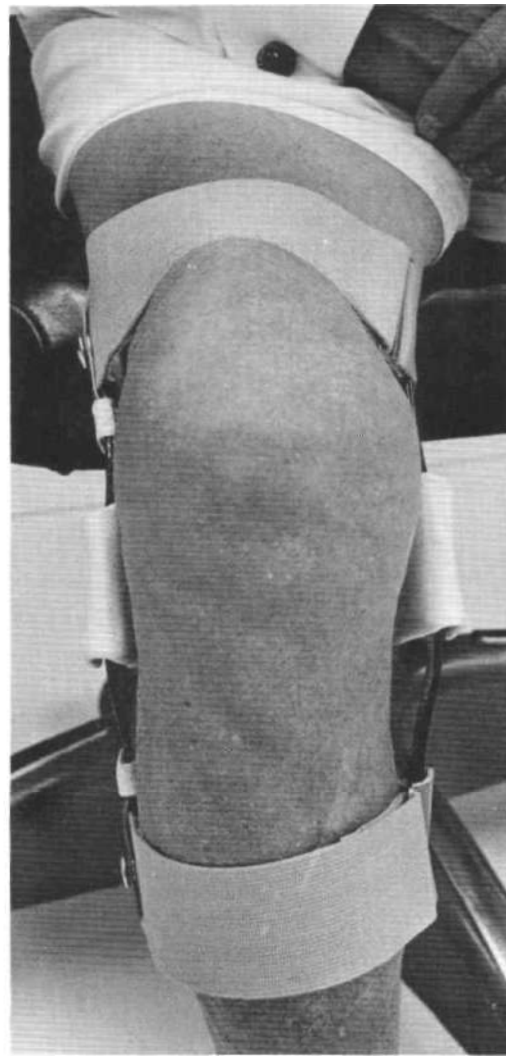

Fig. 6. Free knee flexion is possible with the knee cage.

Development, March 1967 *(1).* Since that time, several modifications in the design. of the Swedish knee cage have been made to overcome the problems noted above.

A major improvement was proposed by Charles Rosenquist,[1] a member of the Workshop Panel on Lower-Extremity Orthotics, in "prefiexing" the uprights to avoid protrusion when sitting (Fig. 8). Other modifications made were the replacement of the fluid-filled pad with a foam-rubber pad and an increase in the range of ajdustment by increasing the number of threaded holes in the uprights. The foam-rubber pad was found to be as effective and comfortable as the fluid-filled pad.

Fitting Considerations

At present, the knee cage is commercially available[2] in only one size, which may be applied either left or right. Usually the brace is fitted with the snap buttons facing laterally. An exception to this would be a hemiplegic patient, for whom the knee cage should be fitted with

[1] Columbus Orthopaedic Appliance Co., Columbus, Ohio 43222.

[2] U.S. Manufacturing Co., 623 S. Central Ave., Glendale, Calif. 91209.

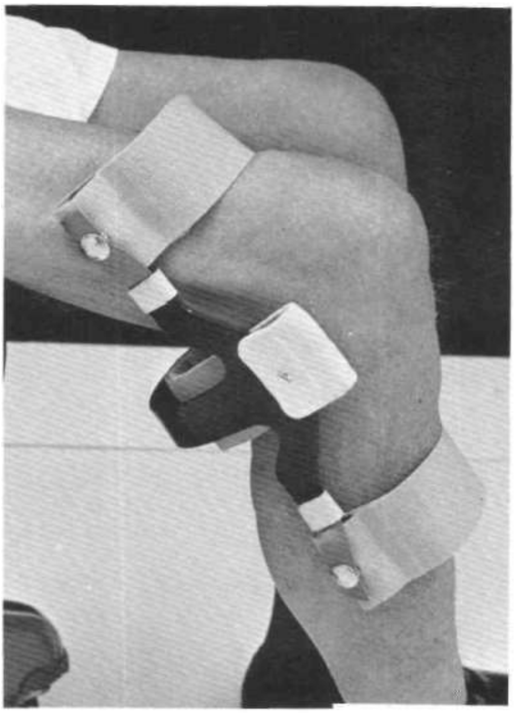

Fig. 7. Protrusion of proximal and distal ends of uprights when sitting with original design.

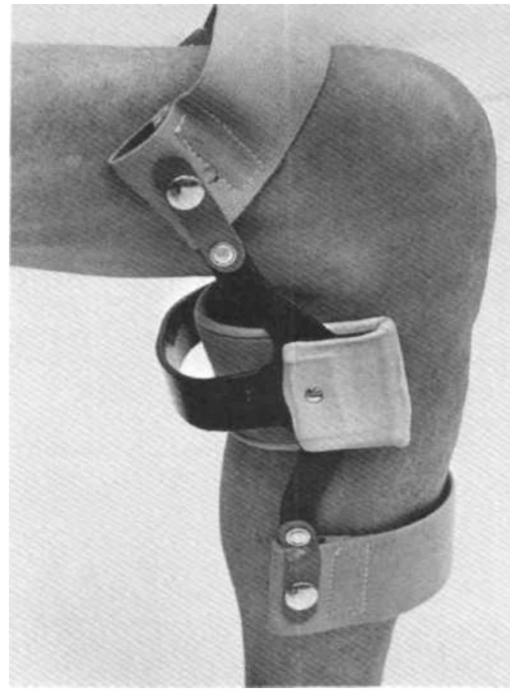

Fig. 8. Rosenquist modification of knee cage. Note that preflexed uprights eliminate protrusion with knee flexed 90 deg.

the snap buttons facing medially to ease donning and removal of the brace.

The uprights can easily be shaped to the contour of the knee. The use of bending irons is rarely required and, in fact, should be avoided since it may damage the plastic coating. Adjustment of the posterior pad should be made after the patient is allowed to stand and after a determination is made as to how much the posterior pad should be advanced or released to achieve proper alignment of the knee. This adjustment can easily be made by changing the screw attachment of the posterior pad in the uprights.

Summary

A new type of knee cage has been described which was found to be superior to other types of knee cages in the orthotic management of genu recurvatum. The unique features of this brace are its simplicity, which is due to the absence of a mechanical knee joint with lock, and its posterior pad, which creates a hammock effect for comfortable and effective control of genu recurvatum.

Acknowledgment

The cooperation of the medical and physical therapy staff of the Institute of Rehabilitation Medicine in the evaluation of the Swedish knee cage is gratefully acknowledged.

—Hans Richard Lehneis, C.P.O.
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News and Notes

Prosthetics-Orthotics Education

University of California, Los Angeles

On Sept. 1, 1968, Dr. Leonard Marmor returned to the UCLA Medical Center from sabbatical leave to resume his duties as Associate Professor of Orthopedic Surgery and lecturer for the Prosthetics-Orthotics Program. From September 1967 through June 1968, Dr. Marmor was the visiting professor under a Fulbright Lectureship at the University of Hong Kong, Department of Orthopaedics, where he taught orthopaedic surgery and prosthetics to the staff and medical students. He presented many of the principles that have been taught in the UCLA prosthetics courses.

While in the Far East, Dr. Marmor gave 18 lectures on subjects related to orthopaedics and prosthetics. He lectured aboard the naval hospital ship, U.S.S. Repose, and also lectured on rheumatoid surgery and peripheral nerve grafting for the Japanese Orthopedic Association.

Bernard R. Strohm, Director of the UCLA Prosthetics-Orthotics Program since July 1, 1968 (see *Artificial Limbs,* Spring 1968).

Dr. Leonard Marmor, Associate Professor of Orthopedic Surgery, UCLA.

A program of interest to Dr. Marmor in Hong Kong was the research program being conducted on peripheral nerve grafting. Three human cases of nerve transplant were carried out, with the use of irradiated homografts and the immunosuppressive drug, Imuran. A nerve bank was also established at the University, and further studies are being conducted in this field.

Endoskeletal Upper-Extremity Prosthesis Feasibility Study

Research is being conducted on an endoskeletal artificial arm feasibility study by Maurice A. LeBlanc at UCLA as **a** part of the Prosthetics-Orthotics Program. This project is supported by the Social and Rehabilitation Service.

Mr. LeBlanc is fabricating below-elbow (BE) and above-elbow (AE) prototypes, which incorporate a nylon tubular struc-

Maurice A. LeBlanc, staff member of the Prosthetics-Orthotics Program at UCLA, who is conducting research on an endoskeletal artificial arm feasibility study.

ture from the socket to a mechanical soft hand, braided Dacron cabling with Teflon housing running inside the tubular structure, a covering of soft polyurethane foam shaped to match the sound side, and a copolymer skin which covers the complete arm from hand to top of socket. In addition to the over-all improved appearance and feel, it is anticipated that funcional endoskeletal artificial arms will possess advantages in fabrication, weight, and adjustment. The prototypes have standard BE and AE body control systems, but offer excellent possibilities of being adapted to external power and skeletal transplants.

New Library Facility

A prosthetics-orthotics library is being established at UCLA for use by faculty and students. The rapidly increasing collection of books and periodicals pertaining to special research interests and programs of instruction will lend tremendous support to educational achievements. The library will include a section devoted to visual aids such as slides, films, and anatomical specimens.

To assure maximum effectiveness and efficiency of the library, Mrs. Corrine Cantor, formerly a staff member of the main research library on the UCLA campus, has been assigned the responsibility of coordinating activities relative to the control and management of the over-all operation.

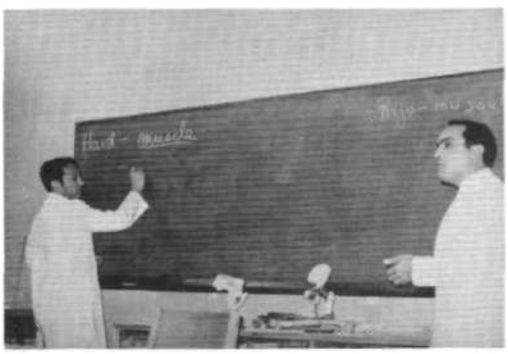
New York University

Registration for the 1968-1969 academic year reflects a steady increase in enrollment in the four-year undergraduate program in prosthetics and orthotics. Among the 27 students, one is from Japan, another from India, and a third from Colombia. Two of the students are women, one of whom is from Israel. Two students have transferred from Cerritos Junior College, and one from Chicago Junior College. In June it is expected that ten graduates will enter the prosthetics-orthotics field.

The 1968-1969 series of short-term postgraduate courses began on Sept. 3 with Course 740 A, *Below-Knee Prosthetics for Prosthetists.* Fourteen prosthetists attended this course. Course 742A, *Lower-Extremity Prosthetics for Therapists,* and Course 741A, *Lower-Extremity Prosthetics for Physicians and Surgeons,* have been completed. There were 23 therapists enrolled in Course 742A, and 49 physicians and surgeons in 741A. Of the 49 physicians and surgeons, 29 were from the United States and 20 from abroad. Members of the latter group were from Argentina, Colombia, Ecuador, India, Israel, Japan, the Philippines, Rhodesia, Taiwan, Thailand, and Turkey.

Final steps are being taken for a pilot course in spinal orthotics for physicians and surgeons that will take place early in November. Following the pilot course, the first regular course in spinal orthotics for physicians and surgeons will be offered from Nov. 25 through 27.

Dr. Fishman's lecture being translated into Portuguese by Dr. Santana-Carlos.



Mr. Berger's lecture being translated by Mr. Carlos, Portuguese prosthetist.

Activities Abroad

In conjunction with the Centro de Medicina de Reabilitacao in Lisbon, Portugal, NYU Prosthetics and Orthotics presented a one-month course in above-knee prosthetics to eleven students, of whom ten were Portuguese and one Spanish. Sidney Fishman, Ph.D., Coordinator of NYU Prosthetics and Orthotics, and Victor M. Santana Carlos, M.D., Director of the Lisbon center, planned and coordinated the program. NYU staff members Norman Berger, Ivan Dillee, and Clauson England provided prosthetics instruction in lectures and laboratories. The course was extremely well received, and it was most gratifymg to see the diligence with which the students worked, not only within the classrooms, but also after scheduled hours. Consideration is being given to the possibility of a return visit during the summer of 1969, with the offering of courses in below-knee prosthetics for prosthetists, lower-extremity prosthetics for therapists, and lower-extremity prosthetics for doctors.

In addition to the course in Portugal, Dr. Fishman attended a United Nations seminar on the training of prosthetists, held in Holte, Denmark. He also made professional visits to prosthetic facilities in Israel and England. In all the countries he visited there was considerable interest in the means of improving communication through interchange of faculty, teaching materials, and research reports. Tentative plans for further professional contracts were made.

Personnel Changes

NYU Prosthetics and Orthotics is sorry to report the loss of the services of Miss Grace Jackson, technical writer, who resigned to become a full-time student at Hunter College to finish her studies in psychology, and Miss Nancy Munson, who resigned as an Assistant Research Scientist to become Director of Recreational Therapy at Gracie Square Hospital in New York City.

Louis Levine
1924-1968

A very sad departure was caused by the untimely death of Mr. Louis Levine, age 44, who was stricken by a heart attack on Sept. 2, 1968, while vacationing in Nice, France. Lou was well known to many in the field of prosthetics and orthotics who had taken courses at NYU. As Administrative Assistant to Dr. Fishman, he skillfully handled the enrollment of numerous students in the postgraduate courses, along with his many other duties. His role as a vital part of the NYU prosthetics and orthotics program will be a difficult one to fill. He is survived by his mother and three sisters.

Students and instructor working in lecture-demonstration classroom.

Northwestern University

New Teaching and Research Facilities

Northwestern University Prosthetic-Orthotic Center opened its new, expanded teaching and research facilities at 401 E. Ohio St. in Chicago at the beginning of the current academic year with a short-term course in below-knee prosthetics for prosthetists. The new facilities are approximately one-half block from the Rehabilitation Institute of Chicago where the original facilities are located.

Increased demand for short-term continuing education courses for physicians, surgeons, therapists, and counselors, plus the addition of an Associate-of-Arts degree in orthotics and new short-term courses for orthotists, necessitated this major expansion of teaching facilities. The expansion realizes an increased footage of 9,200 sq. ft. and includes general administrative offices, patients' waiting room, lecture and demonstration classroom, prosthetics laboratory, orthotics laboratory, orthotic research laboratory, sewing room, plaster and plastics room, fitting room, orthotic machine shop, storage room for flammable items, and general supply and storage rooms.

The prosthetics laboratory and the orthotics laboratory are fully equipped to train 32 associate-degree candidates in the two disciplines. An instructor's bench and teaching area are also provided for in the laboratories.

Prosthetics students observing instructor in demonstration area of prosthetics laboratory.

A spacious waiting room and a prosthetic-orthotic fitting room, divided into 16 cubicles, provide comfort and privacy for both patients and students.

During a recent reorganization, the Prosthetic Research and Evaluation Center and the Systems Development Laboratory, supported by a contract from the Veterans Administration, were joined with Prosthetic-Orthotic Education to form what is now called the Northwestern University Prosthetic-Orthotic Center. Charles M. Fryer, M.A., has been appointed Director of the Center. In addition, Mr. Fryer will continue to direct the orthotic research, evaluation, and education program. H. Blair Hanger, C.P., has been appointed

Director of Prosthetic Education; Frederick L. Hampton, C.P., will serve as Coordinator of Prosthetic Research, Evaluation and Education. They will be assisted by Gunter Gehl, C.P., Ian J. Currell, C.P., James Aylen, B.S., and James Kuss, CO. Dudley S. Childress, Ph.D., is Director of the Systems Development laboratory, and Edward C. Grahn, B.S.M.E., is Director of Prosthetic Research and Evaluation. Clinton L. Compere, M.D., whose encouragement and support are invaluable to the program, will continue to serve as Academic Advisor to the Center. The prosthetic and orthotic research and education programs of the Northwestern University Prosthetic-Orthotic Center are possible through the continued interest and support of the Social and Rehabilitation Service and the Veterans Administration.

The Center will continue to maintain its teaching and research facilities in the Rehabilitation Institute of Chicago.

Wesley Duiker, Assistant Director, Charles M. Fryer, Director, and Susan Moulder, Administrative Assistant, of the Prosthetic-Orthotic Center, Northwestern University Medical School.

Appointment of Charles M. Fryer, M.A., as Director of the Northwestern University Prosthetic-Orthotic Center to succeed Dr. Jack Armold has been announced by Dr. Clinton L. Compere, Academic Advisor to the Center. Mr. Fryer has been with Northwestern University for seven years as an instructor and, most recently, as director of the orthotics research, evaluation, and education program. Mr. Fryer is well known in prosthetics-orthotics circles for his masterly presentations on biomechanics of the musculoskeletal system.

Mr. Wesley Duiker has been appointed Assistant Director of the Center. Mr. Duiker came to Northwestern from the American Medical Association, where he worked for seven years in the Department of Health Care Organizations.

Miss Susan Moulder, who has worked in the Center for the past seven years, was recently appointed Administrative Assistant.

Special Course Announcement

During the 1968-1969 academic year, Northwestern University Prosthetic-Orthotic Center will offer, in addition to courses in prosthetics, three short-term courses for orthotists. Each of the three courses will be of two weeks duration. The titles of the courses, course numbers, and the dates during which they will be offered are as follows:

Spinal Orthotics for Orthotists—Orthotics 701	Nov. 11-22, 1968
Lower-Extremity Orthotics for Orthotists—Orthotics 711	Jan. 27-Feb. 7, 1969
Upper-Extremity Orthotics for Orthotists—Orthotics 721	May 12-23, 1969

Instruction will include techniques of measuring, fabricating, and fitting orthoses for the spine (exclusive of the Milwaukee Brace), lower extremity, and upper extremity. Also included in the course content are current concepts of treatment, functional anatomy, and pathology.

The courses are open to certified orthotists and those preparing for certification. The tuition fee is $200.00 per course; traineeship grants are available.

Application for admission may be obtained by writing to:

Prosthetic-Orthotic Center
Northwestern University Medical School
401 E. Ohio St.
Chicago, LI. 60611

Second Conference on Rehabilitation of the Cancer Patient

The Second Conference on Rehabilitation of the Cancer Patient, sponsored by the New York Academy of Science and the Department of Health, Education, and Welfare, was held at the Princeton Inn, Princeton, N. J., Apr. 21-24, 1968.

A portion of the program was devoted to rehabilitation of the patient with tumor of the bone and soft tissue of the extremities which required amputation. Provision of good prosthetics services and devices for these patients, although requiring great skill and knowledge, was considered essential, and a program directed toward education of physicians and others involved in these problems is indicated. Early rehabilitation of the cancer patient, despite the gravity of the prognosis, was stressed throughout the conference.

Dr. Ernest M. Burgess, Director, Prosthetics Research Program, Seattle, Wash., discussed early and immediate postsurgical fitting and pointed out the physiological and psychological benefits of these procedures.

Mr. Alvin L. Muilenburg, Past President of the American Orthotic-Prosthetic Association, discussed rehabilitation problems from the prosthetist's point of view, and presented a film on hemicorporectomy.

Conference participants further emphasized that an important factor in treatment of the cancer patient is communication between the patient and the family, the general practitioner, the surgeon, the radiologist, and others involved in his care. It was pointed out that the quality of survival and survival rate should be given equal consideration.

The United Nations Interregional Seminar on Standards for the Training of Prosthetists

The International Committee on Prosthetics and Orthotics of the International Society for Rehabilitation of the Disabled for many years has been concerned with the problem of training adequately a sufficient number of prosthetists and orthotists to meet the needs of patients throughout the world. Under the guidance of its chairman, Dr. Knud Jansen, Orthopaedic Hospital, Copenhagen, the Committee has sponsored a number of short-term training courses for prosthetists and orthotists from many countries since 1957.

With this experience as a background the United Nations organized and funded, with the cooperation of the Government of Denmark and the International Committee, a seminar for the express purpose of defining curricula and other standards for the training of prosthetists. The seminar was held July 1-19 at the Rural Development College in Holte, Denmark, a town near Copenhagen.

Many countries, particularly in Eastern Europe, Asia, Africa, and South America, were represented. Resource people and instructors were selected by the United Nations from a number of Western European countries and North America. Included from the United States were:

Dr. Miles H. Anderson, Director, Allied Health Professions Project, Los Angeles, Calif.

Mr. Anthony Staros, Director, VA Prosthetics Center, New York, N.Y.

Mr. William A. Tosberg, formerly Technical Director, NYU Medical Center, New York, N.Y.

Mr. Joseph E. Traub, Consultant, Prosthetics-Orthotics Research and Training, Social and Rehabilitation Service, Department of HEW, Washington, D.C.

Dr. Sidney Fishman of New York University, Dr. Cameron B. Hall of the University of California (Los Angeles), and

Scene during the United Nations Seminar on Standards for the Training of Prosthetists. At the front table, *left* to *right,* Mr. Max Nader of West Germany, Dr. Knud Jansen of Denmark, Co-chairman of the Seminar, and Mr. Anthony Staros of the United States.

Dr. Milo B. Brooks, formerly of the University of California (Los Angeles), attended for brief periods.

Since the main purpose of the seminar was to develop curricula standards and to specify methods for training prosthetists, it was necessary for the seminar participants to define "prosthetist," which, as it turned out, had different meanings throughout the various parts of the world. Time was therefore devoted to the development of definitions of the role of the prosthetist-orthotist and of the supporting role of the prosthetics-orthotics technician. Even those countries which do not now enjoy the availability of prosthetists and orthotists as eventually defined agreed that the levels of professional responsibility as specified would be desirable, constituting a goal to which these countries should aspire.

The seminar treated other topics associated with the main tasks of defining the role of the prosthetist and orthotist and the curricula for training. Conclusions representing agreement among the many different points of view were reached. For example, standards for terminology to assist in international communications were discussed in some detail, and recommendations were made for action to bring about standardization. Careful consideration was also given to an ideal standard for prosthetics-orthotics services. Standards for prefabricated components were also discussed, and recommendations for action by the International Committee were offered.

A good deal of time was devoted to the development of methods for teaching and to the needs in instructor training for the proposed curricula for prosthetists, orthotists, and technicians. The ideal training center was defined as well.

Recommendations were made for the establishment of an international training center in Denmark, the expansion of scope of existing regional prosthetics-orthotics training centers, and the development of additional centers. Emphasis was given to the effectiveness of the regional training center in Teheran, Iran. The training center in Buenos Aires established by Dr. Govi is also considered to have a very positive impact on prosthetics services in the region.

Finally, the seminar developed a code of ethics for prosthetics-orthotics professional practice. It also suggested systems to improve the image of prosthetists-orthotists, both among other professionals and in the community.

The United Nations will publish in time complete reports on the seminar. Many of the findings will be of interest to readers throughout the world.

Orthotic Education at Rancho Los Amigos Hospital

Receiving certificates of completion of the Orthotic Internship Program are, *left* to *right*, Darrell Johnson, Darrell Clark, Robert Junghans, and Guy Rodon. Presenting the certificates is Arthur Guilford, Orthotics Supervisor, Orthotic Department, and watching the proceedings is Dr. N. Elane Wilcox, Education Director, Orthotics-Prosthetics, Rancho Los Amigos. The certificates were awarded on Friday, Aug. 16. Three of the graduates have elected to accept positions in the Department of Orthotics at Rancho Los Amigos Hospital, and one is continuing his formal education. The second internship program starts Sept. 1, 1968, and will be 12 months in duration.

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Canadian Conference on Prosthetics and Orthotics

The Interprovincial Association of Prosthetists and Orthotists of Canada held its National Conference and Assembly at the Hotel Bonaventure in Montreal, Aug. 22-24, 1968.

The Conference took on an international flavor, with a number of countries being represented in both speaker and participant groups.

Professor Marian Weiss, M.D., Chief Rehabilitation Chair, Medical Academy in Warsaw, Poland, discussed his current views on immediate postsurgical fitting and presented a film on the same subject.

The subject of immediate postsurgical fitting was further pursued by Bert Titus, Duke University Medical Center, and Joseph Zettl, Prosthetic Research Center, Seattle, Wash.

Dr. G. Kuhn, Muenster, Germany, described the latest management procedures being used at the Muenster clinic.

Dr. Sidney Fishman discussed problems in establishing prosthetics and orthotics educational programs and listed six countries that have the resources essential to an organized program. They are Canada, Argentina, and the United States in the Western Hemisphere; Denmark and Germany in Europe; and Iran in the Near East. Dr. Fishman and members of his staff described the prosthetics and orthotics educational program at New York University.

Anthony Staros described the efforts of the United States Veterans Administration in improving service to amputee beneficiaries through research and education. A current area of interest in the VA program, emphasized by Mr. Staros, is analysis of the gait of geriatric patients. He stated that although the time factor appears to be altered in geriatric gaits the gait pattern recordings, as compared with those in younger age groups, did not reflect much over-all difference. Mr. Staros went on to describe the new pylon-type prostheses and new studies in fabrication of sockets, all designed to provide new amputees with quicker and more efficient service. He also showed some of the methods being used by the VA Prosthetics Center in trying to arrive at a better understanding of the various factors which contribute to the success of immediate postsurgical fitting of prostheses.

Fifth International Congress of Physical Medicine

The Fifth International Congress of Physical Medicine was held at the Queen Elizabeth Hotel in Montreal, Canada, Aug. 25-31, 1968.

Six major themes were featured: Rheumatological Disorders, Neurologic Disorders, Electronics and Their Application of the Handicapped, Medical Education, Problems of Locomotion for the Handicapped, and A Study of the Role and Educational Needs of Allied Medical and Paramedical Disciplines.

The program on electronics focused on the progress being made in the use of external power in prostheses and orthoses, and included demonstrations of the most recent equipment and technique.

Dr. Edwin L. Lytle, M.C., Associate Director, Rehabilitation Services, The Gaylord Hospital, Wallingford, Conn., and associates presented a new fluid actuator for orthoses and prostheses. The FLEXOR element, "a new concept in motor components," invented by Stanley R. Rich, Worcester, Mass., is a flexible tube so constructed internally that it flexes when fluid is introduced under pressure from a small hydraulic cylinder. In the Flexor hand, five individual Flexors serve both as operating and terminal-grasping elements. It is proposed that the Flexor element be adopted for use in other devices, including hand splints and leg braces.

A session on "Prosthetic Advances" included a discussion on the "McLaurin" Swivel Walkers by Dr. P. M. R. Nichols, Nuffield Orthopaedic Centre, Oxford, England, and a presentation of a new plastic short leg brace by Paul J. Corcoran and associates from the University of Washington.

Dr. Leon Sheplar, Veterans Administration Hospital, Miami, reported that a study completed on 33 patients demonstrated that prolonged tenure on a conventional limb is not in contraindication to use of the patellar-tendon-bearing limb.

Dr. Lewis A. Leavitt and others at Texas Institute for Rehabilitation and Research reported on the methodology being used in a research project for the kinesiological and quantitative evaluation of fit and gait analysis in lower-extremity prosthetics. An attempt will be made to quantify the abnormal qualities of gait and prosthetic fit in those amputees with significant clinical problems. In a feasibility study, instrumentation for the measurement of pressures, temperature, and gait

The above exhibit was displayed by the Rehabilitation Institute of Montreal at the Fifth International Congress of Physical Medicine, held in Montreal, Canada, August 25 to 31, 1968. The exhibit shows five of today's prostheses, from *left* to *right:* the conventional, pneumatic, "hybrid," electromechanical, and hydraulic. The mechanisms of each prosthesis could be manipulated by controls installed in a front panel.

patterns has been developed for use in above-knee prostheses.

Among the many social events of the week was a Mayor's Reception held at the Chalet du Mount-Royal, Tuesday, Aug. 27. Gustave Gingras, M.D., of Canada, was president of the Fifth Congress.

Change in Command at AMBRL

In keeping with general policy of the Department of the Army, Col. Peter M. Margetis, DC, after two tours of duty as Director of the Army Medical Biomechanical Research Laboratory at Walter Reed Army Medical Center, has been assigned as Director of the U.S. Army Institute of Dental Research effective Sept. 1, 1968.

The new Director is Lt. Col. Orlyn C. Oestereich, MSC, who assumed his new duties Sept. 1. Col. Oestereich is no stranger to the Artificial Limb Research Program, having served at AMBRL (when it was the Army Prosthetics Research Laboratory) between 1956 and 1964. Among his duties during those years was responsibility for the limb-fitting facilities, and Col. Oestereich attended the various courses in prosthetics offered by the University Education Programs at that time. Subsequently he was named Executive Officer of the Laboratory. During the intervening years, Col. Oestereich served in Vietnam. He was assigned to Baylor University from June 1965 to June 1966 for further education, after which he reported to Ft. Detrick in June 1966 as Executive Officer of the U.S. Army Medical Unit.

Lt. Col. Orlyn C. Oestereich, MSC, Director, AMBRL.

North American Subcommittee Meets

Anthony Staros, Chairman of the North American Subcommittee of the International Committee on Prosthetics and Orthotics, took advantage of the gathering occasioned by the Annual Assembly of the American Orthotic and Prosthetic Association by convening the Subcommittee in Minneapolis Sept. 26, 1968. Fifteen members and three guests were present.

Plans for design of an exhibit depicting prosthetics and orthotics research, education, and practice in North America were discussed. The exhibit will be shown for the first time at the Eleventh World Congress of the International Society for Rehabilitation of the Disabled in Dublin, Sept. 14-19, 1969.

Also discussed was the desirability of restructuring the Committee and Subcommittee so that activities could include anyone who has a bona fide interest in prosthetics and orthotics, regardless of the type of training he has had. Recommendations for expansion were prepared for transmittal to the parent committee, and Alvin Muilenburg was appointed chairman of an *ad hoc* committee to consider methods of expansion of the North American Subcommittee.

The meeting was concluded by reports from Anderson, Fishman, Hall, Staros, and Traub on the United Nations Interregional Seminar on Standards for the Training of Prosthetists (see p. 63).

The American Orthotic-Prosthetic Association National Assembly

The 1968 National Assembly of AOPA was held at the Hotel Radisson, Minneapolis, Minn., Sept. 27-30. Registered attendance numbered 469.

Under the guidance of Roy Snelson as program chairman, the theme "Education . . . Research . . . Service" was carried out admirably. Included in the presentation was a description by Jimmie C. Steedley and George Lambert of the new nine-month Delgado College Bench Technician Program which, it is hoped, will help to relieve the shortage of prosthetics technicians.

At another session, arranged by the University Council on Orthotic-Prosthetic Education, representatives of six prosthetics and orthotics schools reported on their respective programs. Describing these were Sidney Fishman, New York University; Charles M. Fryer, Northwestern University; Bernard Strohm, University of California at Los Angeles; Chester Pachucki, Chicago City College; and Elane Wilcox, Rancho Los Amigos Hospital and Cerritos College.

Preliminary reports on two surveys conducted by the Committee on Prosthetic-Orthotic Education were also presented. One, a report of the Manpower Survey, was presented by Dr. J. Warren Perry, and the other, the Facility Case Records Study, by Dr. Frank W. Clippinger, Jr.

Other highlights of the program included a panel presentation headed by Clinton L. Compere, M.D., on management of the diabetic amputee. Bert R. Titus and Bernard Strohm teamed up to present methods of gait training for use by prosthetists. Sam Hamontree and Carlton Fillauer discussed some of the latest methods of suspension for below-knee prostheses, and teams from Rancho Los Amigos and the University of Miami described their work in the use of braces in management of fractures of the long bones.

The Committee on Prosthetics Research and Development presented recent developments in the area of research. Panelists Colin A. McLaurin, Charles W. Radcliffe, Anthony Staros, Joseph E. Traub, and A. Bennett Wilson, Jr., discussed progress being made among the various research groups, ranging from externally powered upper-extremity prostheses to braces for the treatment of fractures.

The technical sessions were concluded by a presentation on treatment of the child amputee by Robert Gruman, Richard Jones, Chester Nelson, and Daniel Rowe.

At the business meeting on Monday, Sept. 30, Alvin L. Muilenburg, President, presided over the installation of the new officers for 1968-1969: President, Michael P. Cestaro, Washington, D.C.; President-Elect, William L. Bartels, Portland, Ore.; and Vice-President, Richard G. Bidwell, Milwaukee, Wise. Durward R. Coon, Detroit, Mich., was reelected Secretary-Treasurer.

Jack D. Armold Named Executive Director of the Association of Schools of Allied Health Professions

On Oct. 1, Dr. Jack D. Armold assumed the duties of the newly created position of Executive Director of the Association of Schools of the Allied Health Professions (ASAHP).

Now located in Washington in the new national office of the Association (2011 Eye St., N.W., 20006), Dr. Armold comes from Northwestern University where he has served since March 1961 as Director of Prosthetics-Orthotics Education, a position which has given him experience which will be most valuable in his new post.

The Association, which began with 13 schools of allied health professions, now includes educational institutions, other institutions, organizations, and individuals who are interested in the development of adequate health manpower. It seeks to channel the educational forces of this nation toward improving the quality and quantity of health care for the

Jack D. Armold, Ph.D., newly appointed Executive Director of ASAHP.

American people by providing leadership in education for schools, colleges, and divisions of allied health professions, and serves as their collective representative and spokesman. It also provides a medium for cooperation and communication among schools of allied health professions, promotes the development of new allied health programs, encourages research and study of the development and evaluation of new needs and approaches in allied health fields, and furnishes liaison with other health organizations, professional groups, and educational and governmental institutions.

Earlier this year the Kellogg Foundation awarded a five-year grant to the ASAHP to help support its activities and its development as a unified force toward improvements in the use of manpower, in curricula for training health care workers, and in the recruitment of individuals for health careers.

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

THE NATIONAL ACADEMY OF SCIENCES is a private, honorary organization of more than 700 scientists and engineers elected on the basis of outstanding contributions to knowledge. Established by a Congressional Act of Incorporation signed by Abraham Lincoln on March 3, 1863, and supported by private and public funds, the Academy works to further science and its use for the general welfare by bringing together the most qualified individuals to deal with scientific and technological problems of broad significance.

Under the terms of its Congressional charter, the Academy is also called upon to act as an official—yet independent—adviser to the Federal Government in any matter of science and 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 and its activities are not limited to those on behalf of the Government.

THE NATIONAL ACADEMY OF ENGINEERING was established on December 5, 1964. On that date the Council of the National Academy of Sciences, under the authority of its Act of Incorporation, adopted Articles of Organization bringing the National Academy of Engineering into being, independent and autonomous in its organization and the election of its members, and closely coordinated with the National Academy of Sciences in its advisory activities. The two Academies join in the furtherance of science and engineering and share the responsibility of advising the Federal Government, upon request, on any subject of science or technology.

THE NATIONAL RESEARCH COUNCIL was organized as an agency of the National Academy of Sciences 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 National Academy of Sciences, are drawn from academic, industrial, and government organizations throughout the country. The National Research Council serves both Academies in the discharge of their responsibilities.

Supported by private and public contributions, grants, and contracts, and voluntary contributions of time and effort by several thousand of the nation's leading scientists and engineers, the Academies and their Research Council thus work to serve the national. interest, to foster the sound development of science and engineering, and to promote their effective application for the benefit of society.

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

The *Committee on Prosthetics Research and Development* and the *Committee on Prosthetic-Orlholic Education,* units of the Division of Engineering 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.