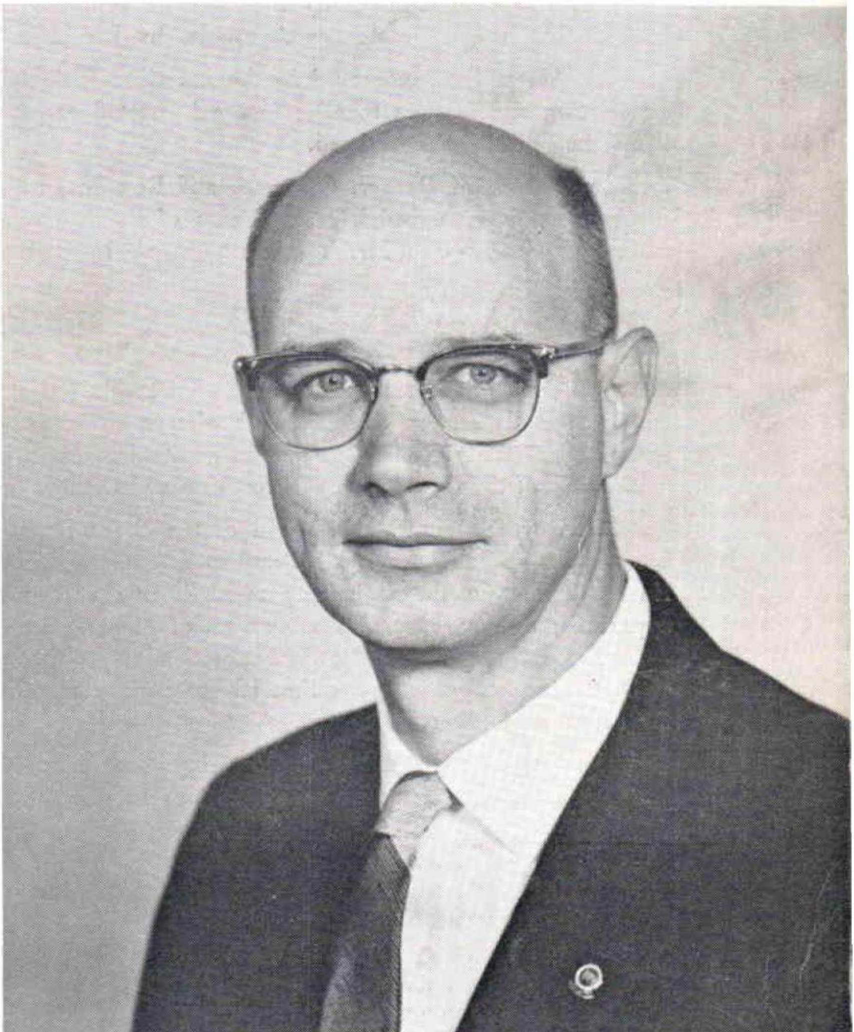
DECEMBER, 1962

ORTHOPEDIC & PROSTHETIC APPLIANCE JOURNAL

The Journal of the Limb and Brace Profession



CARLTON E. FILLAUER, C.P.O.
President 1962-1963, American Orthotics and Prosthetics Association

publisher: American Orthotics and Prosthetics Association

Titus To Plan '63 Assembly

Snelson and Scott Complete Program Committee

Bert R. Titus, C.P.O., has been named Program Chairman for the 1963 Orthotics and Prosthetics Assembly, by President Carlton Fillauer.

The Assembly is sponsored by the American Orthotics and Prosthetics Association and is open to all who are interested in the rehabilitation of the orthopedically handicapped.

Bruce Scott of Denver, Colorado, and Roy Snelson of Downey, California, have been named Vice Chairmen of the Program Committee and will work closely with Mr. Titus and AOPA Headquarters in planning the Assembly.

Mr. Titus was Vice-Chairman of the 1961 Assembly sponsored by the Association at Miami Beach. He has served as Director of AOPA Region IV, covering the Southeastern States. He has taught at New York University and is currently serving as Assistant Professor of Orthotics and Prosthetics at Duke University Medical School in addition to his prime responsibility as Director of the Department of Prosthetic and Orthopedic Appliances.

Mr. Roy Snelson C.O., is head of the Brace Department at Rancho Los Amigos and also operates his own establishment at Downey, California. He has taught at the University of California at Los Angeles and has appeared on the program of a number of Medical Meetings and AOPA Assemblies. Mr. Bruce Scott, C.P.O., well known orthotist and prosthetist of Denver, Colorado, is a long time advocate of high professional standards for orthotists and prosthetists.

The Program Committee invites all persons interested in the orthopedically handicapped to submit suggestions for the 1963 Assembly.

Orthopedic and Prosthetic Appliance Journal

(Title registered U. S. Patent Office)

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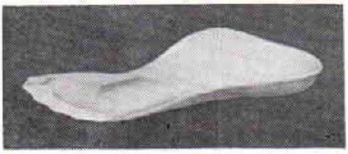

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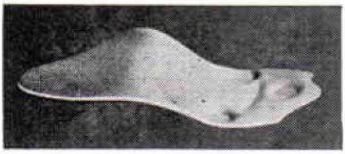

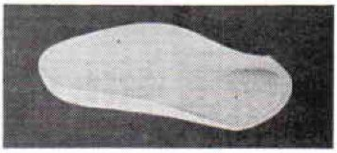

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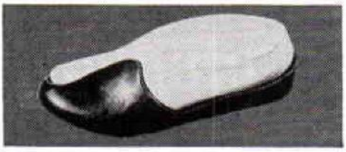

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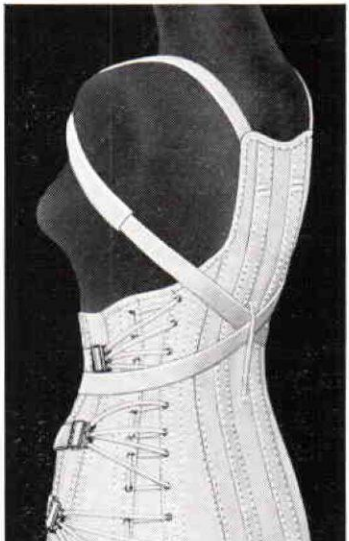

UNIQUE DORSO-LUMBAR SUPPORT

Women's models 1173-HS full skirt (pictured above) and 1174-HS regular length. Men's model 417-HS regular length. Drawing shows single adjustment of shoulder straps in front, retained in "keeper"

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An Experience With External Power In Upper Extremity Prosthetics

ROY SNELSON, C.O.*
and
L. BENSON MARSH, C.P.**

Throughout the years prosthetists have been aware of the need for more efficient and functional upper extremity prostheses. Conventional upper extremity prostheses are now vastly superior to those available in the past. However, there is still much need for improvement, especially for the more severely involved cases. Although previous attempts to increase efficiency and function through the application of external power have met with varying degrees of success, in many instances the designs produced were too complex for practical application.

Greater emphasis is now being placed upon the use of external power in order to provide amputees with an answer to their prosthetic needs. Our cooperative efforts in this direction have resulted in the development of a successful pneumatic upper extremity prosthesis utilizing modified standard prosthetic and orthotic components.

A 20-year-old male S/D amputee was fitted with this type of prosthesis. He is successfully using it at the present time. Three additional shoulder disarticulation patients are now being fitted with similar prostheses. This utilization of standard components has proved to be both economical and expedient, contributing greatly to the degree of success.

BASIC INVESTIGATION

The success of pneumatically activated orthotic devices indicated the possibility of adapting many of the same components for activating prostheses.

A basic investigation indicated the feasibility of utilizing the artificial muscle for motive power. This was abandoned when available space proved inadequate for containing a muscle of sufficient length to fulfill power requirements. Later investigations indicated that the most promising approach would be to utilize two pistons: one piston to be attached to the proximal end of the wrist, and the other to the proximal end of the elbow.

PROTOTYPE DEVELOPMENT

1. *Components*

A push-type piston was designed for attachment to the Sierra Constant Friction Wrist and activation of both hand and hook through the axis of

* Snelson Orthopedic Service, Downey, California
** Sierra Engineering Company, Sierra Madre, California

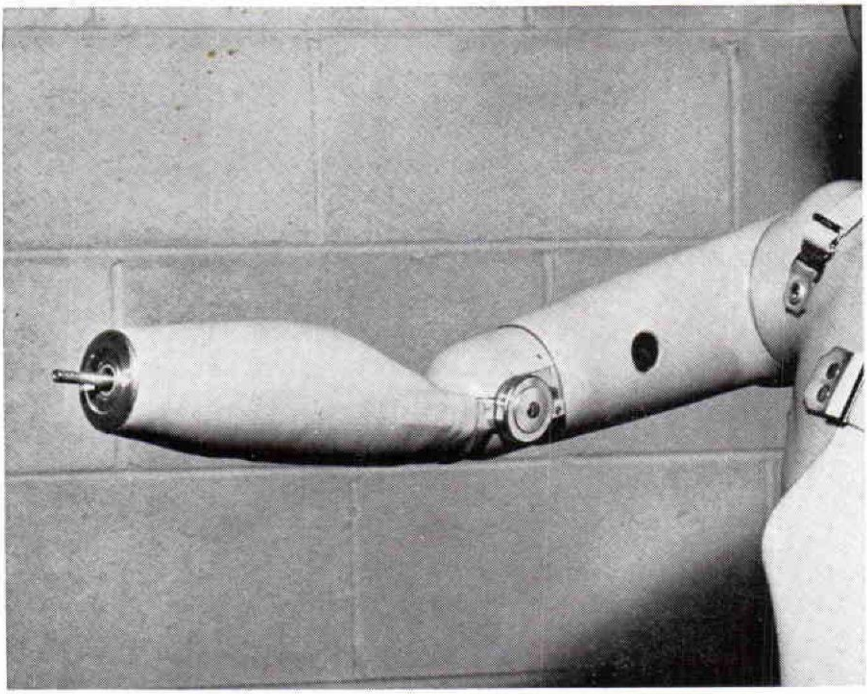


FIGURE 1

their attachment studs (Figure 1). This wrist proved satisfactory for location and alignment of the piston and adjustment of friction without affecting total piston stroke requirements.

A pull-type piston was designed to be attached to the turntable compression ring of the Sierra Elbow which proved to be satisfactory for the retention of adjustable turntable friction and freedom of rotation without affecting location or alignment of the piston.

The elbow was then modified by reversing its position relative to the arm (Figure 2), machining a new shaft with reoriented forearm attachment slots, and drilling a clearance hole in the plate and lock assembly for the piston rod to pass through.

A pin driven into the shaft was connected to the piston rod by means of a short roller chain with disconnect links at each end.

The elbow lock assembly was modified by substitution of a simple shaft and lever in place of the alternator type lever and cam system.

Both the elbow and wrist were designed to permit factory mounting and alignment of pistons to simplify final installation.

The APRL Hand and Hook were chosen for their adaptability to push activation, and then modified by substituting a simple spring loaded, push activated linkage system in place of the usual mechanisms and drilling the attachment studs to permit the piston rod insertion. Both hand and hook are connected to or removed from the wrist in the usual manner.

2. *Complete Prosthesis*

Conventional casting, measurement and fabrication techniques were used, substituting the modified components for those normally installed. The patient was then fitted and harnessed utilizing a conventional chest strap

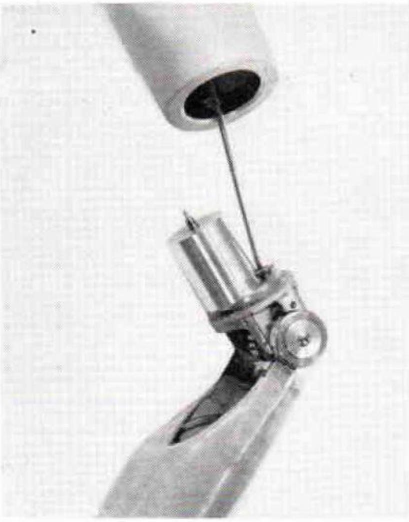


FIGURE 2

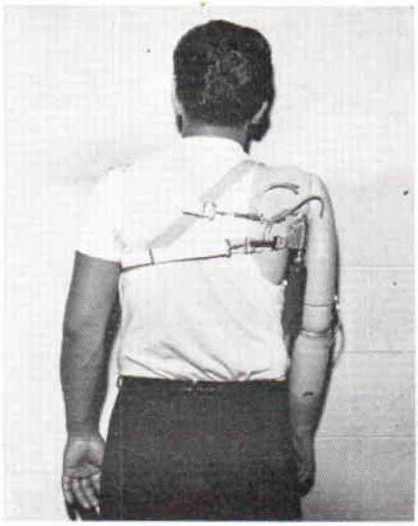


FIGURE 3

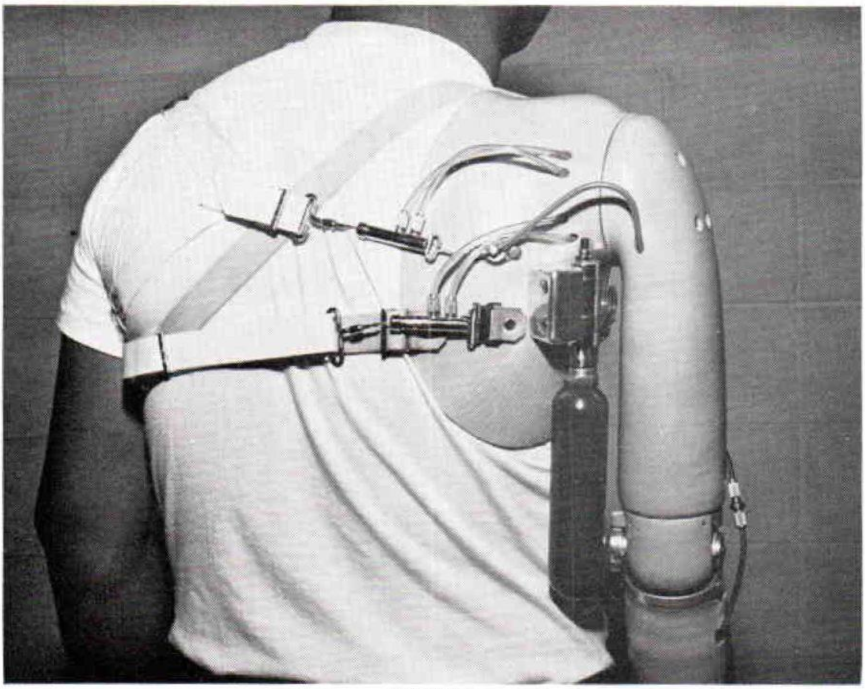


FIGURE 4

and axilla loop harness. The terminal device piston was connected to a standard OSCO slide valve activated by chest expansion (Figure 3). An additional OSCO slide valve was modified by installing a stronger return spring, then connected to the elbow piston and its distal end attached to the lock cable (Figure 4).

Both lock and piston are activated by a single force exerted through the axilla loop. When pull is applied to the valve the elbow lock bar is lifted before the slide valve can move to either the exhaust or fill positions. When tension is released the valve returns to the hold position and the lock bar drops.

A conventional tank and regulator were connected to the valves through a simple combination manifold and flow control block which permits individual adjustment of the rate of flow to both pistons, but does not affect exhaust flow. An additional flow control was installed on the elbow piston vent. The purpose of this system is to provide control over flexion without affecting extension. A Sierra round type shoulder bulkhead permits pneumatic lines to pass through the shoulder axis.

FIGURE 5

FIGURE 6

FIGURE 7

FIGURE 8

CONCLUSION

This prosthesis provides the amputee with a degree of function unobtainable with conventional prostheses. The power source is carbon dioxide. Line pressure is 90 psi. A force of 12 ounces applied to the terminal device control valve through less than 1/4 inch of excursion results in 10 pounds of pinch maximum at the hook finger tips, 15 pounds of pinch at the hand finger tips, and operation through their full ranges of motion.

A force of 2 pounds applied to the elbow control valve through less than 5/8 inch provides sufficient power to lift and move the forearm and hook or hand, plus 1-1/2 pounds through 135° of flexion coupled with automatic lock activation. Additional illustrations of this prosthesis are shown (Figures 5 through 8).

BAY STATE CLINIC TEAM—The Amputee Clinic Team of the Bay State Society for the Crippled and Handicapped, Inc., has been operating for twelve years under the direction of Dr. Hartson. Front row: Miss Nancy Whenman, O.T.R., Robert Hartson, M.D., Chief, Anthony J. Virgilio, Co-ordinator, and Mrs. Lois-Ann Garcia, R.P.T. Back row: Joseph Martino, C.P., Miss Dorothy Walton, Medical Secretary, Miss Brigitta Sorlie, R.P.T., William R. Rogers, C.P., and Theodore G. Williams, C.P., The Journal is indebted to Howard V. Mooney, Manager of the Boston Artificial Limb Co., for this picture.

A Clinical Appraisal of the Plastic Total Contact Above Knee Prosthesis

* GEORGE H. KOEPKE, M.D. and † JOSEPH P. GIACINTO, C.P.

Evaluation of fifty-one unselected above knee amputees for whom this prosthesis has been prescribed reveals satisfactory results. A brief description is given of a fitting technique and the reaction of the stump to total contact. The advantages of this socket over other above knee sockets are apparent from its beneficial effects on several stump disorders.

About ten years ago we began supporting the soft tissue of a stump with an improvised total contact socket which would furnish partial end bearing in above- and below-knee prostheses. Pads of felt, leather, rubber and plastic foam were inserted into the ends of the sockets to provide comfortable support. In 1958, the University of California in Berkeley published the first of a series of reports that have led to vast improvements in the fabrication, fitting and alignment of the patellar-tendon-bearing total-contact prosthesis. Our early clinical experiences with this prosthesis have been reported elsewhere.[1]

The plastic total-contact above-knee prosthesis fabricated by the University of Michigan Prosthetic Shop is similar to the prostheses described by the University of California research laboratory in Berkeley and by the Veteran's Administration Prosthetic Center in New York City.[2] A quadrilateral wooden proximal socket is designed from conventional stump measurements. This socket is about four inches long and is fitted in an adjustable casting stand (Figure 1). To insure initial flexion and adduction of the socket, the distal portion of the stump protruding from the wooden socket is wrapped with plaster in the ischial weight-bearing position (Figure 2). A plastic socket is subsequently fabricated from the wooden pattern and plaster cast (Figure 3). This technique is preferred to other casting methods: it provides total contact, optimal alignment and partial ischial weight bearing. The discrepancy in the dimensions of the socket gradually changes from values of minus 1/4 to 1¼ inches at the level of the ischial tuberosity, to plus ¼ to ½ inch at the end of a mid-thigh stump. Several methods of estimating end bearing have been tried. Practical clinical methods include placing a piece of clay or bouncing putty, comparable in size to a small pea, in the bottom of the socket. It will be flattened with end bearing. Or the examiner's small finger is inserted through the valve opening in the non-weight bearing position to gauge the pressure exerted between the stump and the socket when the amputee has put his weight on the prosthesis.

* Associate Professor of Physical Medicine and Rehabilitation;
† University of Michigan Medical Center Prosthetic Shop;
University of Michigan Medical Center, Ann Arbor, Michigan.

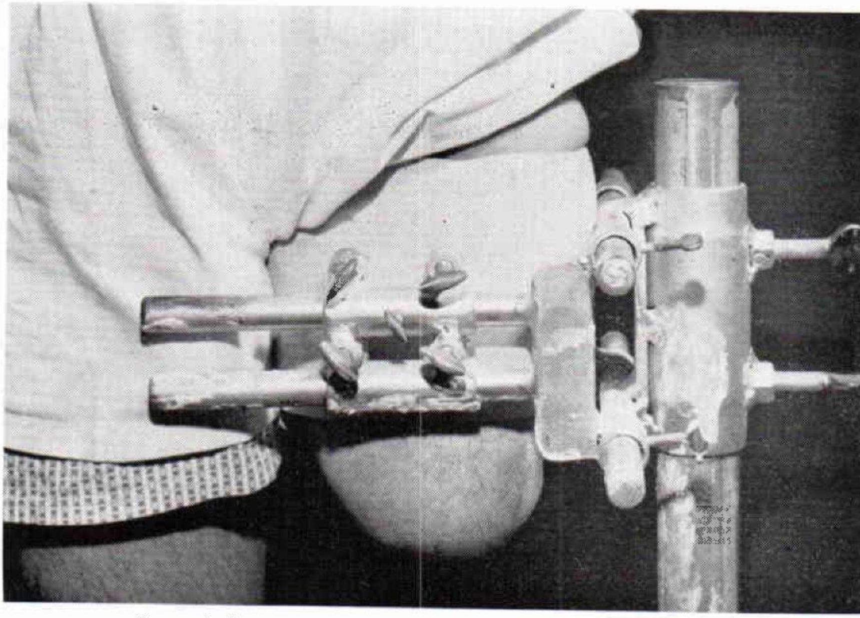


Figure 1. Proximal socket fitted in an adjustable casting stand.

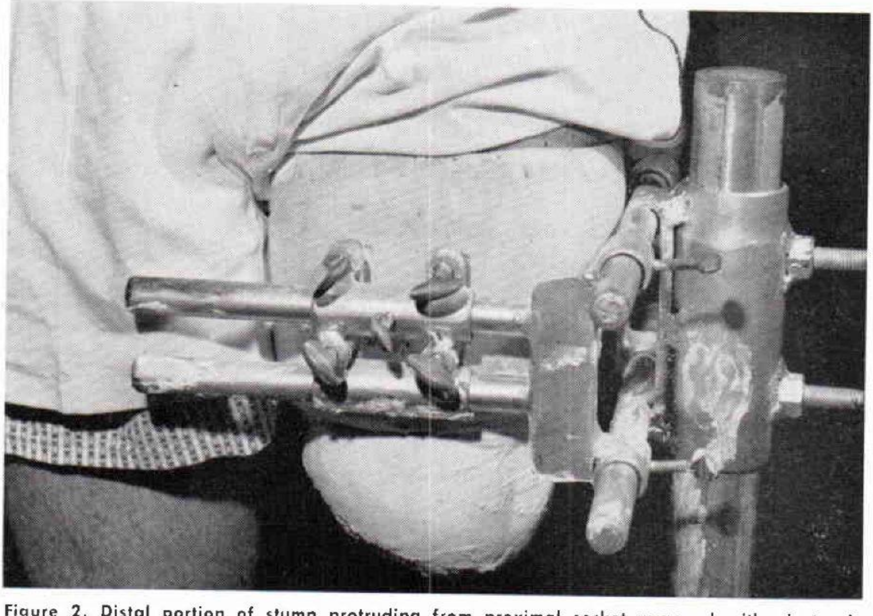


Figure 2. Distal portion of stump protruding from proximal socket wrapped with plaster in the ischial weight bearing position.

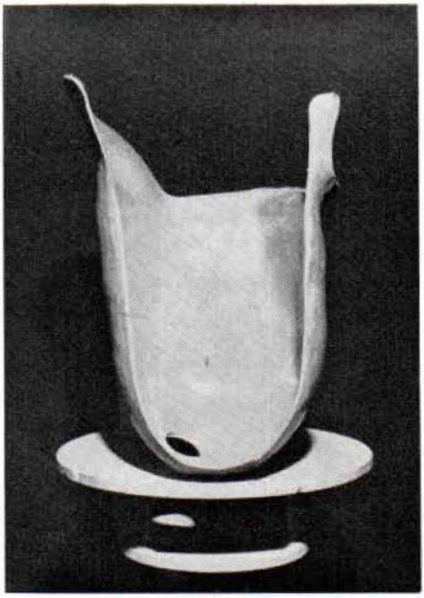


Figure 3. Unfinished plastic socket—split to demonstrate inner wall.

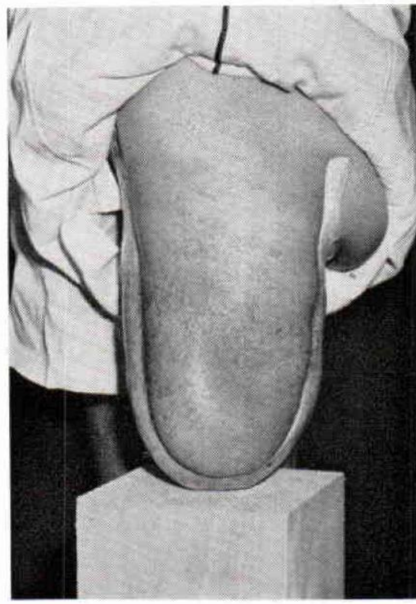


Figure 4. Socket is split to demonstrate relationship of total-contact socket and stump.

Since November 1960, the total-contact socket has been prescribed for 51 unselected above-knee amputees. Periodic evaluations have been made of all patients for at least three months following each fitting. Only one patient rejected the socket. He was accustomed to obsolete methods of fitting and suspension and, despite a tender bony stump, preferred a plug fitting socket. Those who had previously worn open end sockets preferred the total-contact socket; they had better control of the prosthesis and were more comfortable.

The committee on Prosthetic Research and Development of the National Academy of Sciences has reported that counter pressure on the end of a stump will promote circulation and lessen edema.[3] This clinical study supports their report. The total-contact socket is impressively effective in lessening chronic stump edema. It has also lessened fibroelastic diathesis, varicosities of the stump, and irritation about the ischial tuberosity.

The discrepancy between dimensions of socket and stump appear to be less critical if soft tissue is supported at the lower half of the stump. With such support, the tissue is displaced towards the upper half. Fewer adjustments are required to prevent the ischial tuberosity from slipping anteriorly over the brim of the ischial seat. The plastic total-contact socket seldom develops cracks, and the valve seal is easier to maintain than it is in wooden sockets. It would appear that spurs at the end of the femur do not occur more frequently in partial end bearing than in open-end sockets. A patient with a normal stump is seldom aware of end bearing, and the person with a moderately tender stump readily adapts to this socket. A tapered stump frequently takes on a more cylindrical shape after using the socket for a few months, and a bony stump may develop small asymptomatic bursae in response to partial end bearing. Nerve pressure syndromes of phantom sensation and phantom pain are less frequent, because pressures are more widely distributed than they are in open end sockets.

The additional step needed to fabricate the plastic total-contact above-knee prosthesis is justified by the numerous advantages over other above knee sockets.

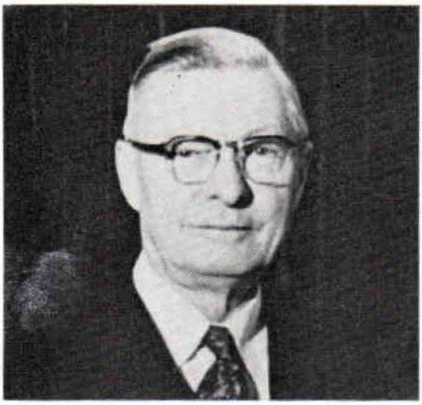
REFERENCES

1. Wolcott, L. W. and Koepke, G. H.: Arch. Phys. Med. and Rehab. Vol. 43: Sept. 1962.
2. Report: Jan., Feb., Mar., 1960. Biochemics Lab. Univ. Calif.—Berkeley, April 8, 1960. p. 2, 3, 4.
3. Annual Report of Activities of the Committee on Prosthetics Research and Development, National Academy of Sciences, July '61 to June '62.

In Memoriam

Frank Oliver Peterson

Frank Oliver Peterson, member of AOPA from Los Angeles, died suddenly September 28th at Los Angeles at the age of 81.



Mr. Peterson and his wife, Mrs. Ethel E. Peterson, had long been active in the affairs of the Association, dating back to their earlier connection with the Rowley Company. Mr. Peterson was a former Treasurer of the Association. Since his retirement to live in Los Angeles he had also served as the Treasurer of the Society of Orthotists and Prosthetists, and took an active interest in the affairs of Region IX of AOPA. Mrs. Peterson is well known for her many years as editor of the ALMA *Almanac*, published in the early 1940's.

MRS. RUTH BEITMAN

The *Journal* has learned with deep regret of the death in October of Mrs. Ruth Beitman, of Newark, New Jersey. Sincere sympathy is extended to her husband, Arthur A. Beitman, and to members of the family.

FREDERICK E. VULTEE, M.D.

Dr Frederick E. Vultee, Chairman, Dept. of Physical Medicine and Rehabilitation, Medical College of Virginia, Richmond, died suddenly after a heart attack on December 4, 1962.

His contribution to the prosthetic and orthotic field was an outstanding one, and his death is a severe loss to the profession and to his many friends.

A Memorial, by Dr. J. Warren Perry, OVR, will appear in the March 1963 *Journal*.

The Pick-Up Cane

BY CATHERINE KEANE

Nelson Orthopedic Co.
Pittsburgh, Pa.

I did not realize the tremendous value of the Pick-up Cane until I was confined to a wheelchair.

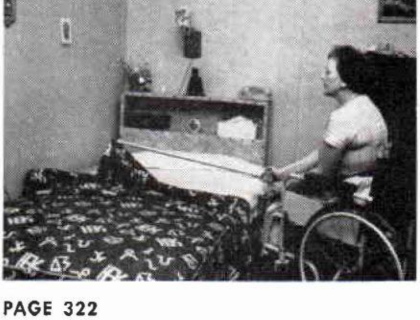
After several weeks of hospitalization with a fractured hip, my doctor permitted me to go home to a wheelchair. Since the bone was not healing too well, I could not walk or even stand on either leg. I live alone which meant I had to take care of myself and my apartment. Believe me, I could not have done it without the aid of Mr. Nelson's Pick-up Cane.

First of all, by grabbing the bed clothes with the pick-up cane, I was able to make my bed quite neatly. A hanger can be taken from and returned to a closet with the pick-up cane, as well as boxes from a top shelf or shoes from a deep shelf. This enabled me to dress and care for my clothes without assistance. I could take cups, dishes, pots, pans and groceries from a cupboard, pull blinds and draperies, turn light switches off and on; to mention nothing of the hundreds of articles which can be picked up from the floor or out-of-reach places. Cleaning was no problem, I placed a dust cloth in the hook, which locks when handle is released, and I can reach any place in the apartment to dust. By placing an SOS pad in the hook, any difficult scouring is quite easy. I found it possible to wash windows and hang clothes up to dry.

The original purpose of the Pick-up Cane is for the person who walks with a cane but has difficulty stooping to pick up something from the floor. The tip of the cane can be removed easily and left on the floor by lifting the hook control which is connected at the cane handle. An article as small as a dime and up to approximately five pounds can be picked up. The tip is replaced by guiding the cane into it with the hook closed but still extended. The patient goes on walking without the slightest change in his balanced position.

Since the Pick-up Cane has been such a wonderful aid to my rehabilitation I feel certain there are many handicapped persons who would like to know about it.

EDITOR'S NOTE: *The Pick-Up Cane, available from Nelson Orthopedic Co., is operated by a trigger which extends a gripping device from the cane tip. Release of the trigger holds any object firmly, or retracts the empty gripper into the cane. The cane is aluminum, with the mechanism located inside.*



Basic Principles of Lower Extremity Bracing*

ODON F. VON WERSSOWETZ, M.D., F.A.C.P.†

All ortheses, however skillfully constructed, are only auxiliary means in the treatment of neuromuscular dysfunctions and musculoskeletal disorders. It is important for the physician, before he selects and prescribes a brace, to make a correct diagnosis, then to carefully consider the indications that present themselves (1), and last, to have a good knowledge of the basic principles governing the fitting and alignment of such ortheses. He should also know the different parts available so that he can prescribe a satisfactory brace which can be worn successfully by the patient within his remaining functional capabilities (2). All braces need modifications, because no disability will remain static indefinitely in a living organism. Therefore, the physician should recheck each patient at certain intervals depending on the course and acuteness of the condition and order such modification individually. *The brace must be fitted and adjusted on the patient; otherwise it will never fit. It should never be ordered by mail or fitted only from a tracing. The orthesis selected should not be more extensive than the disability requires* (3). This means that it must be as light as possible, but strong enough to withstand the stress and torque of the body during weight bearing and locomotion and of any excessive and abnormal muscular activities, such as spasticity. It must fit accurately, be comfortable and be efficient. It must be prescribed intelligently and with forethought to its function and economy. It should be aligned accurately. The design selected should be the simplest that will accomplish the purpose and mission (4). Successful bracing can be obtained only in this way. It is obvious that the basic principles considered in this paper will also apply to various modifications or special devices which are often needed in certain cases to facilitate locomotion.

CHAPTER I. FOUNDATIONS

Ortheses for the lower extremity are composed of uprights and hinges attached to a foundation. This foundation can be a metal arch plate or a shoe.

METAL ARCH PLATE OR SANDAL FOUNDATION

In this type of foundation, the basic attachment is a metal arch support which is placed inside a shoe (fig. 1). The uprights of the brace are welded to this plate. It is hard to make a well-fitting metal plate because of the difficulty of controlling movements between the plate and the foot. This plate requires a larger shoe, in which it must be inserted. It is liable to cause pressure sores, therefore it cannot be used for patients with inadequate skin sensations. The advantage is that shoes can be readily changed. It is used very seldom.

SHOE FOUNDATION

Most of the lower extremity braces are built with the shoes as the foundation. It is, therefore, important to see that the shoe is fitted properly

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† 104 Interstate Building, Chattanooga 2, Tenn.

and so designed that it can be applied easily. The brace cannot be effective or achieve the purpose for which it has been prescribed unless the patient has a properly selected and comfortable shoe. High top shoes are generally used for children and in cases in which ankle support is needed. They are of special value for many cases in which there is tightness in the heel cords or spasticity in the triceps surae muscles, as in cerebral palsy. The Oxford type or a low quarter shoe can be used for other conditions. All shoes should be sturdy in construction, have adequate width and length and be comfortable; however, they should be snug enough to prevent the foot from assuming faulty positions. They should have an adequate steel shank. In certain cases in which edema or deformity of the foot is a problem, or some cases of spasticity, a specially constructed shoe with laces in front to the toes or occasionally front and back is of considerable advantage. This facilitates application of the brace to the leg and provides adjustment for swelling or deformity.

The female patient often feels inconvenienced because the corrective shoe is not of the latest fashionable design. However, our main consideration must be given to the effectiveness and comfort of the brace. The comfort and quality of the shoe are fundamental to a successful fitting. In the female patient, it may be necessary to use a higher heel than in the male patient. As a general rule, such a heel should not be more than 1¼ inches high (5).

To permit a good weight-bearing functional foot (3), a shoe with the brace attached should:

1. *Allow the body weight to be distributed evenly over the plantar surface of the foot.* The weight of the body should fall through the center of a triangle made by the os calcis, the heads of the first and the fifth metatarsal bones. The orthesis must maintain the normal weight-bearing axis from the tibia down through the talus and out between the first and second metatarsal bones. It should provide a maximum amount of push-off during locomotion, with adequate balance. The balance and stability in the lower extremity is controlled by the forefoot through the muscles which act principally on the first and fifth metatarsals.

2. *It should provide a foot aligned with the ankle joint.* The alignment must conform to the patient's axis of the foot in relation to the long axis of the tibia. It should maintain properly aligned supination of the foot, otherwise, it may cause serious complications. The heel should be well positioned in the lateral plane, thus preventing valgus or varus of the ankle. The balance of the shoe should not be disturbed by the brace. If necessary, wedges should be used to obtain a three-point weight-bearing plantar surface and a good weight-bearing axis (6, 7). However, when using wedges it is necessary to evaluate not only the degree of correction they provide, but also the amount of unbalancing they create in the shoe. It is obvious that wedging of one heel of the shoe will cause the shank and sole to slant at a different angle than originally provided, thus changing the alignment of the shoe. This may cause severe disabilities and complications. It is often better to use wedges inside the shoe. These will correct the disability without unbalancing the weight-bearing surface of the shoe. If wedges are used on the outside, they should be placed between the brace attachment and the sole. Otherwise, the whole brace will become maligned.

3. *It should provide good lateral stability to the foot in spite of the muscle imbalance present.* This can be obtained only on weight bearing because it is almost impossible to control a dynamic force of imbalanced muscles by a static force of the shoe or brace.

4. *It should retain the optimal amount of motion in the ankle, considering the necessary stability that must be maintained.* The optimal degree of motion in the ankle is achieved when, on ambulation, the foot is well aligned, showing no abnormal deviations. It is important to allow as much motion as possible because in this way better gait and push-off are obtained, which provides a more normal appearance. Also, in most cases the body balance is better preserved by permitting more motion in the ankle.

Metal Foot Plate

The basic part of all attachments of braces to shoes is a metal foot plate which is secured to the outer sole of the shoe with the heel removed. This basic foot plate is secured by three to five rivets, depending on the type of attachment. At least one of the rivets must go through the steel shank of the shoe to provide proper anchorage and good stability. The basic foot plate should be placed horizontally to the walking surface of the heel. When fastening the foot plate to the shoe by rivets, care should be taken not to twist the steel shank, as this will cause malalignment of the shoe. This will prevent the shoe from having proper contact with the walking surface. The basic foot plate must be so fixed to the shoe as to provide proper alignment of the brace and normal physiologic toe-out of the patient. The amount of toe-out varies in each person, and depends on the amount of torsion in the tibia or femur or both.

In the femur, the degree of torsion is determined by the angle formed by the axes of the knee joint and the femoral neck. The axis of the knee joint is placed approximately through the femoral condyles and is usually maintained during locomotion in the longitudinal and horizontal planes, even in the presence of severe deformities around the knee. The torsion angle of the femur varies from 37 degrees anterior (antiversion) to about 25 degrees posterior, with an average torsion of 14 degree of antiversion of the neck of the femur. The axis of the hip joint bears no constant relationship to the direction of the femoral neck.

The longitudinal axis of the ankle joint is almost always laterally rotated in relation to that of the knee. In the horizontal plane, this axis does not meet the tibial shaft at a right angle but passes obliquely and medially upwards. This causes the lateral malleolus to lie $\frac{1}{4}$ to $\frac{1}{2}$ inch inferior and posterior to the medial one. Because of this relationship, the resting foot assumes a physiologic position of plantar flexion and some inversion.

The position of the foot during walking is not only determined by the amount of torsion or declination angles of the tibia and femur, but is also influenced in the absence of bone and joint involvement by hereditary factors and age. In the very young child, there may be an internal torsion of 10 degrees. As the child grows up, this internal torsion changes to external torsion, which may reach 25 degrees at puberty. However the average toe-out is between 8 and 12 degrees. Therefore most braces are provided with a toe-out of about 10 degrees unless contra-indicated by some malalignment of the bodily segments. The toe-out position compensates to some degree for the normal external rotation of the foot and leg on the femur during locomotion. If the brace is attached to the shoe without regard to the amount of torsion present, the patient will usually have a functional varus and will walk with a varus foot, that it, he will walk on the outer border of the shoe and his gait will be unstable. In addition, the extremity will be internally rotated in the brace and the patella will no longer be in the center of the brace. The medial condyle will be located posterior to the mechanical axis of the brace.

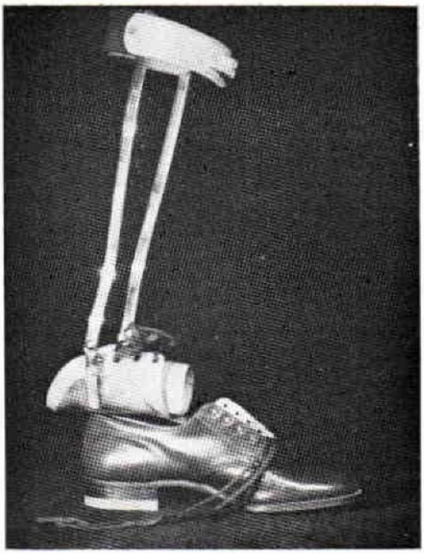

Figure 1. Sandal Foundation.

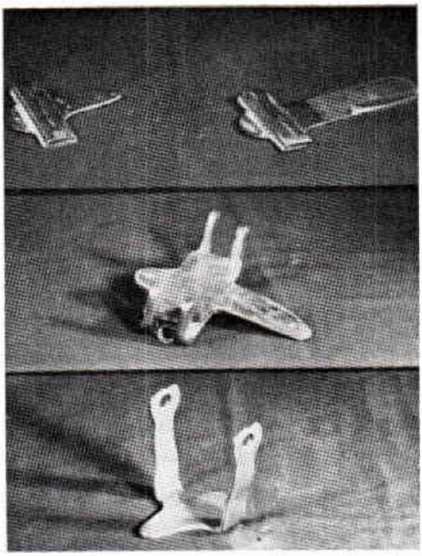

Figure 2. Shoe attachments. Top, rectangular socket; Center, round socket with double stops; Bottom, fixed stirrup.

TYPES OF BRACE ATTACHMENTS TO THE SHOE

Basically, there are three ways of attaching a brace to a shoe. They are the round channel or socket, the flat or rectangular channel or socket, and fixed stirrup (fig. 2).

Round Channel or Socket

The round channel or socket attachment consists of a cylindrical tube which is welded to the basic foot plate. When necessary, stops are attached to this plate. The uprights or points, as they are sometimes called, are round rods bent at a right angle for slipping into these round channels.

Flat or Rectangular Channel or Socket

The flat or rectangular channel or socket, also called split stirrup, is again composed of a basic foot plate aligned to provide the proper toe-out. A rectangular channel is welded to this plate in the same way as the round channel attachment. The only difference is that the points or uprights must be flat to fit this channel. There is no motion in this channel. There is considerable stress in this area. The motion is provided by an ankle joint, suitably located.

Both the round and rectangular channels allow the braces to be easily removed and provide for an interchange of shoes. This is a desired feature because each patient should have at least two pairs of shoes so that he can wear them alternately. The average person does not wear one pair of shoes every day for 4 to 6 months; this does not provide for proper hygiene of the feet. Detachable braces also allow the patient to obtain new shoes and have the channels placed in them without going without his braces. This is a great advantage to a patient who lives far away from a brace shop.

Fixed Stirrup

The stirrup type of attachment is a fixed way of anchoring the brace to the shoe. In this method, the basic foot plate has solidly attached metal side arms on each side (8). These side arms of the stirrup extend from the basic metal plate at a right angle. However, in rare cases they may extend at approximately 50 to 60 degrees from the vertical, being placed more distally. This allows the basic metal plate to be attached further forward on the shoe, thus giving more support to the arch of the shoe. The conventional stirrup attachment is stable and does not provide for interchangeable shoes; however, various modifications have been devised to make it removable.

CHAPTER II. HINGES

In the brace for the lower extremity, hinges may be used at the ankle, the knee and the hip. It is not possible to duplicate, mechanically, the exact action of any anatomical joint because each and every anatomical joint operates in at least two planes and shows translatory and rotary components on movement. Therefore, an important essential for satisfactory fitting of the brace is the successful placement of the mechanical hinges as nearly accurate as possible to the median axis of the anatomical joints. Such alignment will allow the brace to provide proper and adequate support with the least interference with normal function and activity of the extremity.

It also must be remembered that every hinge is a mechanical device and must obey the laws of mechanics. It can operate only in planes provided by its construction. The majority of hinges have only one plane of operation. In addition, it is absolutely necessary to the proper working of any mechanical hinge, whether ankle, knee or hip, that the gliding surfaces of the pair be in the same parallel plane, one with the other. The component parts of each hinge should be aligned in the same longitudinal axis (fig. 3); otherwise, there will be friction, limitation of motion and mechanical failure. There should be no attempt, therefore, to force a hinge in any way to conform to the extremity; otherwise bizarre patterns of locomotion may occur. Hinges may be of different construction. The box joint is a sturdier hinge than the lap joint. In certain cases *e.g.*, cerebral palsy, ball-bearing hinges can be used.

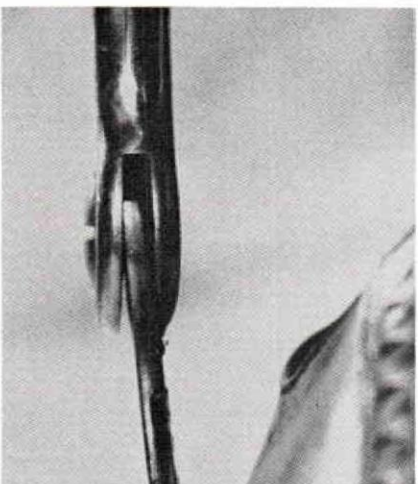

Figure 3. Malaligned ankle hinge showing friction of sliding surfaces and stress of the component parts.

Figure 4. Round caliper brace with double stops.

HINGES AT THE FOOT

A lower extremity brace may articulate at the foot, either by a heel or round caliper hinge or an ankle hinge which is often called incorrectly a stirrup hinge. Because of the placement of the hinges, either method has certain advantages and disadvantages.

The Heel or Round Caliper

The heel or round caliper permits motion in the heel of the shoe. This method readily allows for a change of shoes (fig. 4). It is easy to fit and to adjust. Also, it is inexpensive to maintain. The disadvantages are caused by a malalignment of the hinge to the anatomical joint. The hinge is located in the heel of the shoe, which causes its mechanical axis to differ from the anatomical axis of the ankle joint. Since the mechanical and the anatomical axes do not correspond and do not lie in the same plane, the arcs of motion that are described around these pivots will not be similar, but will tend to be divergent. This incongruity of motion will tend to create undesirable stresses, because during locomotion the upright bars move backward and forward with each step, and may cause compression of the calf band. This lack of synchronized movement between the extremity and the brace will tend to cause in the long leg brace an upward movement of the thigh uprights which will thrust the upper thigh band against the gluteal fold on weight bearing and a downward drag during the swinging phase. In the short leg brace, the calf band and cuff may ride up and down. This undesirable movement may cause chafing and irritation of the skin in the areas of contact. This is particularly dangerous in the patient with deficient cutaneous sensation, for example, the paraplegic, quadriplegic or brain-damaged patient (fig. 5).

Since the shoe is rotating around a lower axis and the foot around a higher pivot, the foot has a tendency to slip during locomotion. On plantar flexion the foot moves forward and may cause cramping of the toes. On dorsiflexion, it moves backward, forcing the heel to slip out of the shoe. This tendency for slipping of the heel may interfere with complete immobilization of the knee with a knee lock. However, in most braces, the calf band

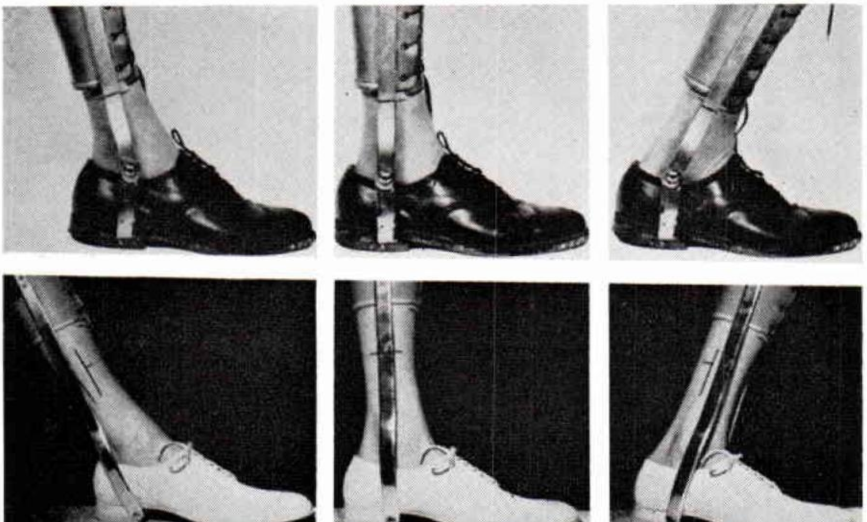

Figure 5. Comparison of upright movement between a heel caliper brace and an ankle joint brace. (From von Werssowetz (9), courtesy of Archives of Physical Medicine)

is not fitted tightly; therefore, some slight motion is present which permits this incongruity of axes to allow some vertical displacement of the uprights during various phases of gait without too much movement occurring between the foot and the shoe. A brace with a caliper hinge, as any detachable brace, has a tendency to be more easily malaligned below the calf band because it is somewhat distorted with each stretch for changing shoes.

Ankle Hinge

The ankle hinge or so-called stirrup hinge is placed on the level with the anatomical ankle joint. This vertical placement is important when functional motion in the ankle is to be permitted, as it appears to be sounder mechanically and physiologically. If the mechanical joint is placed correctly there will be very little, if any, displacement of the upright and of the foot on motion.

The mechanical ankle joint should approximate as closely as possible the anatomical axis of the ankle. The axis of the mechanical joint should be placed at about ½ to ¼ inches above the tip of the lateral malleolus and should bisect the ankle joint, coming out above the level of the tip of the medial malleolus. There are some clinicians who consider the anatomical axis to be placed about ½ inch lower than stated above and who feel that it lies at the apex of the fibular malleolus. Theoretically, for best results, the axis of the anatomical joint and the hinge should be the same. Practically, however, this is impossible to obtain because the axis of the anatomical ankle joint runs obliquely and diagonally between the malleoli, from posteroinferior surface on the lateral side to the anterosuperior surface on the medial aspect of the foot. Most bracemakers today are aligning the hinge slightly diagonally to the shoe, thus providing for the physiologic toe-out.

Free Motion Hinges at the Ankle

Both the heel and the ankle hinges may be free, thus permitting motion. Free hinges are used when muscles of the foot and the ankle are of good functional strength and there is a necessity to: a) correct imbalance of the foot and prevent deformities; b) provide lateral stability of the ankle; c) give support to the knee. Imbalance of the foot may be caused by unequal pull of the muscles, abnormal attachment of the tendons, contractures or elongation of the periarticular tissues, various osseous anaomalies and persistent assumption of faulty posture. These will have a tendency to cause deviation in the normal alignment and when permitted to continue, will eventually cause structural deformities. Involvement of these structures at the ankle often will result in diminished lateral stability and will require appropriate support.

In the athetoid child (10) the joints must move easily and freely, with little or no resistance, therefore ball-bearing free joints are often used. Free hinges at the ankle must be used when there is a necessity to provide support for the knee which because of weakness may require locks, or may be showing deformities such as knock knee or back knee.

Spring Hinges at the Ankle

The ankle hinges can be made dynamic by addition of springs of appropriate tension to correct the imbalance of the muscles or to prevent or release tightness and contractures at the ankle (5, 11, 12). These springs may be attached to the upright bars or may be incorporated into the hinge mechanism, which makes them more versatile and easier to operate. Springs can be used to help either dorsiflexion or plantar flexion. Only springs which are easily adjusted should be used. The tension of the springs should be such that the foot is positioned at a right angle or in slight dorsiflexion when the foot is at rest and non-weight bearing.

Figure 6. Adult dual action spring-controlled ankle hinges attached by a rectangular socket.

When the foot shows weakness in both dorsiflexors and plantar flexors, even with muscle imbalance present, dual action springs may be used (fig. 6). These joints were designed by Unger and Hanicke (13). The principle involved is the use of two springs acting in opposite directions, each spring being adjusted to counter-balance the muscle imbalance present and the tension of the opposite spring. The use of dual action springs can provide a balance at the ankle which approximates, to a much greater degree, the natural action of the foot. Dual action, spring-controlled ankle hinges are excellent for most patients with neuromuscular involvement, such as poliomyelitis, polyneuronitis, muscular dystrophies and other neurologic disorders, as well as in post- tscaumatic paraplegias and quadriplegias. Some have been successfully used in spastic cerebral palsy. The brace with such a hinge provides good motion and helps greatly in maintaining standing balance.

At present, dual action spring hinges come only in adult sizes. These bring the foot up to a right angle at rest from either plantar or dorsiflexion. For children, two single action spring joints can be used, one on each upright but acting in opposite directions against each other, that is, one placed in the conventional manner, the other in a reversed position (fig. 7). Theoretically, there may be some question whether a dual action spring ankle joint does not create a tendency to over-stretch weak muscles. This, at first, may seem to be a logical assumption; however, in a flail or severely involved foot there is equal danger of producing tightness and contractures which could result in structural deformities. With the dual action spring hinge, it is possible to regulate the tension or the degree of motion in each direction so that a balanced movement is obtained. If the allotted range is held well within the limits of the average functional range of motion of the normal foot, then there can be no undue stretching of any muscle because this range is physiologic and is performed normally and constantly by these muscles. Permitting motion to be within the physiologic limits of dorsiflexion and plantar flexion helps to prevent and eliminate tendencies toward the development of contractures. Normally, the allotted range is 15 to 20 degrees of plantar flexion and 20 to 25 degrees of dorsiflexion.

The main disadvantage of all spring joints is casting; they are often hard to shape adequately in and about the ankle for a close fit. Another disadvantage of these hinges is a possibility of getting sand, dirt, or lint or other foreign matter into the castings of these joints. This will interfere with their proper action.

Limited Motion Hinges at the Ankle

When limited motion in the ankle is desired, stops may be used. It must be remembered that stops are static and function only at one phase of the step. They do not provide positive action. Stops can be placed either on the heel caliper or the ankle hinge. Stops may even be provided in hinges with springs. The correct selection of stops depends on present muscular imbalance and prospective functional activity. Muscle imbalance will determine the type of stop used. There are three types of stops: the posterior, the anterior and the double.

The posterior stop is used when the dorsiflexors of the foot are weak and the patient has an equinus or a dropfoot deformity. The stop should allow no more than 5 to 10 degrees of plantar motion. The patient will have to elevate the involved extremity a little bit higher to clear the floor, or otherwise he will drag his toes. There are various methods to provide such limited motion.

The anterior stop is used when the plantar flexors are weak. Here, the extent of permitted motion varies, depending on a number of factors, and usually is no more than 10 to 15 degrees. Anterior stops will not prevent or materially minimize the development of calcaneal deformity, especially

Figure 7. Child dual action spring-controlled ankle hinges.

if it is due to muscle imalance where there are weak triceps surae and strong short plantar muscles of the foot. Anterior stops permitting a range of 20 degrees may be used occasionally to control the extent of hip motion, thus providing stability when there is an isolated involvement of the hip muscles, particularly the extensors, even when there is poor strength in the trunk. These are used in selected patients with spinal cord injuries.

The double stop may be used in a flail foot or one with limited motion in flexion and extension. The only logical use for such a brace with double stops is in a few isolated cases in which the patient has completely flail lower extremities and a good sense of balance. In such cases, a brace with double stops may permit a patient with such severe disability to use a shuffle or a swing-to gait by stabilizing the lower extremities. Such a gait is not very practical and is never independent, although it may permit the patient easier transference from wheelchair to bed, and other activities under supervision of an attendant.

Stops and Functional Activity

In general, stops interfere with locomotion and markedly hinder the patient when going up and down a hill or a ramp, because they do not permit the body weight to assume a proper relation to the base of support. Anterior stops, particularly, should be avoided because they severely interfere with getting into and out of a sitting position and with walking with the hips properly tucked under, that is, in slight hyperextension, which most severely involved patients must do with crutches and braces. An anterior stop also forces the patient to use excessively the metatarsophalangeal joints and causes him to walk on the ball of the foot. This often causes the shoe to break down in the sole where the steel shank ends. As the result of this distal shift of the foot activity, the patient usually tends to compensate by pivoting on the heel when walking.

It is obvious that a thorough evaluation of the patient's general condition, strength, balance awareness, stability, and functional abilities and capacities is necessary before a stop is prescribed. Often stops can be used to advantage with spring hinges to limit excessive motion caused by the overactivity of some muscles.

The Advantages of Dual Action Hinges

The dual action hinges can be used to provide any desired effect at the ankle. That is: a) a free joint by removing both springs; b) a spring assistive joint by using either one spring in a given direction or both springs; c) a limited joint by removing one or both springs and substituting them by rods of appropriate length, which will act as stops. It is obvious that this is a great advantage as it permits an accurate adjustment of the degree of motion at any time without any guess work. It also allows easy change from one type of assist to another as the condition requires, without a costly reconstruction of the brace.

HINGES AT THE KNEE

The artificial hinges should be aligned perpendicular to their axis and be so positioned that they are at the optimal level from the ground. Usually the medial hinge is slightly lower than the lateral one. They should also be parallel to one another. It must be remembered that artificial joints have only motion in one plane, rotating about a fixed point, and they cannot imitate the normal motion of the knee which includes rotation and sliding movement.

There are certain factors that must be considered in selecting an artificial knee hinge.

1. The hinge should not be bulky. This is especially important when bilateral braces are required because this may cause tripping of the patient, who then will walk with a broad base.

2. The hinge should be able to stand stress and strain without frequent breakdown.

3. All hinges should have stops to prevent hyperextension unless disability requires differently (14).

4. The hinge should have a dependable lock, if indicated. A single knee lock may be used in neuromuscular disorders which are manifested by paralysis and weakness of the muscles. They should be placed so that the patient may have easy access to them, that is, depending on the disability of the upper extremities and the ability of the patient to manipulate them independently. They may be placed either on the lateral or on the medial sides (as in hemiplegics). In patients who have no atrophy, or are too heavy, or both, a double lock should be used because a single lock imposes too great a stress on the hinges. To increase the stability, a knee pad or strap must be used.

5. The hinge should not have excessive or sharp projections of the lower bars, as they will damage clothing (15).

The artificial knee hinge should be placed in the median axis of the knee articulation (16). This takes place approximately through the femoral condyles and not through the joint space; therefore, to secure a properly functioning brace, it is necessary to place the artificial hinges opposite the mid-point of the femoral condyles. The best method of determining this point in a person of average weight is to identify the prominences where the collateral ligaments are attached to the femur (fig. 8). If the location is chosen correctly, there will be little, if any, motion in this spot when a

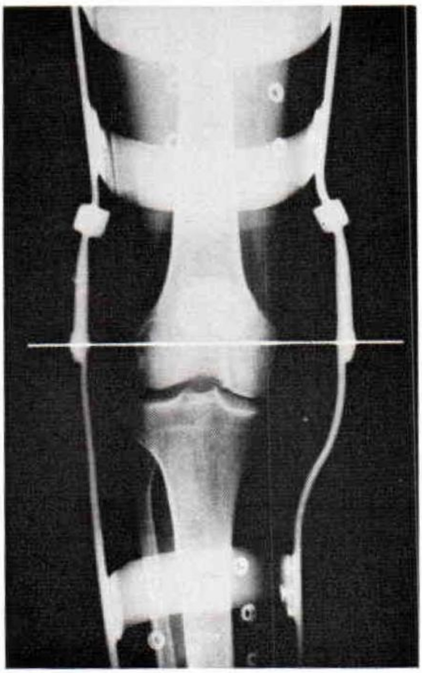

Figure 8. X-ray of knee showing alignment of the hinges. (From von Wersswetz (9), courtesy of Archives of Physical Medicine)

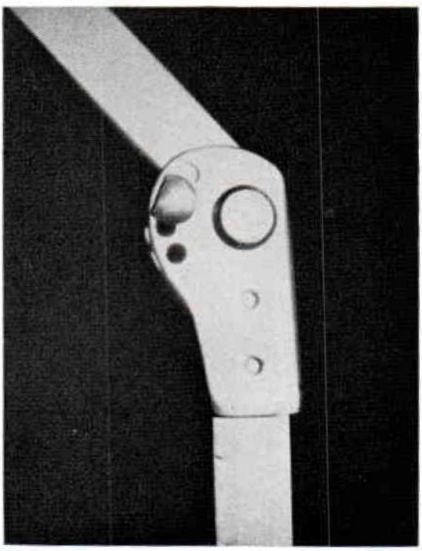

Figure 9. Dial control knee hinge.

patient flexes or extends the knee. It is important to place this location accurately, because, otherwise, the brace will interfere with the locomotion or will be uncomfortable in a sitting position.

a. If the hinges are placed too high, they will interfere with flexion of the knee, and the uprights will be forced upward causing the lower thigh band to press unduly into the posterior aspects of the thigh.

b. If the hinges are placed too low, then the thigh band will be pulled away from the posterior aspects of the thigh, and the calf band will have a tendency to press into the calf muscles. The brace will have a tendency to move up and down on flexion and extension of the knee.

c. If the hinges are placed too far forward, they will cause pressure on the calf muscles by the band and will pull down the uprights. The hinges will protrude forward in the sitting position. This can be corrected by making the bands more shallow.

d. When the hinges are placed too far back, they will have a tendency to create excessive pressure over the anterior cuffs, or knee pads. This can be corrected by providing deeper bands.

Knee hinges may be free, limited or locked.

Free Knee Hinges

Free hinges are used when the muscle strength is sufficient for functional range of motion and is sufficient to stabilize the knee adequately for a short period of time, but insufficient for longer functional locomotion, of if there is a tendency toward deformities like genu recurvatum or genu valgum, or if there is instability in the knee. It is used also to minimize undesirable involuntary or incoordinated movements caused by muscle imbalance, such as occurs in cerebral palsy. Free hinges may be single or double. The double hinges have been used to facilitate motion and approximate it to the normal gliding action of the knee. They seem to provide more comfort to some selected patients. However, there are certain disadvantages, of which the bulk and the difficulty in gaining a synchronized movement of the joints are most important. Ball-bearing free knee hinges are often used in certain patients with cerebral palsy (9).

Limited Motion Knee Hinges

The limitation may be flexion or extension. Limited flexion motion knee hinges are used when there is a necessity to protect the knee and its adjacent structures from excessive stress, e.g., after tendon transfers or other operative conditions. In such cases, the knee is allowed full extension but the flexion is limited to prevent buckling. This limited flexion motion hinge is ofted called a dial-controlled knee (fig. 9). The hinge consists of a pin going through a dial which has an opening at various degrees of motion so that the range can be adjusted to the patient's needs. As strength and stability of the knee increases, the range of motion is also increased.

A limited extension motion knee hinge may be used in a large group of patients whose disabilities or progress of recovery is such that lock hinges are too restricting, yet free hinges are too unstable. Such hinges (fig. 10) are called off-set knee hinges (17, 18). The basic principle of an off-set hinge is to have its axis behind the load line. This arrangement will permit stabilization of the joint on weight bearing and preserve free range of motion. Stabilization is secured by a stop on each hinge which controls the amount of hyperextension. This stop can be adjusted to meet the needs of the individual. It is not necessary to provide more than 5 degrees of hyperextension. Usually 2 or 3 degrees will suffice. These joints can be used successfully at the knee as well as the hip. They can be used successfully in monoplegia, hemiplegia, paraplegia, as caused by such diseases as poliomyelitis, cerebrovascular accidents and cord injuries (19).

Locked Knee Hinges

Locked hinges at the knee are used when there is:

1. Lack of normal extension or stability, or both, of the knee on weight bearing because of: a) weakness or paralysis of knee extensors (primarily quadriceps), especially when associated with normal or spastic knee flexors; b) weakness or paralysis of knee flexors (hamstring) causing severe genu recurvatum; c) weakness and paralysis of both flexors and extensors of the knee.

2. Interference with normal extension of the knee because of short heel cord (gastrocnemius tightness).

The locks selected should be simple and sturdy. There are a number of different knee locks to stabilize the knee. It has been stated that locks should be used on both the lateral and medial uprights to prevent torsion and distortion of the brace. These complications may occur in heavy, stocky or obese individuals, who are muscularly active, as is found in some post-traumatic or other conditions of the lower extremity requiring bracing.

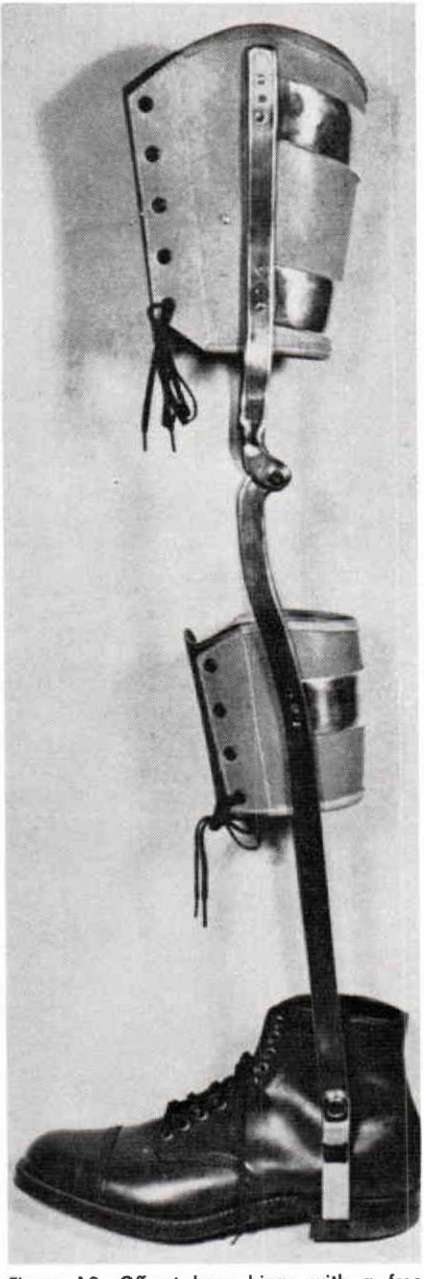

Figure 10. Off-set knee hinge with a free ankle hinge in a supportive brace used in post-traumatic conditions.

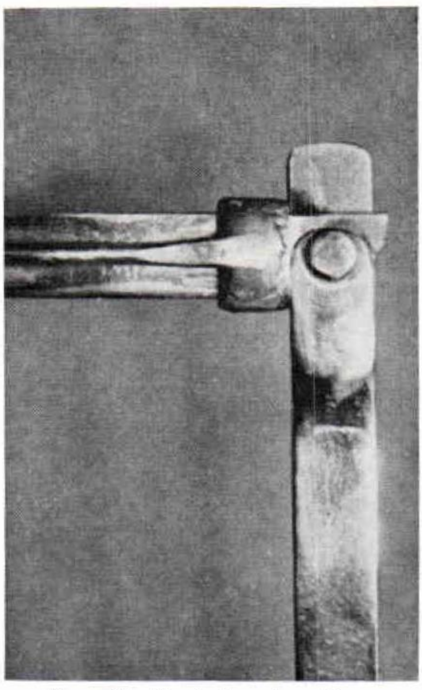

Figure 11. Ring lock on knee hinge.

In most neuromuscular disorders characterized by muscle weakness or paralysis there is a minimal degree of torsion of the brace; therefore single locks are used because patients can manage them more easily, especially if they have to use bilateral braces and crutches. Such patients may have difficulty in maintaining balance, and certainly the unlocking of four locks while holding on to two crutches is a difficult and almost impossible procedure. These patients usually weigh below average, therefore single locks are usually sufficient to provide a soundly locked and stable knee.

There are four basic types of locks used: 1) the ring lock (slip or drop lock); 2) the slot lock (tongue and groove or plunger lock); 3) the pin lock; 4) the bail lock. The first three locks are usually only on one upright; however, they may be used on both. The bail lock always locks both uprights. As a general rule, the single locks are put on the lateral uprights, although this placement depends on the muscle involvement of the upper extremities. It is obvious that it would be easier for a hemiplegic patient to manage a knee lock, if this was necessary, placed on the medial band than on the lateral band.

The ring lock is the most popular lock because it is easily made and is quite sturdy (fig. 11). It is also called a drop lock or slip lock. The lock is composed of a simple ring which rides freely along the upper bar and slips or drops over a projection of the lower upright. This projection is an objectionable feature of this lock because it causes damage to the clothing. This is especially true when the projections are sharp and pointed. Such a projection can cause severe injury to the wearer. This objection has been remedied in England by their ring lock box hinge made so that it has the pivot screw fitted eccentrically. This keeps the sharp projection of the lower upright below the brim of the rounded part of the upper part of the box hinge (15).

The slot lock has been known, also, as the tongue and groove or plunger type. The one that we use (3) has been modified by Witt (fig. 12) and is far superior to the others in its locking ability. The lower upright has a slot in the upper part and a ring is dropped into this to lock it. The ring has one wedge-shaped side which secures the lock tightly. This wedging of one side is most important in providing good stability to this lock. This is one of the best locks available at the present time, and it appears to be quite secure.

The pin lock or McCrae lock (fig. 13) basically consists of a pin which inserts through an opening in both lower and upper uprights, thus engaging them and locking the brace at the knee. For convenience, the pin is attached to an extension arm activated by a spring, thus causing the lock to become automatically fixed on extension. Manipulation of this lever unlocks the brace. This lock should be used only for patients of less than 130 pounds in weight. It should not be used for patients who are heavy or are too active, because the pin which forms the lock may shear off. This lock is not very destructive to the clothing.

Spring Extension Handles for Locks

The three knee locks described above can be made to close automatically on extension by adding to them spring extension handles. In addition, these handles facilitate the opening of these locks in patients who do not have too good balance awareness or have their hands occupied by crutches or canes. These patients cannot bend forward to accomplish the unlocking of braces easily. With the extension handle, they do not have to bend and usually can open the lock more easily. The locking force is provided by a helical compression spring which exerts a constant load force on the

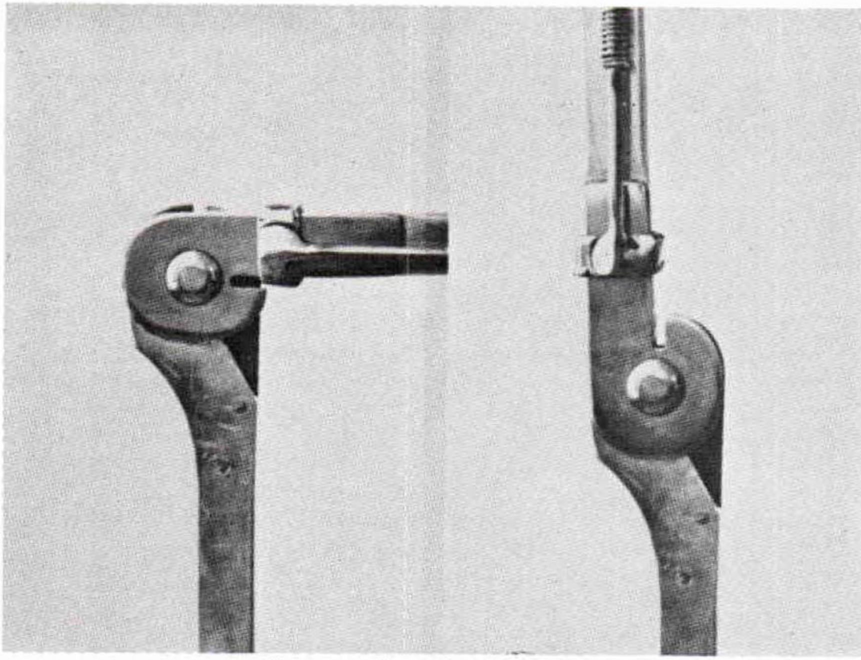

Figure 12. Slot lock on knee hinge.

locking device, forcing it to be constantly engaged when in appropriate position, that is, when the brace is in extension. The lock is released by means of a steel rod or a cable which passes axially through the spring from the locking device to the release extension handle located on the upright at a convenient level for the given patient.

There are several types of release mechanisms used to unlock the braces. The selection of the proper type is very important and depends on the muscular power, dexterity and ability of the hand and arm of the patient.

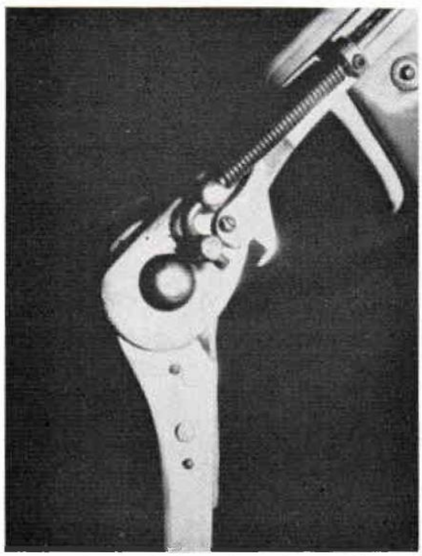

Figure 13. Pin lock on knee hinge. The one illustrated has a catch to permit free knee joint action when desired.

1. The pull method extension handle is used in the ring and slot type of knee lock. It is successful only when the patient has good power in flexion of the elbow, and a satisfactory grip.

2. The rotation method is used primarily in the pin lock and is indicated when the patient lacks flexor power in the elbow but is able to internally rotate the shoulder. The pin lock is often used selectively for women because it is easier to operate through clothing and is less embarrassing than pulling upward on the dress.

3. The squeeze method (fig. 14) is a cable release method and is used

in some patients in whom the muscular power for elbow flexion or shoulder rotation is poor or non-existent. In such cases the squeeze method of lock opening may be tried if the patient has adequate power in his grasp. This method manages to open the ring and slot locks. This method is less secure than the others, especially for a patient walking on crutches, as the lock can be released accidentally by striking it against the crutches.

4. On the trip method the lock is released by a trip mechanism, so arranged that it will be functional for a severely handicapped patient. However, this type of closing is quite dangerous, as it may open the lock accidentally; therefore it is very seldom used.

Opening Catches on Locks

All three of these locks can be made free by adding catches to them to keep them unlocked. This is often a desirable feature because it permits the patient to walk part of the time with a free joint. If the patient becomes fatigued or has to walk on uneven ground or in a crowded area, he can easily release the catch, thus converting the brace into a stable support.

Double Locks

For patients who are heavy and have severe involvements, it may be necessary to lock both sides of the brace, that is, the medial and lateral uprights. Ring locks can be used for such a purpose; however, opening these may prove to be too difficult for patients with poor balance, who are using crutches for ambulation or who have involvement of the upper extremities. These patients can use the bail lock to advantage; this will depend upon the functional capacity and activity of the patient. The bail (fig. 15), which in bracing is a half ring connecting the lateral and medial double lock parts, provides a positive automatic lock on extension and can be locked and unlocked with minimal effort on the part of the patient without using his hands in this operation.

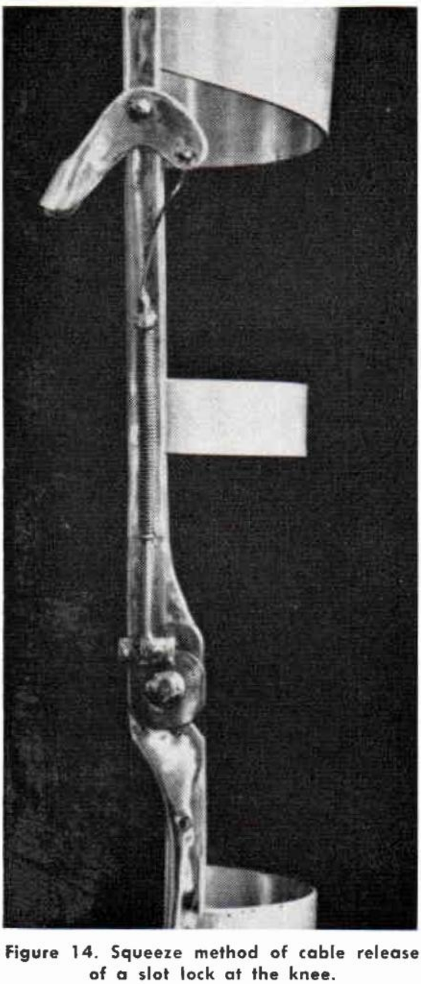

Figure 14. Squeeze method of cable release of a slot lock at the knee.

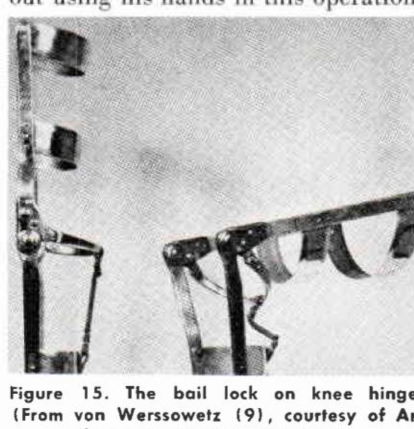

Figure 15. The bail lock on knee hinge. (From von Werssowetz (9), courtesy of Archives of Physical Medicine)

The bail can be used with any type of cam or plunger lock when double locks are indicated. A cam lock, in general, is activated by a spring, rubber or elastic which provides the locking force which acts on a short lever type of projection or a cam, usually on the thigh upright, to force it into the receiving slot on the posterior edge of the hinge box on the lower upright. The patient opens it by tripping the lock hinges, either by lifting the bail with one hand or by pressing the bail on the edge of a chair when sitting down. There is a great variety of cam locks used with automatic locking properties, such as the Schweizer or Swiss lock, the Baeyer lock, the French lock, the bow lock and other types. The principle of action of these various locks is essentially the same.

The most commonly used joints with bail usually have short bars used for locking on each side. These bars are connected by the steel bail posteriorly at the level of the popliteal region, but mostly depending on the type of chair the patient will use. The bail should be placed about 17 to 18 inches above the floor when the patient is to use an ordinary chair. If he is to use a wheelchair, the height should be greater, about 20 to 21 inches. This will improve the patient's ability to manipulate his brace more adequately. The bail is usually connected by a rubber or an elastic webbing with the calf band, or a spring is used on one side of each hinge to keep the brace locked in extension.

It has been said that the bail lock is unsafe and that it will open when the patient backs up against a wall. This will happen only when the semicircular lever or bail is not aligned properly, that is, if it is not pointing slightly downward, but is horizontal or tilted upward. In such a case, any pressure on the lever will open the lock. A patient with severe adductor spasm and scissoring should use bail locks with caution, because sudden spasm may trip the knee and open the lock. Occasionally, the bail lock has a tendency to open during certain functional activities, such as getting out of a wheelchair. If this occurs, the bail lock can be easily transferred into a single lock with spring extension arm.

HINGES AT THE HIP

There is still great controversy regarding the use of trochanteric hinges (20, 21). Some clinicians vehemently opposed to their use, whereas others may use them too much. There is always a happy medium in which a pelvic band or a spinal brace and a trochanteric hinge have a necessary and important place. They are used to prevent abnormal motion at the hip, especially external or internal rotation. It should also provide stability when necessary (3, 18, 22, 23). It has been said that there are very few poliomyelitis patients with hypermobile hips, yet our experience has been that these cases are not too infrequent, and for these patients trochanteric joints may be indicated. Certain other neuromuscular disorders also require the provision of more stability (some paraplegics) or control of involuntary movements (some cerebral palsies) at the hip which can be accomplished by trochanteric hinges.

The trochanteric hinge is placed at the level of the tip of the greater trochanter and slightly anterior to it. If it is not placed properly it will distort the alignment of the entire brace, because on changing position from standing to sitting, the upper trochanteric hinge arm will tend to push or pull on the lateral upright of the long leg brace to which the whole trochanteric hinge ensemble is attached, thus causing a rotation of the long leg brace on the thigh. Trochanteric hinges can be free, limited or locked.

Free Trochanteric Hinge

A simple or double free hinge (fig. 16) corrects abnormal rotation of the extremity but does not provide too great stability. It can be used successfully in cases with weakness of the pelvic girdle, but especially of gluteus medius muscle when it is attached to a well fitted spinal support or a pelvic band. This arrangement may prevent further damage to the muscles. It is especially valuable in children who will not use their crutches. In patients who have involuntary movements and over-activity of muscles, a ball-bearing hinge may be used to provide greater torsional strength and prevent shearing. Also, the ball-bearing joints provide more normal motion with less effort in these patients, although they are heavier.

Limited or Off-set Trochanteric Hinges

Off-set trochanteric hinges are constructed similarly to the off-set hinges at the knees (fig. 17). They can be used with excellent results, especially in children who have hypermobility in the hips, poor balance, and a tendency to dislocation in one or both hips. Off-set hinges provide free range of forward (flexion) motion, but provide limited and secured movement on slight hyperextension, which can be controlled as desired. On flexion the "off-set" unfolds and actually increases the length of the upright, thus compensating for the increased length of the surface of the extremity which occurs on sitting. These facts accomplish two major objectives which are: a) providing better posture, and b) preventing excessive strain on the anterior pelvic and femoral ligaments which tend to stretch under prolonged pressure.

Locked Trochanteric Hinge

A locked trochanteric hinge makes locomotion impossible except when using a swing-to or a swing-through gait with crutches. It also interferes greatly with functional activities of the patient. However, it provides excellent stability which may be needed by some patients who are engaged in certain occupational or vocational pursuits requiring them to stand.

Trochanteric joints are not prescribed routinely. The patient always is tried first on long leg braces with crutches and is instructed in a proper gait. He is then observed and evaluated. If it becomes apparent that he is not going to ambulate correctly, he may be given a trochanteric hinge if it is thought it will help him. Later, he is evaluated again and if the trochanteric hinge accomplishes some correction, it is left on, but if it does not improve the gait or posture, it is removed. It is necessary to re-check a patient with trochanteric hinges very carefully. If it becomes evident that the trochanteric hinges have performed their function and are no longer necessary, they are removed.

The pelvic band is placed in the hollow below the crest of the ilium and above the tip of the greater trochanter. It should be molded to conform to the contour of the pelvis. It should be made of sturdy metal which will maintain its contour. Pelvic bands usually extend from one anterior superior spine of the pelvis around to the other side. Such a solid pelvic band provides the best stability. In some cases, especially those in which rotation is the only problem, a half pelvic band can be used.

CHAPTER III. UPRIGHT BARS, BANDS AND CUFFS

UPRIGHT BARS

The upright bars should conform to the contour of the leg and thigh and should clear the ankle and the knee. They should not touch the skin, and the clearance should be about 1/8 to 3/8 inch except when the construction of the hinges does not permit this fitting, or when proper alignment of the orthesis demands otherwise, as it usually does on the thigh. Usually two uprights, that is, a medial and a lateral bar, are used because it is difficult to hold an extremity securely with only one upright, no matter how strong this bar

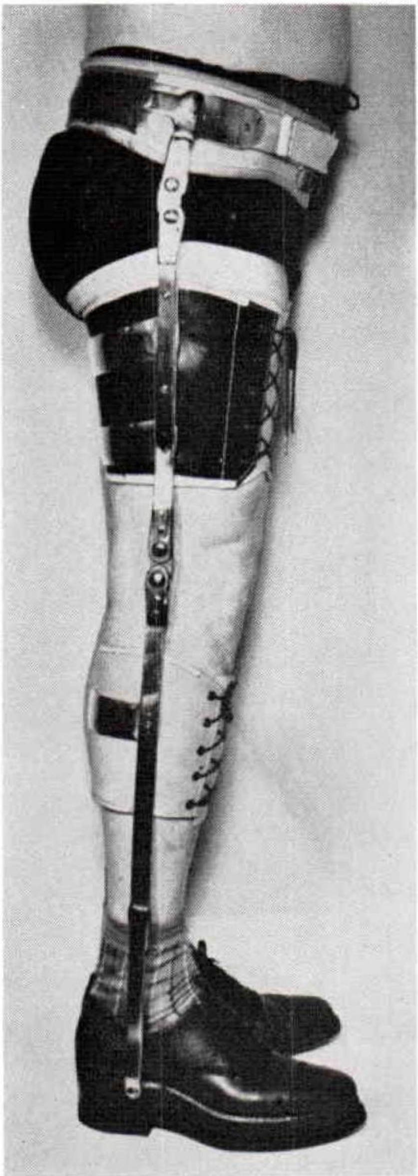

Figure 16. Double free hinges at the hip and knee used in post-traumatic condition.

Figure 17. Off-set trochanteric and knee hinges used in a paraplegic patient who had exceedingly good balance awareness. The patient is wearing urinary collecting device.

may be. A single bar may be used to advantage in some hemiplegic patients who have minor muscle imbalance. Hessing and Hasslauder (24) and after them, Jordan (5) and lately Schillinger (25) suggested the use of one spiral bar in certain specific neuromuscular conditions for special reasons. However, as a general rule, bilateral bars are preferred.

Flat solid bars of steel or hard aluminum are the best. Cylindrical or tubular uprights, though offering relatively more lightness in relation to strength and rigidity, are not used much because mechanically they are hard to fit and adjust, especially in a growing child. It does little good, for example, to make a brace from a light weight alloy which provides adequate strength only at the cost of greatly increased bulk. Such a procedure defeats its own end. The upright bars should be attached to the shoe so that the foot will be held in a neutral alignment. They should help in preventing any tendencies to eversion or inversion. The uprights are like columns which transmit eccentric load forces. The lower part of the upright should be as vertical as possible to the point where it is bent to join the basic metal plate of the shoe where it is fastened. If the uprights flare out wide at the heel, the eccentric force is exaggerated and a greater stress is put on the uprights. Therefore, the uprights should be fitted close to the shoe. This also improves stability.

As a general rule, the upright bars should be so aligned that on weight bearing they will enable the sole and heel to assume a parallel relation to the walking surface. Bennett (26), in certain special conditions as in the deviation of the heel due to muscle imbalance in poliomyelitis, uses a lateral bar which is slightly longer at the distal end than the medial upright. This increase in length should not exceed 3/16 inch for the adult or ⅛ inch for children. If the outside bar is too long, the shoe will be held in a varus position. If the patient's foot does not conform to this position of the shoe, it will result in a misfit about the heel.

A longer lateral upright will have a tendency to correct some external rotation, and shift the brace medially on weight bearing, permitting the body load to come more directly over the hip. This enables the patient to get over the hip more smoothly, thus facilitating locomotion. If the lateral upright is too short, it will cause the foot to go into a valgus deformity and tend to produce an abducted gait. The upright bars in the long leg brace should extend on the lateral side to the base of the greater trochanter and on the medical side to about ½ to ¾ inch below the perineum. If the lateral bar is placed too low, it will interfere with proper placement of the upper thigh band. Also, the brace will have a tendency to rotate more frequently. The fitting of the medial upright should take into consideration the width of the crotch, the bulk of the adductor muscles and the skin sensitivity of the region. It is obvious that in a stout or obese individual or in one who has a narrow crotch, medial bars may have to be lowered or placed at an angle posteriorly, especially if the patient has to use long leg braces on both extremities; otherwise these high bars, in addition to pinching, will cause the patient to walk with a wide base in an effort to clear them from being tangled. This will tend to produce a valgus of the ankle and a forefoot varus.

For children, the upright bars should be adjustable in the leg and the thigh so they can be extended with their growth. In the short leg brace, the bars should extend to just about the prominent part of the calf but must be approximately ½ to ¾ inch below the head of the fibula to avoid pressure on the peroneal nerve as it comes around and below the head of this bone. As a general rule, a short leg brace should not be used for a long time in a growing child because it has a tendency to create and increase the torsion of the tibia. This is a mechanical factor brought about by the necessity of the lower extremity to rotate during weight-bearing phase of locomotion (27). During locomotion the foot usually has a good purchase on the walking surface and as the body is carried over this support, it rotates from an extremely external position into internal rotation in relation to the body. Saunders *et al.* (28) have shown that most of this occurs in the ankle. When the ankle is stabilized by a brace and the foot by its purchase on the ground, the lower extremity has to find another point for rotation. Often this may occur in the epiphysis of the proximal end of the tibia which has inadequate lateral protection. When this occurs the result is external torsion of the tibia.

A certain amount of torsion can be compensated by rotating or twisting the upright bars below the knee or calf band of a long leg brace (fig. 18). This modification is in addition to that obtained by attaching the basic metal plate at 15 to 25 degrees of external rotation. Attempts to fit a straight brace on an extremity with excessive tibial torsion will result in a varus of the foot unless the entire brace is rotated externally to a degree equal to the amount of torsion. This will allow the foot to maintain its normal relationship with the ankle, but the knee and the hip will be internally rotated. A small degree of torsion can be corrected to some extent by a long leg brace. A short leg brace will not have any significant influence on torsion because this brace does not have enough purchase to hold it securely in place and it will tend to twist on the calf. A brace cannot correct fixed deformities; it can prevent their occurrence. Tendencies toward rotational deformities are hard to prevent and correct. If there is a struc-

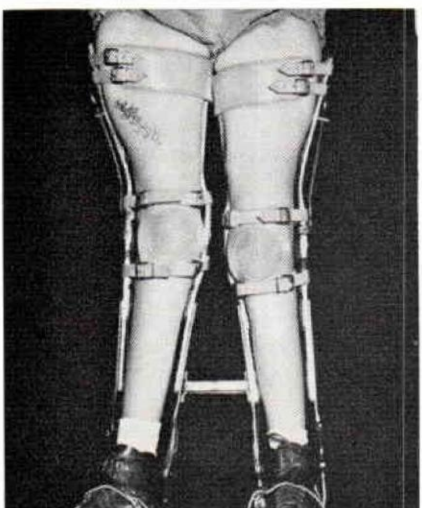

Figure 18. Upright bars on the right are rotated below the knee to compensate for excessive torsion.

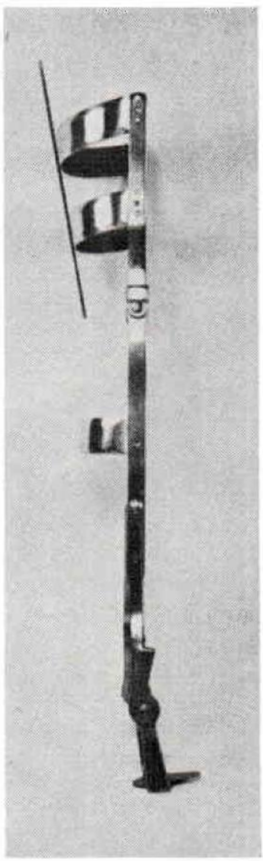

Figure 19. Inclination angle of thigh bands.

tural varus deformity associated with severe tibial torsion, these deformities should be corrected surgically; otherwise, a brace cannot be fitted adequately.

Knock-knee deformity can be prevented and sometimes corrected by proper alignment of the uprights. Knock-knee is usually associated with some degree of recurvatum. The attempt to prevent knock-knee is made in constructing the brace with uprights as straight as the patient can comfortably tolerate. A small medial knee pad is given for pressure. This type of fitting tends to distribute the corrective pressure over a wider surface and permits the use of greater force with lesser discomfort to the patient than if a large pad at the knee were used for this purpose. In addition, this method permits better and closer fitting of the entire brace. Sometimes it is necessary to use a T-strap on the lateral side of the ankle to compensate for the force exerted to bring the leg in proper position and to keep it in proper alignment.

The upright bars must be rigidly connected with metal bands. Usually two thigh bands and one calf band are used. The thigh bands should follow the contour of the thigh. The inclination angle of these bands should be the same and should correspond to that of the thigh (fig. 19). If one band is changed in its alignment, the other has to be changed and realigned in order to obtain the same inclination plane. Otherwise, one of the edges of either band or both, will cut and dig into the thigh because the distribution of pressure is not equal along the upper and lower border of the band. The metal bands should extend half way around the thigh and should be fitted to the contour of the soft parts.

The lower or mid-thigh band should be placed high enough above the knee to permit free motion of the hamstrings. The relative position of this band to the calf band is very important because if the adjacent edges of these bands are too close, the knee cannot be flexed to 90 degrees. If the mechanical knee hinge is offset posteriorly, the bands can be closer together.

The upper thigh band is placed obliquely, curving upward and outward (fig. 20). Its upper edge should be approximately parallel to the inguinal ligament. It should be placed ½ to ¾ inch below the ischial tuberosity and fitted well into the gluteal fold (fig. 26). This will minimize and control the rotation of the brace and not pinch the patient. If it is too high, it will have a tendency to throw the patient forward, and the patient will be unable to stand or walk satisfactorily. The band should be placed low enough to cause no undue pressure in this area but not too low because then the brace is too short, and the patient will have a tendency to sit back on the brace (fig. 21). This position on top of the brace causes flexed knees and predisposes to flexion-abduction contractures at the hip and knee which may result in severe disabilities. This is one reason why it is important to check braces after they have been fitted and why it is of equal importance to re-check the patient at frequent intervals.

The band should be made of very good metal to preserve its shape. If an inferior metal is used, the bands will flatten out during sitting, causing malalignment, torsion and spreading of the brace. The best metal for these bands is good surgical steel or 24 ST 0.102 aluminum, because these materials will retain their shape under stress. It is important that the depth of these bands be accurately calculated, because the proper relationship of the depth between the upper and lower thigh bands will control the position of the knee in the standing or weight-bearing position and will determine the fit of the brace. If the lower thigh band is too shallow, it will cause buckling of the knee or at least a tendency to flexion, with decreased stability around this joint. If the lower thigh band is too deep as compared with the upper thigh band (which is usually shallow), it will cause a back knee or recurvatum in spite of a strong 180-degree stop on the knee hinges. Therefore, it is essential that the depth of the thigh bands be individually evaluated and fitted so that proper alignment at the knees is obtained. A shallow lower thigh band may have to be used to correct or prevent tendencies to genu recurvatum.

The calf band is used only to provide stability to the uprights below the knee. It should not press against the calf muscles, especially in early phases after poliomyelitis or other neuromuscular disorders, as this may interfere with the functional recovery of the triceps surae muscles. As a general rule, the calf band should be fitted so loosely that daylight shows through it when the patient is standing. In very unusual cases, the calf band can be used to help to realign the knee, that is, when there is so much relaxation around the knee capsule and ligaments that there is a tendency to posterior dislocation of the tibia. A shallow calf band will have a tendency to control this condition.

CUFFS

The metal bands may have individual leather cuffs, or they may be incorporated in a corset or lacer, or have no anterior attachment. In the treatment of patients with poliomyelitis or other neuromuscular disorders, where special emphasis is placed on the lightness of braces, corsets or lacers generally are not used. Another objection to the use of corsets or lacers is that they require considerable functional ability in the hands to put them on, which is lacking in these patients. Simple straps with buckles are easily managed by most patients. If the brace has been aligned properly, they provide sufficient counter-force to give the brace desired stability. For those patients who have difficulty, even with simple straps and buckles, Rudolph (29) suggested the use of the overshoe buckle. This buckle requires very little dexterity, therefore it can be used by patients with considerable disabilities of the hands. This type of fastening is especially recommended for hemiplegic patients.

Figure 20. Alignment of bands. The upper thigh band follows the gluteal fold.

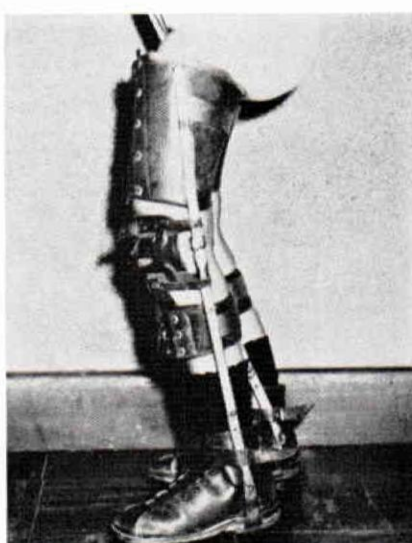

Figure 21. Too short brace; thigh band too low. Patient is sitting on the brace.

Usually straps are used on both thigh bands and usually none are used with the calf band. Often the lower thigh strap is eliminated in favor of a knee pad which constitutes the active kinetic force in the three-point system of bracing. Theoretically, this type of support is not adequate because when the pad is tight and the knee is secured, as it should be when the brace is extended, it will not allow the knee to bend during flexion. If there is a slack in the pad, or if it is not tightly secured, it does not afford sufficient stability. The pad is used, however, because it has been found from practical experience that a little motion in the knee evokes proprioceptive and other reflexes which have a tendency to stimulate the anti-gravity muscle and increase their tone.

CHAPTER IV. WEIGHT-BEARING BRACES

There are two types of weight-bearing braces, the ischial weight-bearing brace and the tibial weight-bearing brace.

ISCHIAL WEIGHT-BEARING BRACES

The ischial weight-bearing brace is so constructed that it permits the superincumbent load to be taken on the ischial tuberosity or the adjacent gluteal muscles or both. Actually the body weight is most often taken by the fibro-fatty fold of the buttock around the ischial tuberosity. This brace is used when it is necessary:

1. To protect a diseased, injured or post-operative hip joint, as found in Legg-Perthes disease, in dislocation of the hip, in osteoarthritis and post-operative cup arthroplasty and femoral head prosthesis. The brace in such cases must be abutted against the ischial tuberosity.

2. To immobilize the extremity to provide healing of a fractured femur.

3. To prevent abnormal movements at the hip caused by muscle imbalance such as occurs in gluteus medius or gluteus maximus limp, or both. A gluteal bearing brace may be used. This brace tends to minimize both the limp and the resultant strain of muscles and ligaments on the affected side. It should not be used in early convalescent poliomyelitis, as the pressure on the extensor muscles of the hip may interfere with recovery and cause greater atrophy.

The brace must be made of rigid material so that there is no give when weight is borne on it. When it is fitted properly, no weight should be borne on the patient's heel, which should lie at least ¼ to ½ inch above the inner sole of the shoe. Exception to this rule is made for weight-bearing braces used for control of gluteus medius or maximus limps. In such cases the sole of the foot can be in contact with the inner sole of the shoe (fig. 22).

The Thomas leg splint is the basic model for these braces. It consists of two lateral upright rods and an ischial ring. The ischial ring is objectionable because it interferes with comfortable sitting and often shows through clothing as a bulge. A flat ischial support has been used successfully (fig. 23). Also, ischial seats can be constructed by extending the upper thigh band to fit the tuberosity. The leather covering of this band can be molded to make the seat. A more lasting seat is made by reinforcing this molded covering with several layers of plastic. Other types of ischial seats have been used (30, 31). The most comfortable seat is one which provides a slight slope to its bearing surface. It must be remembered that the ischial tuberosity normally shows a 23-degree slope.

Originally the ischial weight-bearing brace was made of round uprights and did not have knee joints. This lack of joints made the brace unyielding and difficult to manage during sitting. At the present time most of these braces have flat uprights and are equipped with knee locks, which permit easier sitting (32). Great care should be taken about the fitting of the ischial seat so that there is no possibility of its slipping from the ischial tuberosity. Therefore it is necessary to ascertain that:

1. The ischial tuberosity does not ride high above the ischial seat. This indicates a fit that is too tight.

2. The ischial tuberosity does not slip into the band. This means that the outlet of the brace is too large and the ischial tuberosity will have a tendency to gravitate to the lowest level of the expansion. In such cases the extremity will tend to rotate internally, causing toeing-in, because the patient finds this position most comfortable on weigh bearing.

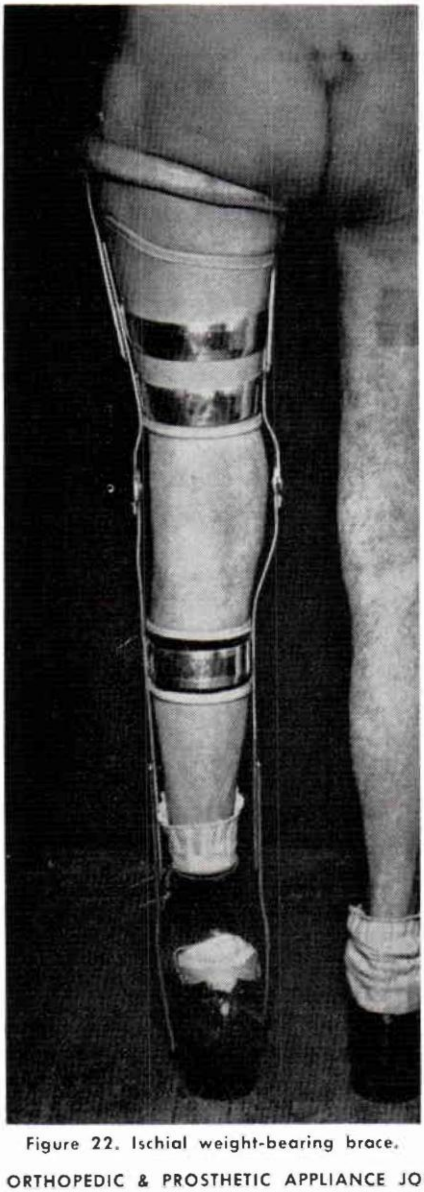

Figure 22. Ischial weight-bearing brace.

Figure 23. Flat ischial weight-bearing brace.

Figure 24. Weight-bearing brace with suspended foot. The weight-bearing surface is a re-inforced upper thigh band properly fitted.

3. The ischial seat expansion does not crowd or fit too tightly in the adductor region, especially at the junction of the band and the medial upright bar. If this happens, the patient may have pain and discomfort. He will tend to rotate the foot outward at the heel strike and carry the extremity in abduction. In addition, tightness in this area may produce severe skin irritation.

The gait of a patient with an ischial bearing brace will be altered because the weight-bearing line is shifted about 7 to 8 degrees posteriorly to pass through the ischial tuberosity instead of the head of the femur.

Occasionally the upper part of the thigh is used for weight bearing. In such a case, a long molded leather cuff or lacer is provided. Experience has shown that this type of bracing is satisfactory only for very short lengths of time. The thigh, except for its cone shape contour, does not provide adequate foundation for purchase of such a brace. Also, the shape of the thigh changes with movement and position, thus making it difficult to obtain a satisfactory fit. Excessive pressure on the thigh muscles even for a short time always leads to atrophy, which causes malalignment of the brace. A brace using only the thigh for weight bearing, that is, one that does not use the ischial tuberosity or the gluteal fold area, will not be a satisfactory weight-bearing brace.

WEIGHT BEARING BRACES WITH A SUSPENDED FOOT

Ischial weight-bearing braces may be used for treatment of Legg-Perthes disease of the hip. However, in such a case it is necessary to prevent the child from putting the weight on the toes by rocking movements. Therefore, the affected leg should be suspended in the brace about 3 to 4 inches above the walking surface on a platform. This platform is so mounted that it slips up and down on the upright bars. This movable platform is necessary to be certain that no weight is taken by the diseased hip. When this type of brace is used, it is necessary to provide an appropriate lift on the other shoe to balance the patient (fig. 24).

WEIGHT-BEARING BRACES WITH SOCKET

Recently, a weight-bearing brace was developed in which the upper thigh band and the ischial expansion were replaced by a wooden socket-like ring which provided the weight-bearing surface. The wooden part is constructed and fitted exactly like the suction socket prosthesis. It provides an excellent weight-bearing surface.

TIBIAL WEIGHT-BEARING BRACES

The tibial weight-bearing brace is used seldom, and only when the lower extremity is normal, except for involvement below the knee requiring unweighting of the legs. It gives satisfactory results in decreasing the weight-bearing pressure on the ankle joint or the foot. It is also used to support convalescent fractures of the bones of the leg or to prevent fractures in a tibia after the removal of a bone graft. A long leg weight-bearing brace often produces, in such cases, discomfort and undue restriction of the free and normal knee. The basic principle of fitting of the tibial weight-bearing brace is to transfer the weight of the body on the out flaring tibial tuberosity and the patella. Frequently the tibia expands very little, and the side of its upper end is almost parallel. Even if it is possible to fit a tibial weight-bearing brace, precautions should be taken to prevent or eliminate excessive pressure on the head of the fibula and the vessels in the popliteal space.

Recently, McIlmurray (33) had used below the knee prosthetic sockets supported by conventional brace uprights and a stirrup to provide a below the knee weight-bearing brace. The socket permits bearing weight with comfort. The socket for this brace is fabricated in the standard manner from laminated plastic. In addition, it has incorporated two retaining rings and a stainless steel upright which articulates at the ankle hinge with a stirrup attached to a shoe. The ankle hinge is of limited motion, permitting 10 to 15 degrees of plantar flexion and no dorsiflexion. The socket may be split to facilitate its application. The use of heel caliper hinges is not recommended with this type of brace. The stirrup and the upright are fitted and aligned as in a convenional short leg brace (ankle brace).

CHAPTER V. EVALUATION OF PROPER FIT AND ALIGNMENT

When a lower extremity brace is being examined for alignment, the patient wearing this appliance should be stripped as much as possible. This is important because it is only in this way that the relationship of postural mechanics can be seen. At first, the brace should be inspected with the patient in a standing position. Then the gait should be analyzed. After this, the alignment is checked in a sitting position. Then the extremity is examined for evidence of pressure, and finally the brace itself is inspected for workmanship. During the examination of the brace for proper alignment and fit, it is essential to note the following points:

1. Is the brace, as a whole, and each essential part, smoothly fitted? Do the upright bars touch the skin? Is there sufficient, but not excessive clearance between the brace and the knee and the ankle joint? Does the clearance exceed $\frac{1}{8}$ to $\frac{3}{8}$ inch? Does it interfere with locomotion? Does the brace minimize the unbalanced action of muscles? Does it provide good stability?

2. Is the relative position of natural and artificial joints proper? Do the axes of artificial hinges correspond with the axes of natural joints? Do the various parts of the brace have the proper relation to each other, and to the weight-bearing line of gravity? Is there any motion between the extremity and the brace?

3. Is the foot in a good weight-bearing position? Is the motion permitted in the ankle hinge optimal for the patient? If used, is the T-strap in proper position?

4. Are the bands and cuffs properly fitted to the contour of the soft parts of that half of the limb contained within them? Are the bands smoothly lined?

5. If used, is the pelvic band around the pelvis horizontal? Is the trochanteric joint attached in the proper place to the pelvic band?

6. Are the pressure, and the counter-pressure equally distributed, or are they unequal, causing discomfort and pain? Are all bony prominences protected? Is there any pressure over the midtarsal region, at the insertion of the malleioli, at the crest of the tibia, at the head of the fibula or the patella? Are there any pressure sores in these areas? Has proper care been taken to avoid excessive pressure in cases in which the skin shows trophic changes, where there is atrophy of subcutaneous tissue or muscle, or where there is disturbance in the peripheral circulation?

7. Is the brace well, but simply constructed? Is it strong and sturdy? Is it easily applied? Are there any unduly sharp projections?

8. Is the brace designed for the patient's needs? Does it accomplish the task for which it was prescribed? Does it meet the demands of the patient's vocation or profession?

Functional braces for lower extremities should enable the patient to resume locomotion in general and if possible to return to gainful occupation. However, it is essential that such a patient receive adequate training in the proper use of his appliance. This has not been emphasized sufficiently. A brace which gives stability to the limb imposes certain limitation in the rotary components of motion during locomotion. This change causes altered motion of the individual body segments and disturbs dynamic balance. Furthermore, there are changes in inertia, speed, acceleration and the location of the center of gravity caused by added weight or mechanical limitations of the brace. To correct these factors, training is necessary for balance and musuclar coordination if effective ambulation and use of the appliance is to be expected.

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The Problems Of Phocomelia

By CHARLES H. FRANTZ, M.D.

In recent months, newspapers, magazines and medical journals have devoted many columns of space to the severe congenital malformations which have occurred in great numbers in West Germany and elsewhere. The word 'phocomelia' appears extensively in these reports, but we are not entirely certain that all of these children are phocomelics according to the methods of classification used in the United States. Illustrations from Germany indicate the occurrence of proximal femoral focal deficiency, hemimelia, paraxial radial hemimelia and amelia, as well as phocomelia.

Unfortuntely, very little has been written concerning the positive aspects of this much-publicized problem. The affected children are not automatically condemned to empty futures of idleness and stagnation, as is sometimes suggested. Many can be satisfactorily fitted with prosthetic limbs and trained to lead useful, productive lives within the normal framework of society. This fact is known to every enlightened prosthetist in the United States who is familiar with the methods and techniques now available to aid such handicapped children.

During the past decade particularly, the Committee on Prosthetics Research and Development, the Subcommittee on Children's Prosthetics Problems, the research laboratories at New York University, the University of California at Los Angeles, Northwestern University, the Army Prosthetics Research Laboratory and elsewhere, together with the prosthetic industry of the nation, have cooperated closely in providing improved prosthetic service for children with congenital anomalies. Great advances have been made in the field of amputations and in the development of appropriate prosthetic components and fitting techniques, and new concepts are constantly being introduced. Through the joint pathways of intensive research and increased practical experience, goals which were thought impossible just a few years ago are now attainable.

One calamitous event—World War Two—provided the stimulus for greatly needed research to provide better prostheses for the adult amputee. Similarly, the current crisis may give impetus to the further improvement of prosthetic services for the severely handicapped child.

Parents who are confused and depressed should not give up hope. A great deal can now be done for the child with a congenital abnormality and much more should be possible with a concentrated attack on the problem.

Frequency Of The Congenital Defect-Anomalies Of The Extremities In The Federal Republic Of Germany*

By PROF. DR. OSCAR HEPP

Director, the Orthopedic University Clinic and Polyclinic,

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A survey of the recent increase in frequency of phocomelia based on the number of cases observed at the University Clinic and Polyclinic, Muenter, up to the end of 1961, is contained in this report. Advice to be given to the parents of afflicted children is outlined; and steps necessary for the prosthetic care of these children in order to prepare them, as far as possible, for school and a profession are also presented.

In the last two years the number of children born with severe congenital deformities of the extremities has risen by leaps and bounds in the Federal Republic of Germany. Already, the damage done is so catastrophic as to require a service of extraordinary magnitude. While the full extent of the damage cannot be estimated as yet, the known number of afflicted children is already so large that one can predict which measures will be necessary and in what manner the many parents concerned should be advised.

Based on the number of children examined at the Orthopedic University Clinic and Polyclinic up to the end of 1961, this study provides the first survey as to the kind and frequency of the present extremity deformities which, in combination with other anomalies, presents a situation far exceeding other previous experience. Types of congenital extremity deformities once rarely seen are now very prevalent and constitute a much higher proportion of the total population.

The opinion has been frequently expressed that the anomalies were caused during the first weeks of pregnancy by one or more drugs or other substances which were put on the market in the Federal Republic in recent years and used extensively. This view is probably correct, but has not yet been proven in detail. It is not appropriate for me to question the causes in this study, since many others are now working ferverishly to determine the possible causes.

However, it appears certain that our initial presumption that the anomalies were caused by radioactive fallout from atomic bomb tests was incorrect. No similar accumulation of severe extremity deformities have been observed in the fallout regions of the rest of the world. Thus we are apparently confronted with some unknown factor(s) X, Y or Z as toxic agent(s).

Table One Discussion

Table 1 indicates the extent of the damage among the respective patients in our clinics. The number of children with extremity anomalies is shown in squares per case according to year of birth. Anomalies of the extremities

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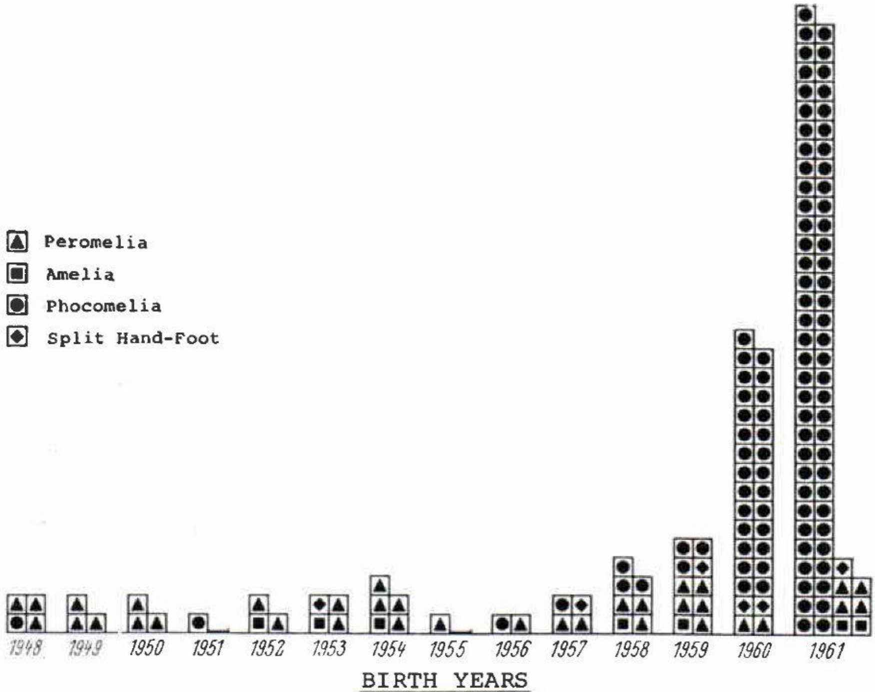


TABLE ONE 148 DEFECT-ANOMALIES OF THE EXTREMITIES

have been registered, but other orthopedic conditions such as clubfoot, dysplasy of the hip joints, arthrogryposis multiplex, vertebra deformity, etc., are not shown. A triangle represents a peromelia: a defect of the extremity which resembles an amputation, even though bud-like, rudimentary parts of the peripheral limb segment sometimes exist in great variety. A square represents amelia; complete absence of an extremity at shoulder or pelvic girdle. A circle represents phocomelia: seal-hands or stump-limbs of various lengths with predominant defects of the medial limb part and of the thumb side. A rhombus represents peripheral hypoplasia of the type involving split hands and split feet.

Only seven cases of these types of extremity deformities were seen in our clinic during the individual birth years of 1948-58. Of these, the quasi-amputations, amelia and peromelia were predominant. Since 1960, however, a large number of phocomelia extremity stumps, which had appeared only ten times between 1948-1959, with six in 1958-1959 alone, suddenly appeared. Among our 148 cases of extremity deformities, there were 27 cases of phocomelia in 1960 and 65 in 1961.

The avalanche of phocomelias is thus recognizable at a glance. The climax of 1961 may not have been reached at this time, since many of the babies may not yet have been presented for clinical consultation. The increase between 1960 and 1961 is therefore probably considerably higher. What the birth year of 1962 will show cannot be anticipated. Even if a drug is found to be the cause and eliminated from the market, figures similar to 1961 are expected.

The unique rise of phocomelia indicates that something absolutely new has occurred. One cannot assume that perhaps the research and development efforts of our clinic in the field of fabricating prostheses was responsible for the increased admittance of children with extremity deficiencies since other clinics have shown similar increases.

One hundred and twenty-five of our cases are in the Nordrhein-Westfalen region. Ninety similar cases who were seen by Professor Imhaeuser in the Department of Orthopedics of the City Hospital in Dortmund, and numerous children who were presented in Wuppertal, Dusseldorf, Koeln and Bonn, should also be added to the total, and new patients are being presented daily in increasing numbers as a result of instructions given to the State Health Departments in the reporting of such cases.

Consideration of the files of Dr. Pfeifer of the University Children's Clinic in Muenster and of Dr. Herbig, State Physician for Disabled from Westfalen-Lippe, plus the records of our own clinic, indicate there are more than 200 children with defect anomalies of the extremities at the present time. A total of 1,000 cases in the North German region may be a conservative estimate.

Table Two Discussion

Table 1, as stated earlier, indicates the frequency of the cases and their distribution between four kinds of deformities, with a rising increase in phocomelia cases since 1960. Table 2 represents the distribution of extremity involvements in the 148 cases. The black corner of the case-square represents a malformation, and according to the direction, shows left or right, upper or lower extremity. In this Table, the severity of the malformations in each of the four groups is subdivided in order to demonstrate the magnitude of the rehabilitation task in general and for the affected individuals.

As noted in Table 1, cases of amelia, peromelia, and split hands and feet have been observed in a fairly even proportion over the years. Thus in Table 2, our attention is focussed on the forms of phocomelia which have recently appeared in such large numbers.

The most frequent cases are those with seal hands in which a more or less complete elbow joint is inserted in the intercalary piece. Occurring

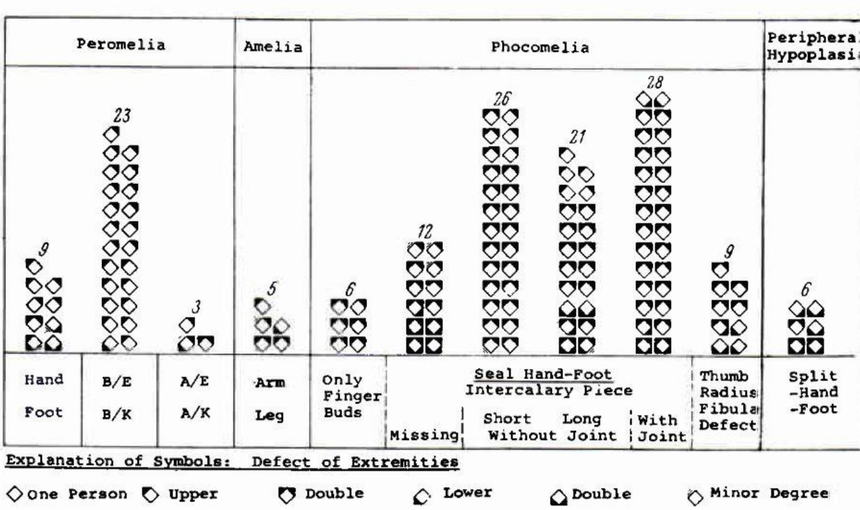


TABLE TWO 148 DEFECT-ANOMALIES OF THE EXTREMITIES almost as frequently are those cases with seal hands and short intercalary pieces, followed by the seal hand and long intercalary piece group, both of these being without an elbow joint. All three of these predominant subdivisions are distinguished by the absence of the thumb and in longer extremities by more or less large radius defect. They consistently lead to some cases of club hands without thumb with or without partial radius defect, and club feet with fibula defect, partly also with tibia defect.

Therefore, we have intentionally included as a group of the phocomelia deformities those cases with loss of thumb and a radius or fibula defect, which is usually considered a special group of anomalies. The symmetric bilateral occurrence of these conditions in the upper extremities of the recent birth groups indicates clearly that this deformity pattern should also be evaluated as a reduced form of phocomelia.

Cases of seal hands with complete absence of an intercalary piece occurred less frequently than those involving an intercalary segment. However, this group of twelve patients included four with quadrilateral defects.

The number of cases characterized by a bud extremity, or individual finger buds at the shoulder girdle, were least frequent of all and verge on the amelia classification.

There is no clear distinction between the peromelia and the phocomelia groups. In our classifications we had to determine whether a limb defect more greatly affected the middle part of the limb or whether the distal part of the limb was so severely underdeveloped that an amputation-like condition obtained. In our classification, therefore, we knowingly placed the amelia between the peromelia and the phocomelia because there are consistent transitions to either side.

It would be difficult to specify the multitude of variations, especially since the transitory forms are less common than the typical phocomelia cases. Furthermore, a study of the data reveals that the upper extremities are afflicted more frequently than the lower, and that only two cases of phocomelia of both legs alone (club feet with short intercalary pieces), were found in our series. Among the total number of 102 cases of phocomelia, there were just seven cases in which one or both legs alone were involved. The arms were deformed in 95 cases—only three times unilaterally.

Among the 92 arm phocomelia cases, the left side was shorter and afflicted more severely than the right side on six occasions. The right side was more deformed than the left in only two cases. It has been known for a long time that there is a preponderance of left side deformities among the amputation-like below-elbow peromelia cases. Our data reveal thirteen left side peromelia cases, compared with nine right side casees.

A pathetic sight is presented by nine children with phocomelia of all four extremities, five with short deformities, four with longer ones; and five others wth triple deformities (only one leg not afflicted).

Comparison With U. S. Cases

The impact of the current crisis in West Germany is most strikingly illustrated by a comparison of the 148 classified cases of defective extremities at our clinic in Muenster with the distribution of extremity in 273 children compiled at the Michigan Crippled Children Commission's Clinic

The fact that the types of deformities, despite a difference in classifications, were divided and sub-divided into the same groups according to photographs, as our own cases, greatly aided the comparison. Although the American series was only twice as large as the Muenster sample, their data shows approximately five times as many peromelia and amelia cases as ours; on the other hand, the ratio of phocomelia cases in the two samples is approximately 1:1 despite the difference in total numbers, with the Muenster upper extremity sub-group outnumbering their American counterparts by approximately 3:1.

The differences in the two samples are even more clearly illustrated by a comparison of the percentage of total cases falling in the major categories of defects. The pertinent figures are:

	Muenster	USA
Peromelia-Amelia	25%	70%
Phocomelia		
Upper Extremity	62%	11%
Lower Extremity	13%	19%

(Frantz, Charles H., M.D., and O'Rahilly, Ronan, M.D., "Congenital Sketetal Limb Deficiencies", *The Journal of Bone and Joint Surgery,* 43-A, 8, December 1961.)

The increased frequency of upper extremity symmetrical (bilateral) phocomelia cases is perhaps best indicated by the following: the relation of the bilateral to the unilateral cases in our phocomelia group is in the proportion of approximately 5:1, compared to the United States ratio of 1:3.

Besides the extremity deformities, the present syndrome frequently shows haemangioma, especially on the forehead and upper lip, saddle-nose, deformities of the external, perhaps also of the inner ear, stomach—intestinal atresia and heart deformities. In the event that the latter two are severe, the children die early or cannot live at all. Only an accurate study of the still-born and of abortions would reveal the total embryopathy caused by one or more toxic factors.

Other deformities of the skin, the ear and the internal organs have not yet been surveyed. However, a careful pediatric and otological examination is indicated even if the superficial symptoms do not imply circulatory and nutritional disorders.

In the last two birth years, hydrocephalus was noted once in a child witth extremity deformities. A marked mental defect was also noted once during this period. However, most children have alert, pretty and kind expressions. Ear deformities and haemangioma are, of course, disfiguring, but intelligence does not appear to be affected. A three-year-old girl with a four-fold deformity (bilateral upper extremity amelia, phocomelia with a long intercalary piece at the right leg and peripheral phocomelia of the left leg) is advanced for her age in intelligence and development and is the special favorite of the ward.

Inquiries to colleagues in the countries bordering Germany—e.g., Denmark, England, Holland, Belgium, France, Switzerland, Australia and in the Soviet occupied areas of Germany, revealed that no special increase in frequency of phocomelia cases has been observed. Several cases in the vicinity of Basel and in East Berlin, however, indicate a spreading of the toxic agent across the border. Very recently we learned of an accumulation of embryopathic cases in England and Australia, from areas into which one of the drugs in question has been exported in sizable quantities until recently.

Immediate Action Required

This catastrophe in the Federal Republic requires that immediate steps be taken to limit the damage or to eliminate it. The population, the physicians, and the authorities should act immediately, without red tape.

1. Husbands and wives, in the event that a pregnancy is possible or probable, should avoid all drugs and possibly toxic new preparations which

have been on the market for only the last three years. Preferably, they should use old, proven drugs, detergents, etc., until the toxic agent has been correctly identified.

2. Physicians should prescribe preparations placed on the market within the last three years for only as long a period as is necessary and with utmost reluctance until factor X, Y or Z has been established as the certain cause of the anomaly-rate. Information about possible damage before and during early pregnancy is urgently required for patients in the child-bearing age. Even if the probable cause of the catastrophe should be limited eventually to one toxic factor, the public should be made aware of the danger of the thoughtless misuse of drugs.

3. Pregnancy tests with hormone tablets should be halted until the harmlessness of the tests alone or in combination with other medication has been proved. The AZR at present yields sufficient and harmless possibilities for proof of pregnancy.

4. All known possible causes of damage before and during pregnancy should be avoided, such as X-ray examinations, treatment with radio-active preparations, or with the proto-plasma poisons from the group of the zytostatica. If X-ray or radio-active treatments are essential for a woman's health, she should avoid pregnancy for an adequate period of time. Hormone treatments and agents promoting menses in treatment of an undefined amenorrhea should involve only drugs which have proven to be safe for many years.

5. Physicians and authorities should cooperate closely in order to discover the causal factors as rapidly as possible. Laboratories of the chemical industry and universities are already cooperating vigorously on this problem.

Physicians and authorities should report all cases of abortions and stillborn babies, as well as normal births with corresponding anomalies. It is my opinion that when a critical situation exists, such as the present one, there is an obligation to report without consideration of the fundamental law, since common welfare requires it for protection of future generations.

We are confronted with a new and terrible situation in which physicians and the chemical industry are concerned about their liability. This concern is unjustified until a substance in continuous use is proven harmful or if it is found that a substance has been marketed without thorough prior research regarding toxicity. Neither condition has been demonstrated to date.

The five suggestions listed above are designed to limit the damage, but emergency measures are also necessary to ease the distress of patients and parents. The number of children with severe extremity deformities, especially of the arms, is so great that insufficient institutions are available to train the children to attain their full possibilities as valuable members of the community.

Children up to the age of six and seven years, with normal intelligence and character, should be prepared for general or special schools. The development of their mental abilities is of great importance, since they will be unable to perform many manual activities during their life spans. Many of them will only become independent of care at great cost.

Parental Consultation

The immediate steps for relieving the psychic and physical distress of the parents and children concerned are as follows:

6. The parents should be reasonably and carefully informed about the future situation of their child. They should be advised of the proper role

they must play in the care of the child. The first thoughtless, ill-advised statement to parents or nursing personnel in the presence of the parents sometimes decides whether the child receives the essential "nest-warmth" of an understanding home, or whether he will become an outcast left to the care of the community.

The parental consultation should include the following:

a. The parents are not to be blamed; nor should they experience guilt feelings; or feel that they have been subjected to a "Godly punishment for sins committed." The poisoning of the pregnancy was an outside event unforeseeable up to now.

b. As far as we know at this time, these children are amiable individuals unimpaired from the standpoints of character and mental ability. Character and spirit will determine their fate much more than the defect of their extremities and internal organs (insofar as the defect will not shorten their life expectancy).

c. Character, spirit and personality have enabled people without arms to become painters of artistic accomplishment and were vital factors in helping handicapped people in other professions to lead full, useful lives.

d. In the age of automatization technical aids of all kinds are now available or can be manufactured in order to secure a full life for these children, according to their abilities.

e. If the phocomelous arms in bilateral cases have the length to touch each other at the ends, grasping functions will probably exist to make eating, writing and a large part of body care possible without technical help.

f. In extremely short bilateral arm stumps the feet will be able to take over the function of the hands in many cases, even if they are malformed but have sufficient leg length.

g. In the initial stages the children should be cared for, reared and handled in the same manner as all other babies and small children. Their extremity stumps should be activated in order to attain efficient development for future functions. Their shape is not of consequence.

h. Splints and bandages have no positive influence on growth but rather hinder activity and functional development.

i. These children grow up according to their mental ability in the same rhythm as normal children. They "touch" their world in the second half of the first year in life as do other children. In the second year of life they "understand" and from the third to the fourth years they really learn to "comprehend." It is absurd to provide aids or instructions to children afflicted with phocomelia before they have reached the proper age to understand and mentally digest the training measures. All training procedures should be in accordance with the child's age and should be adjusted to his degree of maturity.

j. Operative treatments should be postponed until the child has reached proper maturity. An extremity stump should never be amputated until it is absolutely certain that it is and will remain obstructive. It is possible that within a few years a slightly movable fingerbud at the shoulder can control a prosthesis which is operated by some external energy-source.

7. Shortly after birth, the children should be admitted to a special, properly equipped orthopedic clinic, erected as a center for the region, where medical consultations will take place. The general situation and future possibilities should be discussed with the parents prior to the child's admission to a neighboring children's clinic. A complete examination and a

thorough anamnestic research of the possible cause should be conducted at the clinic. It is also helpful when the parents can be shown another patient as an example of the development which can be expected of their child.

Treatment

Centralization of treatment centers into a few areas of the Federal Republic is desirable. The inquiry pertaining to a child's history should be limited to a few interrogators if dependable information about the possible causes of the malformation is to be secured. A large number of cases would be necessary for statistical significance. If useful results are to be obtained a very experienced staff is required to formulate remedial plans, exploit educational possibilities and arrange for the application of prosthetic and technical aids for phocomelia cases. Close contact between the attending and consulting physicians in the Federal Republic is essential in order to establish an effective defense against this catastrophe.

The children should be sent to kindergarten at an early age so that they will learn to move around and adjust to society. At the same time society should learn to associate with them and to respect them.

A constructive program for children with amputations and peromelia has been conducted and promoted in the United States for many years with large funds. We in the Federal Republic are just beginning to fill the gap which exists in the fabrication of prostheses for children. Almost all children's prostheses here are fabricated with adult components which are either too large or too heavy. Individual parts must of necessity be reduced or constructed according to the special requirements of children. Leg prostheses for children are relatively easy to fabricate. Artificial arms with grasping hooks and joints were prescribed in previous years only in puberty or to unilateral amputees who had become accustomed to their one-armed status and were rarely able to learn anew.

The experiences of the Americans has demonstrated that children should be provided with prostheses which can assist them to perform functions in accordance with their age group and degree of maturity. Children between one and one-and-a-half years of age with unilateral below-elbow peromelia are provided with simple aids so that they can crawl with arms of equal length. When the child wants to grasp at the age of three, he receives simple grasp instruments which he operates with the muscles of the shoulder girdle. More complicated prostheses are provided during the later stages which help to set higher standards for the child.

From a practical standpoint, this relatively simple program for unilateral and even for bilateral peromelia cases cannot be applied to the great number of newly-born children with bilateral severe phocomelia in the Federal Republic.

The 148 cases in our clinic presented in Table 2 are so severely damaged that 40 (almost 30%) have bilateral arm deformities from amelia to seal hands with short intercalary pieces which do not permit combined grasp-function with both extremity buds. This fact indicates that without aid they must depend on their feet, which are deformed in the same way in five cases.

These extremity buds, which are often grotesque, do not fit into any conventional prosthesis. Many could be utilized to control and make use of prostheses with grasp instruments by motion and sensation. Extended research and development studies are necessary, however, to construct these instruments and make them safe for use.

In many cases it is also an extensive task to guide the children to learn substitute performances with mouth or feet or trunk and shoulder motions.

This problem was previously handled only in specific cases in the large German institutions for the education of the disabled but we now must consider the problems of several hundred arm amputees who should not be allowed to waste away as nursing cases.

Conclusions

Let us suppose that all of the children with phocomelia with a long intercalary piece or with lesser degrees of bilateral arm deformities will be able to attend regular school but that 40 of the 148 cases with severe bilateral arm deformities in our small statistical survey will require care in institutional and special schools. Ths means that two or three groups of children will be ready to enter special schools in five or six years. The number of children is so great that our large institutions for the disabled are already making the necessary preparations.

Many of these children will require various kinds of technical aids during the coming years: arm prostheses which will be operated by their own physical strength or by external power from other energy resources, aids for eating, writing and body care, toys for exercises, leg prostheses and walking apparatus, self-propelled wheel chairs which will be developed for children with severe quadrilateral extremity deformities. These are tasks which the German orthopedic mechanics trade cannot handle properly as a sideline. The problems can only be mastered by a large-scale research and development program with training workshops.

A system of artificial arms has been developed and improved for a number of years at the Orthopedic University Clinic Schlierbach near Heidelberg. These arms are operated by compressed gas as an energy source—the Heidelberg pneumatic prosthesis. Our research workshop and school for the disabled has tried over a period of many years to fabricate artificial arms which would be useful for children. It is desirable that both clinics continue their close cooperation in a sustained effort to solve these acute problems.

In the majority of cases, children with phocomelia are given initial training in the use of their limb stumps. An attempt is then made to promote function with assistive apparatus. Later, a final apparatus or prosthesis which is individually practical can be fabricated.

Children grow up and require revisions in their prosthetic devices from time to time. It may be assumed that the second and later provisions can be handled by local orthopedic mechanics. The developers of special components and those who train orthopedic mechanics should work together closely in the construction of these aids.

As children mature, their requirements regarding technical aids for daily life and professional needs become more demanding. For many years to come, intensive work will be required from all professional groups concerned with the rehabilitation of disabled young people and, at the same time, institutions are greatly needed to assist the children to become accepted and productive members of society.

Committee on Prosthetics Education and Information*

of the

Division of Medical Sciences

National Academy of Sciences-National Research Council

ANNUAL MEETING

October 14, 1962—Phoenix, Arizona

HAROLD W. GLATTLY, M.D., *Executive Secretary*

At the invitation of the President of the American Orthotics and Prosthetics Association, Mr. Fred Quisenberry, the Committee on Prosthetics Education and Information met this year with that Association during their annual assembly that took place at the Ramada Inn in Phoenix, Arizona. Ever since its organization, CPEI has had a community of interests with AOPA in the area of educational activities that relate to improving the practice of prosthetics and orthotics. A joint meeting of the Committee with the Association was considered to be desirable in order that the members of CPEI could become better acquainted with the individuals of AOPA who furnish the leadership of that organization.

There are today many organizations that are concerned with the rehabilitation of the orthopedically handicapped. All too frequently these groups are relatively unfamiliar with the objectives and programs of other organizations. Often there are projects that can advantageously be pursued jointly. For example, CPEI and AOPA have very successfully cooperated for the past year in an endeavor to collect data that will better describe the character of our amputee population. In the interest of furthering a more coordinated attack upon the rehabilitation problems involving amputees and other cripples, it was decided to invite to this meeting representatives of certain other organizations that have overlapping interests in this field with both CPEI and AOPA. All groups could then gain by the exchange of information that such a conference would permit. The following agenda was therefore designed to achieve this objective.

1. Opening of the Meeting
   Chairman of the Committee, Dr. C. Leslie Mitchell
2. Chairman's Report
3. Subcommittee Chairmen's Reports
   a. Prosthetics in Medical Education—Dr. J. Hamilton Allan, Chairman, Department of Orthopedic Surgery, University of Virginia School of Medicine
   b. Prosthetics in Paramedical Education—Miss Dorothy Baethke, Director of Physical Therapy, University of Pennsylvania Hospital
   c. Prosthetics Clinical Studies—Dr. Roy M. Hoover, Medical Director, Woodrow Wilson Rehabilitation Center
   d. Advisory Committee on Prosthetics in Pennsylvania—Dr. William

* The Committee on Prosthetics Education and Information is jointly supported by the Training Division, Office of Vocational Rehabilitation, Department of Health, Education, and Welfare, and the Prosthetic and Sensory Aids Service of the Veterans Administration.

Erdman, Chairman, Department of Physical Medicine and Rehabilitation, University of Pennsylvania School of Medicine

4. Interests of the Training Division, Office of Vocational Rehabilitation
   Dr. J. Warren Perry, Assistant Chief of the Training Division of OVR, Washington, D. C.
5. Interests of the Prosthetic and Sensory Aids Service of the Veterans Administration
   Mr. William M. Bernstock, Assistant Chief, Research and Development Division, Prosthetic and Sensory Aids Service, Veterans Administration, New York City.
6. American Board for Certification and Education Committee, American Orthotics and Prosthetics Association
   Mr. Leroy W. Nattress, Jr., Executive Director, American Board for Certification in Orthotics and Prosthetics, Inc.
7. Report of the Committee on Prosthetics Research and Development of the National Academy of Sciences
   Mr. A. Bennett Wilson, Jr., Technical Director
8. Interests of the American Academy of Orthopaedic Surgeons
   a. Committee on Braces and Prosthetics—Dr. Cameron B. Hall
   b. Committee on Orthopedic Rehabilitation—Dr. Vernon Nickel, Chairman
   c. Seminar on Orthopedic Rehabilitation—Dr. Vernon Nickel
9. Interests of the Committee on Rehabilitation of the American Medical Association
   Dr. Ralph E. DeForest, Executive Secretary
10. Interests of the American Academy of Physical Medicine and Rehabilitation.
    Dr. Frederick E. Vultee, Chairman, Department of Physical Medicine and Rehabilitation, Medical College of Virginia.
11. Interests of the Liberty Mutual Insurance Company
    Dr. Melvin J. Glimcher, Assistant Director, Liberty Mutual Rehabilitation Center, Boston
12. Reports of the Directors of the Prosthetics Schools
    a. University of California at Los Angeles—Dr. Miles H. Anderson
    b. New York University—Dr. Sidney Fishman
    c. Northwestern University—Dr. Jack D. Armold
13. University Council on Orthotics and Prosthetics Education
    Dr. J. Warren Perry, Executive Secretary
14. Film on Locomotion
    Dr. Cameron B. Hall, Department of Orthopedic Surgery, University of California Medical Center at Los Angeles
15. Orthotics Education
    Mr. W. Frank Harmon, Certified Orthotist, Atlanta

Following the close of the regular meeting, the group joined the main Assembly of AOPA for the purpose of presenting an orientation program to give the attending prosthetists and orthotists a picture of the activities and projects of the Committee. Dr. Frederick E. Vultee was moderator for this program that consisted of brief presentations by the Chairman of CPEI, the chairmen of the subcommittees and the directors of the prosthetics schools. Dr. J. Warren Perry represented the Training Division of OVR and Mr. William M. Bernstock the Prosthetic and Sensory Aids Service of the Veterans Administration at this session. Dr. H. W. Glattly closed the program with a preliminary report on the results of the amputee census. These results appeared in the December issue of the AOPA *Almanac.*

President Fillauer Reports on Association Committees

The Journal's circulation includes a great many physicians and rehabilitation workers generally, in addition to membership of the American Orthotics and Prosthetics Association. For this reason, it seems desirable in my first column as President to restate the fundamentals of the Association's program and the Committees which guide its efforts.

Our Association was organized in 1917 and grew out of a meeting of prosthetists called to Washington, D. C., by the U. S. Council of National Defense. In the years since then, the Association has increased its membership to a total of 456 including corresponding members in five other countries.

The Association has maintained permanent Washington, D. C. Headquarters since 1946, and the current Executive Director is Lester A. Smith, who is also editor of the Journal.

In addition to the Journal, the Association publishes a monthly news bulletin for members only which is known as "The AOPA Almanac," and an annual Orthotics and Prosthetics Yearbook. The Yearbook includes the roster of members, the by-laws of the Association and an index of supplies.

Broadly stated: the purpose of the Association is to assist members in their dedication to serving the handicapped and physicians.

In addition to its publications, the Association sponsors the annual Orthotics and Prosthetics Assembly or Convention and a series of Regional Meetings held throughout the United States. The purpose of these meetings is twofold: to bring to members the latest in technical developments and to offer a meeting ground for all who are concerned with rehabilitation of the orthopedically handicapped.

In 1963 the Association will also sponsor special programs to be presented at (1) meeting in Bremen, Germany, to be held in connection with the German Association of Prosthetists and Orthotists and (2) at the World Congress for the Rehabilitation of the Disabled held in Copenhagen, June 23-29.

The Association has worked closely with the National Research Council on research projects and with the U. S. Veterans Administration on improving service for the Veteran amputee or brace wearer. For this purpose, the Association has established two important committees:

1. Committee on Advances in Prosthetics and Orthotics and
2. the Veterans Administration Liaison Committee.

These two committees work closely with those in the research program and with officials of the Veterans Administration. The Committee on Advances meets once a year with technicians of the VA Prosthetic Center in New York City to review new appliances and see which are suitable and should be made available to the veteran.

ASSEMBLY COMMITTEES: The 1963 Orthotics and Prosthetics Assembly sponsored by this Association will be held at the JUNG Hotel in New Orleans, November 2-7. Three experienced orthotists and prosthetists make up the Assembly Program Committee: Bert Titus of Durham, North Carolina, Chairman; and Vice-Chairmen Bruce Scott of Denver and Roy Snelson of Downey, California. This Assembly is open to all who are interested in the rehabilitation of the orthopedically handicapped. Suggestions for the Program may be sent to any one of the Committee.

ASSEMBLY EXHIBITS: The technical supply and educational exhibits at the National Assembly are one of its most valuable features. The Exhibits Committee for 1963 is headed by William Bartels of Portland, Oregon as Chairman, and Ronald Snell of Memphis, Tennessee as Vice-Chairman. All persons interested in preparing exhibits for this convention are asked to communicate with members of the Committee or with AOPA National Headquarters in Washington.

MEMBERSHIP COMMITTEE: Membership in AOPA is today the hallmark of the efficient and ethical establishment in the field of artificial limbs and braces. Mrs. Alice Crowell of Truform Anatomical Supports, Cincinnati, Ohio is our capable Membership Chairman. The eleven Regional Directors of the Association serve with her as a Committee to consider desirable applicants for membership and to acquaint potential members with the services of the Association.

PUBLIC RELATIONS Chairman: Herbert J. Hart, Vice-President of the Association, is Chairman of this Committee and is charged with advising the National Officers on public relations activities of the Association.

JOURNAL COMMITTEE: On the masthead of this issue of the *Journal*, page 299, will be found the names of the twelve of this Committee. Persons preparing articles for contribution to the *Journal* may receive assistance and suggestions from any member of the Committee.

SUPPLY COMMITTEE: The ten members of this Committee advise the National Office on advertisements, suppliers, and on the proper listings for the Supply Index in the Orthotics and Prosthetics Yearbook. Persons and individuals wishing to make use of this service may obtain helpful information from any member of this Committee, listed on the inside back cover of this issue.

In addition to these Committee assignments, the Association from time to time asks the aid of individual members on special assignments to help carry out the program of the Association.

Sincerely,
Carlton Fillauer,
President

Qualifications for Prosthetists and Orthotists

By LEROY WM. NATTRESS, JR.[1]

Introduction. During the past fifteen years the American Orthotics and Prosthetics Association, as well as the American Board for Certification in Orthotics and Prosthetics, Inc., has been concerned about the qualifications of prosthetists and orthotists. The former was concerned because of the programs of education it was called upon to offer to its membership; the latter, because of the standards it was called upon to establish and maintain.

As a result of this concern, in 1959, the then President of the Association, Karl Buschenfeldt, appointed a Committee on Education for the primary purpose of drawing a profile of the prosthetist and orthotist. After two years of work, the task of completing the "profile" was given to the newly formed Committee on Educational Standards of the American Board for Certification. It is the culmination of this three years of study and work that we now present to the readers of the *Journal.*

The reader is asked to keep in mind that the profile of the prosthetist and orthotist is being drawn today in an effort to direct the steps of the educators who will be training these specialists in the future. Nothing stated here is intended to be final; we are only setting down principles that will hold true in the future as we see them today. It is likely that developments in medicine, engineering, and our own fields, will alter what we have stated here. As a result, some will feel that what we have stated is too general, while others will feel, just as strongly, that our statements are too specific. The underlying philosophy, however, will not change.

The statements made by the Committee on Educational Standards are to be considered as guides to formal curriculum development for prosthetists and orthotists—they are *not* the curriculum itself. In this, the Committee has asked and reasked four questions:

1. What educational purposes should the institution of higher education be expected to attain?

2. What educational experiences are likely to achieve these purposes?

3. How can these experiences be effectively organized?

4. How can we determine whether these purposes are being achieved?

Definition. The Prosthetist is a person who is skilled in the fitting and fabricating of appliances that replace extremities which have been removed through accidents, as a result of disease, or due to a congenital anomaly.

The Orthotist is a person who is skilled in the fitting and fabricating of appliances which replace lost musculo-skeletal function following disease or trauma, and support weakened segments of the body.

[1] This is to be considered an interim report of the Committee on Educational Standards of the American Board for Certification in Orthotics and Prosthetics, Inc., M. P. Cestaro, Chairman; Thorkild Engen, Robert Gruman, and Basil Peters, Members; LeRoy Wm. Nattress, Jr., Secretary.

Both the prosthetist and the orthotist, when they have attained a level of proficiency in their specialty, may be recognized as Certified after successfully passing the examination of the American Board for Certification in Orthotics and Prosthetics, Inc.

Personal Qualifications. The qualifications for prosthetists and orthotists begin with the dedication to the service of the physically disabled. This is the cornerstone upon which the specialities of prosthetics and orthotics are built, and is their justification for existence within the field of medicine.

The prosthetist or orthotist must also develop and maintain personal relationships within the field of medicine, particularly with prescribing physicians. This is important so that the best understanding and mutual agreement may be promoted between both professions. It is equally important in providing the best possible service to the patient.

In addition, the prosthetist or orthotist must have a sincere desire to upgrade the status of his profession, and be willing to devote time and effort to effect the realization of this goal. He must be willing to share the responsibility of supporting and maintaining the ideas of his profession as embodied in the Certification Movement.

General Educational Requirements. We recognize that a broad foundation must underlie the specific educational requirements for persons desiring to enter the fields of prosthetics and orthotics. The major reason for this is that the prosthetist and orthotist must use the knowledge and resources of many fields to adequately serve the physically disabled. In addition, he must be able to communicate effectively with numerous, related specialities in the larger field of medicine and rehabilitation, as well as with the general public. Finally, he must have the academic background and discipline to utilize the many resources available to him for solving the problems with which he is confronted daily: problems to which there are no solutions today, but which, through future research, will be solved tomorrow; problems which today are considered unanswerable but, through continued study, will be solved; and problems which are not yet recognized.

In order to form this broad foundation it is indicated that a prosthetist and orthotist should begin his formal study in a Liberal Arts program.

The beginning of this program is the learning of self-expression and, with this, the appreciation of the expression of others. Basically, this beginning comes through the improvement of the skills of reading, writing and speaking. Implied in this is the study of literature and the mastery of the art of creative writing and public speaking.

Following this must come the study of the laws of natural science, beginning with mathematics, and including biology, chemistry, and physics. The study of each must include sufficient material to prepare the student for the advanced study of prosthetics and orthotics. In mathematics the foundation must be laid for the understanding of the principles of biomechanics, design and economics; in biology for anatomy, kinesiology and physiology; in chemistry for the property of materials; and in physics for mechanics. In this, the interrelation of the areas of natural science to specialization in prosthetics and orthotics is readily observed.

The social sciences must also be included in this broad foundation. This begins with the knowledge of normal behavior in individuals and the practical application of these principles in everyday living, including the mechanisms of personal adjustment, emotion, and motivation. An understanding of the individual within a group, and of the group itself, is also a necessity, as is the study of the systems of reasoning as they occur in ordinary life and the theories of the ethical aspects of human conduct. Finally, an appreciation of the development of our civilization and the factors which have created our modern world must be obtained.

Specific Educational Requirements. Up to this point we recognize that the qualifications for prosthetists and orthotists do not vary considerably from the qualifications of those wishing to prepare for other professions. However, at this point, the prosthetist and orthotist must begin specialized study intended to develop necessary skills for his profession. The study of numerous curricula leads us to believe that this can only be done by creating new course material from the research and development carried on in these fields, and not by borrowing course material from curricula already established leading to proficiency in other professions. If the latter approach is followed, we cannot conceive of an adequately trained prosthetist or orthotist resulting from a program whose duration is but four of five years.

We consider the following eleven areas of subject matter vital to the qualifications of a prosthetist and orthotist:

1. *Anatomy and Physiology:* The study of the human body and its systems with emphasis on the skeletal structure of the body; the muscles and their enervation; the vascular system as it applies to prosthetic or orthotic service; and the pulmanary system relating vital capacity to rehabilitation potential.

2. *Kinesiology:* The study of musculo-skeletal systems of the human body as they relate to normal and abnormal human movement.

3. *Biomechanics:* The study of man-machine relationships with emphasis upon the replacement of normal musculo-skeletal systems with mechanical systems. In this the concepts of support and correction, of assistance and resistance, of dynamic and static forces, and of comfort and cosmesis must receive special attention.

4. *Property of Materials:* The study of the working characteristics of materials used in prosthetics and orthotics.

5. *Survey of Pathological Conditions:* An overview of the etiology and course of conditions leading to prosthetic and orthotic care, concluding with the medical considerations involved in the prescription of appliances, the importance of proper hygiene and an introduction to dermatological conditions.

6. *Survey of the Rehabilitation Field:* An overview of the patient and selected community resources available for his care; patient-centered organization and treatment planning.

7. *Mechanical Aids for the Disabled:* An overview of the devices and appliances in current practice which are used to ameliorate disability and which are fitted by prosthetists and orthotists.

8. *Professional Development of Prosthetics and Orthotics:* The study of the history of the professions of prosthetics and orthotics with emphasis on the factors which maintain professional standing such as ethics, the preparation of technical reports, continued education, affiliation with professional organizations, etc.

9. *Business Management:* The study of sound business principles as they apply to the establishment and maintenance of the practice of prosthetics and orthotics.

10. *Fabricating and Fitting Appliances:* The study of fabricating and fitting all the basic types of prosthetic and orthotic appliances through the construction and fitting of appliances to patients.

11. *Clinical Affiliation:* The application of the principles of prosthetics and orthotics under supervision in approved facilities. The emphasis during this period, which should be considered as a post graduate residency or internship, is on the fitting of appliances, the analysis of post-fitting problems and the solution of these problems as well as on the practical aspects of functioning within the structure of a prosthetic and/or orthotic facility.

Conclusion: In considering the qualifications for prosthetists and orthotists we have put forth what we consider to be the educational purposes which an institution should accept, and the educational experiences which an institution should provide in attaining these purposes.

We have not discussed whether prosthetics and orthotics should be combined or separated specialties. While there is a trend toward the combination of these two paramedical specialties, as seen in the development of private practice, centralized fabrication, and the physician requiring more total service for his patient, the answer will come in time, not through reflection.

New Facilities Certified

By action of the Committee on Facilities of the American Board for Certification, the following Facilities have been granted Certification since the publication of the *1962 Registry of Certified Prosthetic and Orthopedic Appliance Facilities.*

CALIFORNIA

Whittier:

LERMAN AND SON — O
16541 East Whittier Blvd. — OWen 1-4619
Max Lerman, C.O.

ILLINOIS

Peoria:

MODERN ORTHESIS — O
4615 North Prospect Road — 683-0431
James Russ, C.O.

IOWA

Waterloo:

RAY TRAUTMAN AND SON — P
217 East Fifth Street — ADams 4-4010
Dale Clark, C.P.

PENNSYLVANIA

Lemoyne:

KLINGEMAN ARTIFICIAL LIMB CO. — P
722 State Street — REgent 7-7831
Thomas J. Klingeman, C.P.

Pittsburgh:

HOME FOR CRIPPLED CHILDREN — O
1426 Denniston Avenue — 521-8608
Theodore P. Hipkens, Executive Director

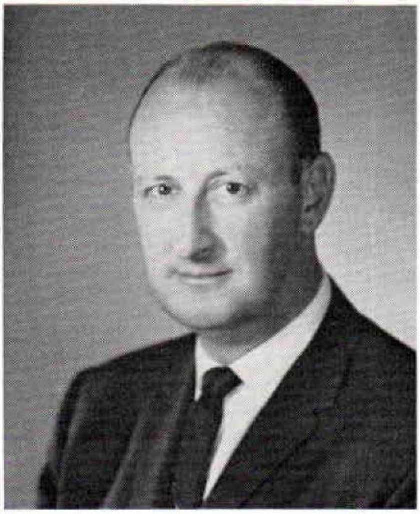
WISCONSIN

Milwaukee:

ACME SURGICAL APPLIANCE CO. — P&O
1116 South 16th Street — EVergreen 4-0660
George A. Schultz, C.O.

New AOPA Officers Elected

PRESIDENT-ELECT ROBERT C. GRUMAN—who will take office at the 1963 Assembly as President of the Association. Mr. Gruman, President of the Winkley Co., of Minneapolis, is the son of the late A. P. Gruman, Association President 1948-49. Mr. Gruman has been a member of the VA Liaison Committee, and was Program Chairman in 1957 and Director of Region VII for two terms.



VICE PRESIDENT HERBERT J. HART—Mr. Hart is Vice President and Manager of C. H. Hittenberger, in Oakland, Calif. He has served as Program Chairman for the 1956 and 1962 Assemblies, and as Director of Region X for over ten years.

New Members Appointed To ABC Board

DR. RICHARD H. JONES, M.D.—Orthopaedic surgeon and consultant at the VA Area State Office and VA hospital in Minneapolis.

THEODORE W. SMITH—of the Knit-Rite and W. E. Isle Companies of Kansas City, Missouri. Mr. Smith was certified in 1951, and has served as both Program and Exhibits Chairman.

A Report From the President of the American Board for Certification

Comments by Orthopaedic Surgeons

When we evaluate our movement, that of a standards-setting body, we can be proud in that ours has been voluntary and has enjoyed continuing growth and recognition. In the interest of further elevating the standards of our young men in training, I would like to share with you some of the comments of the 25 Orthopaedic Surgeons who served as oral examiners during our annual examinations conducted in New York and Los Angeles the latter part of August and the early part of September this year.

Many of the comments centered about the Candidate's background in anatomy and kinesiology which are the cornerstones in the relationship between our fields and the field of Orthopaedic Surgery. For example:

"I met some very competent artisans; however, none had the knowledge of anatomy or kinesiology. In fact, my impression of Orthotists as experienced by these men was that theirs was a memorized art without a background of logic. It showed few men had a reason for doing anything except the fact that they had been taught to do it that way."

"It was interesting to see in examining the Candidates that many do not know some of the simple deformities seen in the upper and lower extremities with which they deal daily. There was quite a deficiency in the anatomy that they know."

Other comments centered about over specialization within either Prosthetics or Orthotics such as:

". . . at least two or three of the men whom I examined were experts in lower extremity work. While I am quite certain that they do good lower extremity work, I do not feel that I could pass a man that did not do upper extremity work . . . Certification indicates that the individual is competent in all phases of Prosthetics."

A third group of comments indicated the need for formal training:

"In reviewing the examination I recall that it was like night and day between those who seemed to understand and know their field and those who did not. The singular thing which seemed to make the difference was a background of formal training. Those who had had formal courses in Orthotics and Prosthetics seemed to be much better able to converse in the language of the specialty."

". . . it would be my suggestion that the candidates be required to attend at least one of the courses at the schools for prosthetists and/or orthotists. I am sure that those who had attended these schools did much better on the exams."

The final identifiable group of comments may be implied from those already stated. They are summed up by one Orthopaedist in this way:

"I feel that failure in the Examinations is due to the lack of physician supervision and interest as much as to the individual's lack of preparation, and initiative."

All of us who worked on these Examinations profited from the association with these Orthopaedic Surgeons. We should profit further from their comments as we strive for the professional recognition of Prosthetics and Orthotics.

Richard G. Bidwell, C.P.O.

President

Prosthetists and Orthotists Certified in 1962

The Committee on Examinations of the American Board for Certification announces that the following men have received Certification as a result of successfully passing the 1962 Examinations of the Board. (The five men listed as Certified Prosthetists and Orthotists had previously received Certification in one of these two fields.)

Certified Prosthetists & Orthotists

Werner Greenbaum
Alfred Maier
George E. Newton
Vernon T. Pate
Donald D. Strand

Certified Orthotist

Steve Andrusky
Donald M. Baker
Joe L. Bowman
George B. Counts, Jr.
James R. Fenton
David M. Heizer
William R. Lundin
Hubert V. McElfresh
Harold E. Norwood
Guenther E. Piepenhagen
Simon Slawner
Stanley Wells

Certified Prosthetist

Ronald W. Cheney
Glenn A. Cook
Carmine J. De Nisi
George A. Gorman
Willard L. Holkestad
Leonard W. Jay
Charles L. Jones
Cecil T. Johnston
Paul M. Lawson
Paul G. Lund
Leonard E. Mumaugh
Jackson D. Reid
Tokio Shiomichi
Blondell Smith
Howard E. Thranhardt
Joseph H. Zettl

To The Ladies:

FROM AOPA'S AUXILIARY

Mrs. Elinor Bohnenkamp
President

Mrs. Esther Pava
Vice President

Mrs. Ted W. Smith
Secretary-Treasurer

Mrs. Lorraine Scheck
Past President

Dear Members:

Hello again to all of you who attended our marvelous meeting in Phoenix, especially the 38 new members of the Auxiliary. It is my pleasure to serve as your President for the coming year. My goal will be to keep the women's activities as interesting as they have been in the past so that our organization may continue to grow in strength as well as numerically.

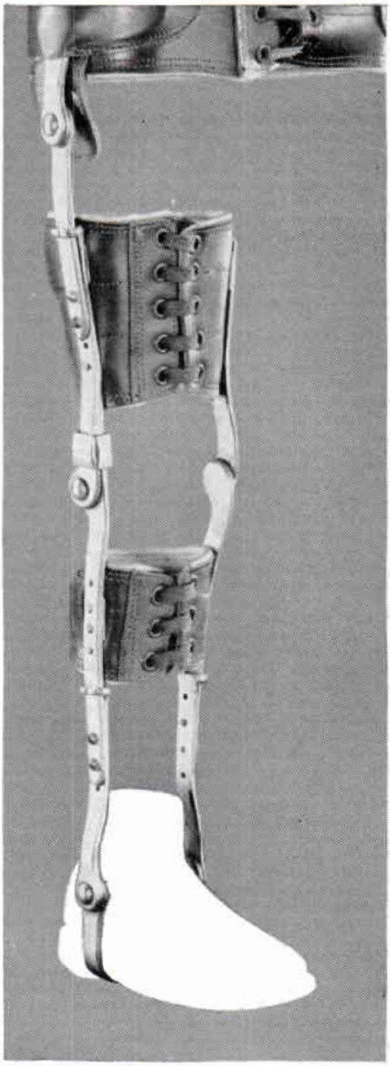
A brief resume of some of the Phoenix highlights for those who were unable to attend and to refresh the memories of all those who were with us—The largest registration of any convention yet, both men and women. . . The party and buffet at the Clyde Aunger home . . . The overwhelming response to the activities arranged for the women . . . Not one, but two busses had to be chartered for the 4-hour trip through Phoenix and the surrounding valley . . . The delicious luncheon at beautiful Mountain Shadows Resort, enjoyed by 94 women, with shopping in Scottsdale afterward . . . That enticing pool at the Ramada Inn, with sun, sun, sun, no clouds and never a drop of rain . . . And how about that 30-mile jaunt most people took into the desert on a washboard road for a juicy 2-lb. T-bone at Pinnacle Peak? . . . The birthday cake given Clyde Aunger at the banquet, complete with cowboy decorations and presented to the accompaniment of cap pistols . . . Square dance demonstration and instruction at the poolside party . . . And finally those gamblers who went on to that den of iniquity, Las Vegas, to lose all their money (if they had any left)!

If all this activity doesn't give you convention fever for New Orleans, I don't know what will. I DO know that we will try to plan as interesting a program as this year's, though it would be impossible to do any better.

The thanks of the entire Auxiliary is extended to Mrs. Clyde Aunger, who with her husband did so much beyond the call of duty toward this successful convention.

I will discuss the business portion of our meeting with you when I meet you through the pages of our next Journal.

Sincerely,
Elinor Bohnenkamp



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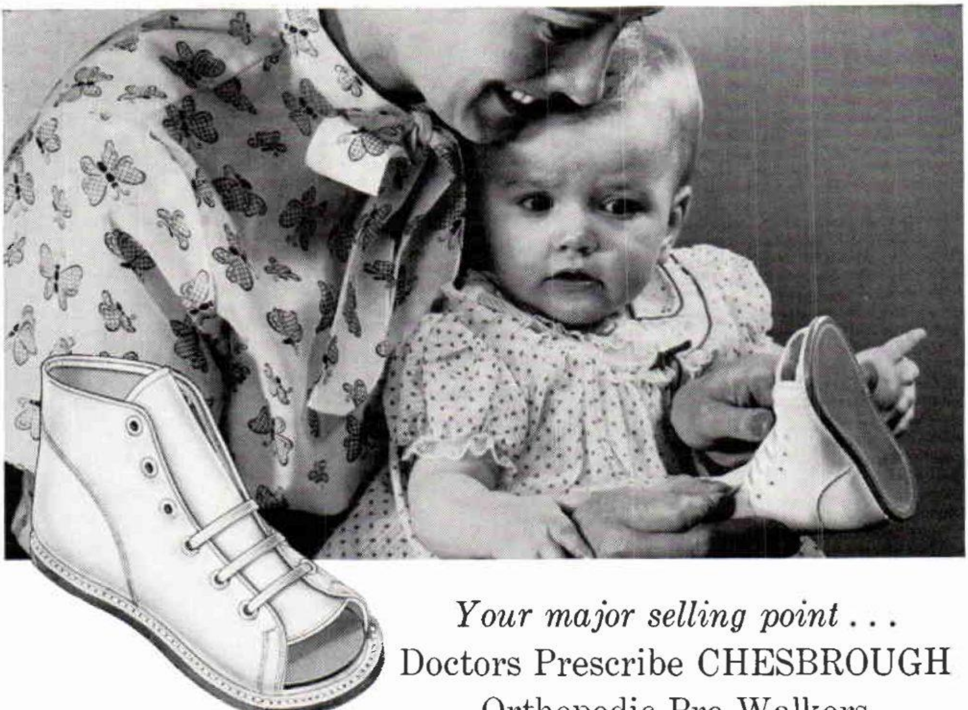

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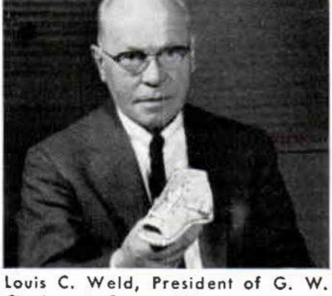

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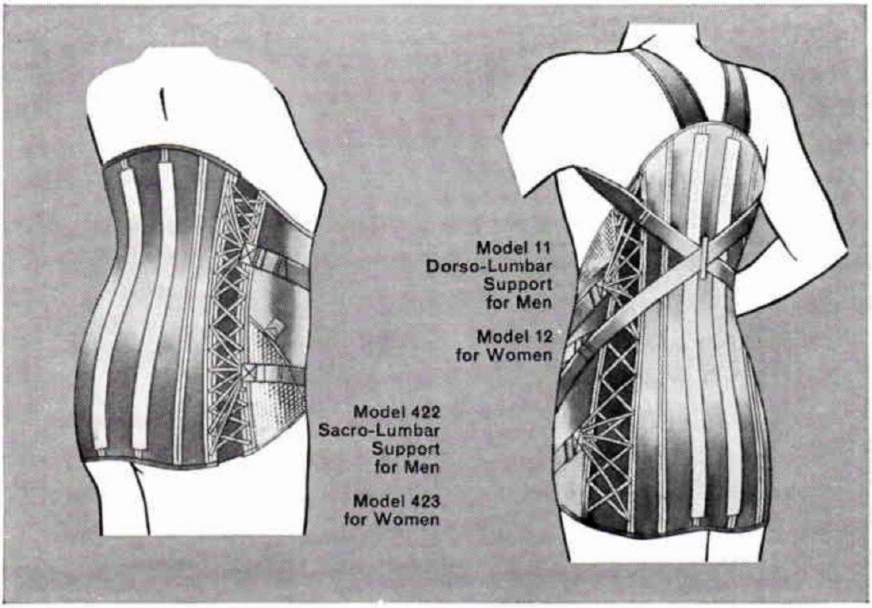

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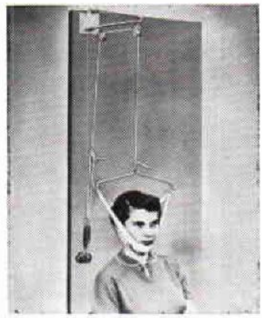

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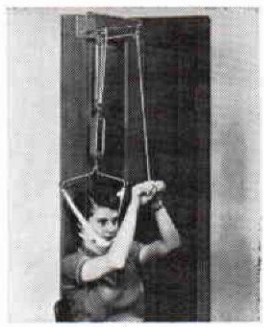

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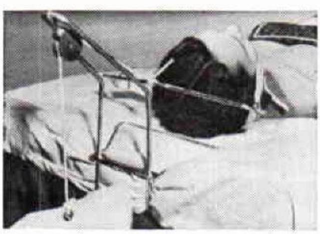

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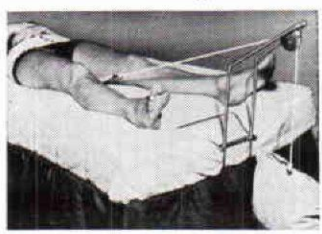
w/Spr. Bar, Head Halter &
Weight Bag



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